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EDUCATION: University of Iowa, 1965-69, B.A.; 1971-76, Ph.D.

ACADEMIC EXPERIENCE

Institution	Dates	Rank
University of Iowa	1971-76	Teaching Assistant
University of Utah	1976-79	Instructor
Arizona State Univ.	1979-82	Assistant Professor
Arizona State Univ.	1982-87	Associate Professor
Brown University	1985-86	Visit.Assoc.Prof.
Arizona State Univ.	1987-	Professor
Arizona State Univ.	1991-92	Interim Chair
Georgia Institute of Tech.	1992-93	Visit. Res. Scientist
University of Minnesota	1999-2000	IMA long-term visitor

Research Interests: Differential Equations, Dynamical Systems, Applications to Mathematical Models in Biology.

BOOKS and MONOGRAPHS

The Theory of the Chemostat, with Paul Waltman, Cambridge University Press, 1995. (Japanese Translation published by Nihon-Hyouron-sha, 2004.)

Monotone Dynamical Systems: an introduction to the theory of competitive and cooperative systems, Amer. Math. Soc. Surveys and Monographs, 41, 1995.

An Introduction to Delay Differential Equations with Applications to the Life Sciences, Texts in Applied Math vol 57, Springer, 2010.

Dynamical Systems and Population Persistence, with H. Thieme, Graduate Studies in Mathematics, Vol. 118, Amer. Math. Soc., 2011; 405 pp.

NSF RESEARCH SUPPORT

DMS-8521605, 1986-88, Nonlinear competitive and cooperative dynamical systems.
DMS-87222279, 1988-1990, Monotone Dynamical Systems.
DMS-9141550, 1990-1993, Monotone Dynamical Systems.
DMS-9300974, 1993-1996, Dynamical Systems in Biology.
DMS-9700910, 1997-2000, Dynamical Systems in Biology.
DMS 0107160, 2001-2004, Dynamical Systems in Biology.
DMS 0414270, 2004-2008, Dynamical Systems in Biology.
DMS 0918440, 2009-2011, Dynamical Systems In Biology: Persistence And Models Of Bacterial And Viral Infection And Treatment

GRADUATE STUDENT SUPERVISION

A. Elkhader, Ph.D., Aug. 1989, "Systems of differential equations with some monotonicity properties."
H.-R. Zhu, Ph.D., Dec. 1991, "The Existence of Stable Periodic Orbits for a System of Three Dimensional Differential Equations that are Competitive".
Baorong Tang, Ph.D., Dec. 1994, "The Analysis of Predator-Prey Systems with Distributed Delay".
Zhao Tao, Ph.D., Dec. 1995, "The analysis of delay chemostat models".
Smith, Ed, MA, Aug. 1998, "Effects of random motility on steady state concentrations of a microbial population in a flow reactor".
Miller, Chris, MA, Aug. 1998, "Single Resource Plant Competition".
Stemmons, Eric, Ph.D., May 1999, "Competition in a chemostat with wall growth".
Wise, Nicole, MA, May 2000, "Modeling animal guts as chemical reactors with periodic food inputs".
Imran, Mudassar, Ph.D., Aug. 2006, "Mathematical Models in Biofilm and Antibiotic Treatment".
Malik, Tufail, Ph.D., Apr. 2007, "Microbial Quiescence: A survival strategy in environmental stress".
Paul Salceanu, Ph.D., Apr. 2009, "Lyapunov Exponents and Persistence in Dynamical Systems with Applications to some Discrete-Time Models".
Zhun Han, Ph.D., Apr. 2012, "A Chemostat Model of Bacteriophage-Bacteria Interaction with Infinite Delay".

EDITORIAL BOARD SERVICE

Differential Equations and Dynamical Systems
Journal of Difference Equations and Applications

Electronic Journal of Differential Equations
SIAM Journal of Applied Mathematics
Mathematical Biosciences and Engineering

PROFESSIONAL SERVICE

NSF Review Panel for Interdisciplinary Grants in the Mathematical Sciences, March, 2002
NSF Review Panel for Mathematical Biology, March, 2005
NSF Review Panel for Mathematical Biology, April, 2011

AWARDS

Bellman Prize for best paper, with M. Ballyk, published in Mathematical Biosciences for two-year period 1998-1999. See vol. 179, <http://www.elsevier.com/locate/mathbio>

JOURNAL ARTICLES/ CONFERENCE PROCEEDINGS:

Bounded Oscillation in a class of Functional Differential Equations, *J.Math.Anal.Appl.*,56,1976,223-232.

On Periodic Solutions of a Delay Integral Equation Modelling Epidemics, *J.Math.Biol.*,4,1977,68-80.

Fixed Point Techniques in a Cone with Applications, with J.Gatica, *J.Math.Anal.Appl.*,61,1977,58-71.

Periodic Solutions for a class of Epidemic Equations, *J.Math.Anal.Appl.*,64,1978,467-479.

Positive Solutions and Conjugate Points for Systems of Differential Equations, with K.Schmitt, *Nonlinear Analysis T.M.A.*,2,1978,93-105.

Periodic Solutions for an Epidemic Model, *Rocky Mountain J.Math.*,9,1979,131-142.

On Eigenvalue Problems for Nondifferentiable Mappings, with K.Schmitt, *J.Differential Eqns.*, 33, 1979, 294-319.

Periodic Solutions of some Nonlinear Delay Differential Equations, with M.Martelli and K.Schmitt, *J.Math.Anal.Appl.* ,74,1980,494-503.

On uniqueness of fixed points for k -set contractions, with C.A.Stuart, Proc. Amer. Math. Soc., 79, 1980 , 237-240.

A note on disconjugacy for second order systems, Pacific J. Math., 89, 1980, 447-452.

Competitive coexistence in an oscillating chemostat, SIAM J.Appl.Math., 40, 1981, 498-522.

Nonresonant periodic perturbation of the Hopf bifurcation, J.Applicable Anal., 12, 1981, 173-195.

An abstract threshold theorem for one parameter families of positive noncompact operators, Funkcialaj Ekvacioj, 24, 1981, 141-153.

The interaction of steady state and Hopf bifurcation in a two predator- one prey competition model, SIAM J. Appl. Math., 42, 1982, 27-43.

Hopf bifurcation in a system of functional equations modeling the spread of an infectious disease, SIAM J. Appl. Math., 43, 1983, 370-385.

Convexity preservation of inverse Euler operators and a problem of S.Miller, with M.Goldstein, R.R.Hall and T.Sheil-Small, Bull.London Math.Soc., 14, 1982, 537-541.

On the basin of attraction of a perturbed attractor, Nonlinear Anal.T.M.A., 6, 1982, 911-917.

Fredholm alternatives for nonlinear differential equations, with K.Schmitt, Rocky Mountain J.Math., 12, 1982, 817-841.

Subharmonic bifurcation in an S-I-R epidemic model, J.Math.Biol., 17, 1983, 163-177.

Multiple stable subharmonics for a periodic epidemic model, J. Math. Biol., 17, 1983, 179-190.

Infinite subharmonic bifurcation in an SEIR epidemic model, with I.Schwarz, J. Math. Biol., 19, 1983, 233-253.

Normal forms for periodic systems, J. Math. Anal. Appl., 113, 1986, 578-600.

Invariant curves for mappings, SIAM J. Math. Anal., 17, 1986, 1053-1067.

Periodic solutions of periodic competitive and cooperative systems, *SIAM J. Math. Anal.*, 17, 1986, 1289-1318.

Periodic competitive differential equations and the discrete dynamics of competitive maps, *J. Diff. Eqns.*, 64, 1986, 165-194.

Cooperative systems of differential equations with concave nonlinearities, *J. Nonlinear Anal. T.M.A.*, 10, 1986, 1037-1052.

On the asymptotic behavior of a deterministic model of cooperative species, *SIAM J. Appl. Math.*, 46, 1986, 368-375.

On the small oscillations of a periodic Rayleigh equation, *Quart. Appl. Math.*, XLIV, 1986, 223-247.

Competing subcommunities of mutualists and a generalized Kamke theorem, *SIAM J. Appl. Math.*, 46, 1986, 856-874.

Systems of differential equations which generate a monotone flow. A survey of results, *SIAM Review*, 30, 1988, 87-113.

Monotone semiflows generated by functional differential equations, *J. Diff. Eqns.*, 66, 1987, 420-442.

Oscillations and multiple steady states in a cyclic gene model with repression, *J. Math. Biol.*, 25, 1987, 169-190.

Periodic orbits of competitive and cooperative systems, *J. Differential Eqns.*, 65, 1986, 361-373.

A classification theorem for three dimensional competitive systems, with P. Waltman, *J. Differential Eqns.*, 70, 1987, 325-332.

Competition in the Gradostat: the role of the communication rate, w. B. Tang, *J. Math. Biol.*, 27, 1989, 139-165.

Competing Subcommunities of Mutualists, *International Journal of Computers & Mathematics with Applications*, vol.18, 1989, 949-957.

Quasiconvergence and stability for strongly order preserving semiflows, with H. Thieme,

SIAM J. Math. Anal., 21, 1990, 673-692.

A Discrete Lyapunov Function for a class of Linear Differential Equations, Pacific J. Math., 144, 1990, 345-360.

Abstract functional differential equations and reaction-diffusion systems, with R. Martin, Trans. of A.M.S., 321, 1990, 1-44.

The Poincaré-Bendixson theorem for monotone cyclic feedback systems, with J..Mallet-Paret, J. Dynamics and Diff. Eqns., 2, 1990, 367-421.

Microbial growth in a periodic gradostat, Rocky Mountain J. Math., 20, 1990, 1173-1194.

Global stability in diffusive delay Lotka-Volterra systems, with Y.Kuang, J. Diff. and Int. Eqns., 4, 1991, 117-128.

Convergent and oscillatory activation dynamics for cascades of neural nets with nearest neighbor competitive or cooperative interactions, Neural Networks, 4, 1991, 41-46.

Monotone semiflows in scalar non-quasi-monotone functional differential equations, with H.Thieme, J. Math. Anal. Appl., 150, 1990, 289-306.

Reaction-Diffusion Systems with Time Delays: Monotonicity Invariance, Comparison and Convergence, with R.Martin, J. reine und angewandte Mathematik, 413, 1991, 1-35.

Convergence for strongly order preserving semiflows, with H.Thieme, SIAM J. Math. Anal., 22, 1991, 1081-1102.

Competition in a modified gradostat, Proceedings of the 2nd International Conf. on Mathematical Population Dynamics, edited by O.Arino, D.Axelrod, M.Kimmel, Lecture Notes in Pure and Applied Math., Marcel Dekker, 1991.

Periodic Tridiagonal competitive and cooperative systems of differential equations, SIAM J. Math. Anal., 22, 1991, 1102-1109.

Convergence in Lotka-Volterra systems with diffusion and delay, with R.H.Martin, Proceedings of workshop on "Differential equations with applications in biology, physics and engineering", Retzhof, Austria, 1989, eds. J.A.Goldstein, F.Kappel, W.Schappacher, Marcel Dekker, Lect. Notes in Pure and Applied Math, vol 133, 1991.

Strongly order preserving semiflows generated by functional differential equations, with H.Thieme, *J. Diff. Eqns.*, 93, 1991, 332-363.

Competition in an n-vessel gradostat, with B.Tang and P.Waltman, *SIAM J. Appl. Math.*, 51, 1991, 1451-1471.

Stable Periodic solutions for the hypercycle system, with J.Hofbauer and J.Mallet-Paret, *J.Dynamics and Differential Equations*, 3, 1991, 423-436.

Equilibrium distribution of species among vessels of a gradostat. A singular perturbation approach, *J. Math. Biol.*, 30, 1991, 31-48.

The gradostat: A model of competition along a nutrient gradient, with P. Waltman, *J. Microbial Ecology*, 22, 1991, 207-226.

Generic failure of persistence and equilibrium coexistence in a model of m-species competition in an n-vessel gradostat when $m \geq n$, with W.Jager and B.Tang, *Differential Equations Models in Biology, Epidemiology and Ecology*, proceedings of conference held in Claremont, CA, Jan. 13-16, 1990, ed. S. Busenburg, M.Martelli, *Lecture Notes in Biomathematics 92*, Springer-Verlag, 1991.

Global stability for infinite delay, dispersive Lotka-Volterra systems: weakly interacting populations in nearly identical patches, with Y.Kuang and R.H.Martin, *J.Dynamics and Diff. Eqn.*, 3, 1991, 339-360.

Structured Population Models, Threshold-Type Delay Equations and Functional Differential Equations, *Delay and Differential Equations*, Proceedings in honor of George Seifert on his retirement, edited by A.M.Fink, R.K.Miller, W.Kliemann, World Scientific, 1992, Singapore.

Periodic solutions of differential delay equations with threshold-type delays, with Y. Kuang, *Oscillation and Dynamics in Delay Equations*, *Contemporary Mathematics*, 129, 1992, American Math. Soc., 153-176.

Periodic Rotating Waves in a model of Microbial Competition in a Circular Gradostat, *Canadian Applied Math. Quarterly*, 1, 1993, 83-114.

Slowly Oscillating Periodic Solutions of Autonomous State-dependent Delay Equations, with Y.Kuang, *Nonlinear Analysis T.M.A.*, 19, 1992, 855- 872.

Some Results on the Existence of Periodic Solutions of State-dependent Delay Equations, proceedings of International Conference on Differential Equations and Applications, Edinburgh, Texas, May, 1991. in Ordinary and Delay differential equations, J.Weiner and J.Hale eds., Pitman Research Notes in Math., 272, 1992.

Reduction of structured population models to threshold-type delay equations and functional differential equations: a case study., Math.Biosciences, 113, 1993, 1-24.

Convergence in Lotka-Volterra type diffusive delay systems without dominating instantaneous negative feedbacks, with Y.Kuang, J. Austral. Math. Soc. Ser. B, 34, 1993, 471-493.

Threshold delay differential equations are equivalent to standard FDE's., Proceedings of International Conference on Differential Equations, Barcelona, Spain 1991, ed. C.Perello, C.Simo, J. Sola-Morales, World Scientific , 1993.

Global stability for infinite delay Lotka-Volterra type systems, with Y.Kuang, J. Diff. Eqns., 103, 1993, 221-246.

Strictly nonautonomous cooperative system with a first integral, with Baorong Tang, Y.Kuang, SIAM J. Math. Anal. 24, 1993, 1331-1339.

Convergence in Lotka-Volterra type delay systems without instantaneous feedbacks, with Y. Kuang, Proc. Royal Soc. Edinburgh, 123A, 1993, 45-58.

A structured population model and a related functional differential equation. global attractors and uniform persistence., J. Dynamics and Differential Eqns. 6, 1994, 71-99.

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Stable periodic orbits for a class of three dimensional competitive systems, with H.-R.Zhu, J. Diff. Eqns. 110, 1994, 143-156.

Competition for a single limiting resource in continuous culture: the variable yield model, with P.Waltman, Siam J. Appl. Math. 54, 1994, 1113-1131.

Equivalent dynamics for a structured population model and a related functional differential equation, Proceedings of 2nd G.J.Butler Memorial Conference on Differential Equations and population Biology, Rocky Mountain J. Math., 25, 1995, 491-499.

Dynamics of Competition in the unstirred chemostat, with S.Hsu and P.Waltman, Canadian Applied Math. Quart. , 2, Fall 1995, 461-483.

Asymptotically Autonomous semiflows: chain recurrence and Lyapunov functions, with H.Thieme, K.Mischiakow, Trans. A.M.S. 347, 1995, 1669- 1685.

On the existence and stability of bounded,almost periodic and periodic solutions of a singularly perturbed nonautonomous system, Differential and Integral Eqns. 8, 1995, 2125-2144.

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Competition in an unstirred multi-dimensional chemostat, with P. Waltman, in Differential Equations and Applications to Biology and to Industry, Proceedings of Claremont International Conf. dedicated to Stavros Busenberg, ed. Martelli et al, World Scientific, 1996.

Tridiagonal competitive-cooperative Kolmogorov systems, with H. Freedman, Differential Equations and Dynamical Systems,3, 1995, 367-382.

A discrete, size-structured model of microbial growth and competition in the chemostat, J.Math. Biology 34, 734-754, 1996.

A parabolic system modeling microbial competition in an unmixed bio-reactor, with Le Dung, J. Diff. Eqns. 130, 59-91, 1996.

Global existence of periodic solutions in a class of delayed Gause-type predator-prey systems, with Tao Zhao and Y.Kuang, Nonlinear Analysis, T.M.A. 28,1997, 1373-1394.

Competitive exclusion and coexistence for competitive systems on ordered banach spaces, with S.B.Hsu and P. Waltman, Trans.Amer.Math.Soc. 348, 1996, 4083-4094.

The periodically forced Droop model for phytoplankton growth in a chemostat, J. Math. Biol. 35, 545-556, 1997.

Complicated dynamics for low-dimensional strongly monotone maps, Proceedings of 2nd World Congress of Nonlinear Analysts (WCNA96), Nonlinear Analysis, 30,#3,1997,p. 1911-1914.

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335-359,1998.

Perturbation of a globally stable steady state, with P. Waltman, Proc. Amer. Math. Soc. 127, 1999, 447-453 (electronic).

Effects of random motility on microbial growth and competition in a flow reactor, with M. Ballyk, Le Dung, D. Jones, SIAM J. Appl. Math. 59,no. 2, 573-596,1998 (electronic).

Growth in the unstirred chemostat with different diffusion rates, with Le Dung and P. Waltman, Fields Institute Communications 21, Amer. Math. Soc., 1999, 131-142.

Steady states of models of microbial growth and competition with chemotaxis, with Le Dung, J. Math. Anal. Appl. 229, 1999, p295-318.

A Flow Reactor with Wall Growth, with M. Ballyk, in Mathematical Models in Medical and Health Sciences, M. Horn, G. Simonett, G. Webb (eds.), 1998 Vanderbilt University Press, Nashville, TN.

A model of microbial growth in a plug flow reactor with wall attachment, with M. Ballyk, Mathematical Biosciences, 158, 1999, 95-126.

Dynamics of a periodically pulsed bio-reactor model, with Xiao-Qiang Zhao, J.Diff. Eqns. 155, 1999, 368-404.

Microbial growth in a plug flow reactor with wall attachment and cell motility, with X.-Q. Zhao, JMAA 241, 134-155, 2000.

Global Asymptotic Stability of Traveling Waves in Delayed Reaction-Diffusion Equations, with X.-Q. Zhao, SIAM J. Math. Anal. 31, 514-534, 2000.

Microbial competition for nutrient and wall sites in plug flow, with D. Jones, SIAM J. Applied Math. 60, 1576-1600, 2000.

Analysis of a Model of Competition between Plasmid-Bearing and Plasmid-Free Microorganisms in a Chemostat, with Bingtuan Li, Yang Kuang, Can. Appl. Math. Quarterly, 7, 1999, 251-282.

A semilinear hyperbolic system, Proceedings of the Mathematics Conference, eds. S.Elyadi, F.Allan, A.Elkhader, T.Muhgrabi, M.Saleh, World Scientific 2000.

Competition in a chemostat with wall attachment, with E. Stemmons, SIAM J. Appl. Math. 61, 2000, 567-595.

Competition in the Periodic Gradostat, with P. Waltman, Nonlinear Analysis: Real World Applications 1, 2000, 177-188.

Stable periodic orbits for a predator-prey model with delay, with M. Cavani, M. Lizana, JMAA 249, 2000, 324-339.

Chain transitivity, attractivity and strong repellers for semidynamical systems, with X.-Q. Zhao and M.W. Hirsch, J. Dynamics and Diff. Eqns. 13, 2001, 107-131.

Competitive exclusion in a discrete-time size-structured chemostat model, with X.-Q. Zhao., Discrete and Contin. Dynamical Systems 1, 2001, 183-191.

Microbial competition in reactors with wall attachment: a comparison of chemostat and plug flow models, with M. Ballyk and D. Jones, Microbial Ecology, 41, 2001, 210-221.

Robust Persistence for semi-dynamical systems, with X.-Q. Zhao, Proc. WCNA 2000, Non-linear Analysis 47, 2001, 6169-6179.

Global dynamics of a SEIR model with vertical transmission, with M. Li and L. Wang, SIAM J. Appl. Math. 62, 2001, 58-69.

How many species can two essential resources support?, with B. Li, SIAM J. Appl. Math. 62, 2001, 336-66.

Stable coexistence and Bi-stability for competitive systems on ordered Banach spaces, with H. Thieme, J. Diff. Eqns. 176, 2001, 195-222.

Bacterial wall attachment in a flow reactor, with Don Jones, Hristo Kojouharov, and Dung Le, SIAM J. Appl. Math. 62, 2002, 1728-1771.

Strong positivity property of solutions to parabolic and elliptic equations on nonsmooth domains, with Dung Le, J. Math. Anal. & Applications 275, 2002, 208-221.

Feedback Control for chemostat models, with Patrick de Leenheer, J. Math. Biol. 46 (2003) 1, 48-70.

Microbial competition for nutrient in a 3D flow reactor, with Jones, Kojouharov, Le, *Dynamics of Continuous, Discrete and Impulsive Dynamical Systems* 10 (2003) 57-67.

Competition for Essential Resources: a brief review, with B. Li, in *Dynamical Systems and Their Applications in Biology* Edited by: Shigui Ruan, , Gail S. K. Wolkowicz, Jianhong Wu, *Fields Institute Communications* 36, 2003, 213-227.

Virus Dynamics: a global analysis, with Patrick de Leenheer, *SIAM J. Appl. Math.* 63, 1313-1327, (electronic) 2003.

Monotone systems, a mini-review, with M.W. Hirsch, in *Positive Systems. Proceedings of the First Multidisciplinary Symposium on Positive Systems (POSTA 2003)*. Luca Benvenuti, Alberto De Santis and Lorenzo Farina (Eds.) *Lecture Notes on Control and Information Sciences* vol. 294, Springer-Verlag, Heidelberg, 2003.

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Periodic Coexistence of 4 species competing for 3 essential resources, with B. Li, *Math. Biosciences* 184, #2, 115-135, 2003.

Global analysis of HIV models, with P. de Leenheer, in *proceedings of European Control Conference 2003 (ECC2003)* University of Cambridge, UK: 1- 4, September 2003.

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Generic Quasi-convergence for strongly order preserving semiflows: a new approach, with M.W. Hirsch, *J. Dynamics and Diff. Eqns.* 16 (2004) 433-440.

Biofilms and the Plasmid Maintenance question, with Mudassar Imran and Don Jones, *Mathematical Biosciences*, 193, issue 2, 2005, p183-204.

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Monotone Maps: a review, with M. Hirsch, *J. Difference Eqns. & Appl.* 11(2005) 379-398.

Monotone Dynamical Systems, with M. Hirsch, *Handbook of Differential Equations , Ordinary Differential Equations (volume 2)*, eds. A.Canada,P.Drabek,A.Fonda, Elsevier, 239-357, 2005. ISBN 0 444 52027 9

Asymptotically Stable Equilibria for Monotone Semiflows, with M. Hirsch, *Discrete and Continuous Dynamical Systems* 14, 385-398, 2006.

Non-monotone systems decomposable into monotone systems with negative feedback, with E. Sontag, G. Enciso, *Journal of Differential Equations*, Volume 224, Issue 1, 1 May 2006, Pages 205-227.

A resource-based model of microbial quiescence, with Tufail Malik, *J. Math. Biology* 53, 2006, 231-252.

The discrete dynamics of monotonically decomposable maps, *J. Math. Biol.* 53, 2006, 747-758.

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Multiple limit cycles in the standard model of three species competition for three essential resources, with B. Li and S. Baer, *J. Math. Biol.* 52, 2006, 745-760.

The pharmacodynamics of antibiotic treatment, with M. Imran, *Computational and Mathematical Methods in Medicine*, 7, 2006, 229 - 263.

The Dynamics of Bacterial Infection, Innate Immune Response, and Antibiotic Treatment , with M. Imran, *Discrete & Cont. Dynamical Systems*, ser. B., 8, 2007, 127-143.

Global dynamics of microbial competition for two resources with internal storage, with B. Li, *J. Math. Biol.* 55 (2007) 481-515.

Dynamics of Stoichiometric Bacteria-Algae Interaction in Epilimnion, with H.Wang, Y.Kuang, J. Elser, *SIAM J. Applied Math.* 68, p. 503 (2007)

Prevalent behavior of strongly order preserving semiflows, with G. Enciso, M.W. Hirsch, *J.Dynamics and Diff. Eqns.*, Volume 20, Number 1 / March, 2008, p115-132

Does Dormancy increase Fitness of Bacterial Populations in Time-Varying Environments, with T. Malik, *Bulletin of Mathematical Biology*, Volume 70, Number 4 / May, p 1140-1162, 2008. DOI:10.1007/s11538-008-9294-5

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Persistence in a Discrete-time Stage-Structured Fungal Disease Model, with P. Salceanu, *J. Biological Dynamics* 3, 271-285, 2009. doi:10.1080/17513750802379028

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Lyapunov exponents and persistence in some discrete dynamical systems, with P. Salceanu, *DCDS-B* 12, (2009) 187-203.

Lyapunov Exponents and Uniform Weak Normally Repelling Invariant Sets, with P. Salceanu, *Positive Systems, Proceedings of third multidisciplinary international symposium on positive systems: theory and applications, Valencia, Spain, Sept. 2009*, in *Lecture Notes in Control and Information Sciences* 389, R. Bru and S. Romero-Vivo eds., Springer, Berlin.

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Well-Posedness and Dissipativity for a Model of Bacteriophage and Bacteria in a Flow Reactor, *Rocky Mountain J. of Math.*, (2011) 41 no.2, 597-613.

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Global Dynamics of the smallest Chemical Reaction System with Hopf Bifurcation, *Journal of Mathematical Chemistry* 50 (2012) 899-995.

Persistence of Bacteria and Phages in a Chemostat, with H. Thieme, Journal of Mathematical Biology: Volume 64, Issue 6 (2012), Page 951-979

Global Dynamics of a Discrete Two-species Lottery-Ricker Competition Model , with Yun Kang, J. Biological Dynamics. Volume 6, Issue 2, 2012 , 358-376. <http://dx.doi.org/10.1080/17513758.2011.586>

On Spread of Phage Infection of Bacteria in a Petri Dish, with Jones, Rost, Thieme, SIAM Journal on Applied Mathematics (2012) Vol.72, No.2, 670-688, <http://dx.doi.org/10.1137/110848360>

A Reaction-Diffusion System with Time-Delay Modeling Virus Plaque Formation, with H. Thieme, Canadian Applied Math. Quarterly, 19, No. 4, 2011, 385-399.

Bacteriophage-Resistant and Bacteriophage-Sensitive Bacteria in a Chemostat, with Zhun Han, Math. Biosciences and Eng. 9, No. 4, 2012, 737 - 765.
doi:10.3934/mbe.2012.9.737

ARTICLES ACCEPTED OR SUBMITTED FOR PUBLICATION

Spread of Viral Infection of Immobilized Bacteria, with D. Jones and H. Thieme, accepted, Networks and Heterogeneous Media.

PERSISTENCE AND GLOBAL STABILITY FOR A CLASS OF DISCRETE TIME STRUCTURED POPULATION MODELS, with H. Thieme, accepted in 2013.

Chemostats and epidemics:competition for nutrients or host, with H. Thieme, accepted in 2013, Mathematical Bioscience and Engineering.

OTHER SCHOLARLY WORKS

"Monotone Semiflows", Lefschetz Center for Dynamical Systems Technical Report #86-19, Brown University, Providence R.I.,1985.

"Convergence for strongly order preserving semiflows", with H.Thieme, Semesterbericht Funktionalanalysis Sommersemester, Math.Inst., Eberhard-Karls-Universitat, Tubingen,1989.

"Dynamics of Competition", Lecture notes at CIME summer school, Martina Franca, Italy, June 13-20, 1997. Published in Springer Lecture Notes in Math. 1714, 191-240,1999.

Review of "Compartmental Modeling with networks", by G.Walter and M. Contreras, for SIAM Review, 42, 2000, p. 546-548.

Review of "Differential Equations and Mathematical Biology", by D.Jones and B. Sleeman, SIAM Review 46, 2004, 183-184.

Review of "Spatial Ecology via Reaction-Diffusion Equations", R.S. Cantrell and C. Cosner, Notices A.M.S. 41,#4 , 551-557

The Biofilm Model of Freter: a review, with M. Ballyk and D. Jones, chapter in "Structured Population Models in Biology and Epidemiology" eds. P. Magal and S. Ruan, Lecture Notes in Mathematics, Mathematical Biosciences Subseries, Springer-Verlag, 2008

RECENT INVITED TALKS

"Monotone dynamical systems with applications to reaction- diffusion systems", 8 lectures, Universidad de los Andes, Merida, Venezuela, Mar. 8 -30, 1995.

"Asymptotically Autonomous Semiflows and Chain Recurrence", minisymposium on Time-dependent perturbations of dynamical systems, 3rd SIAM Conf. on Applications of Dynamical Systems, Snowbird, Utah, May 21, 1995.

"The Dynamics of Competition", plenary lecture, 2nd Marrakesh International Conference on Differential Equations, June 16-20, 1995.

"Microbial Ecology in the Chemostat", featured speaker, SWRIMS Conference on Modeling in Population Dynamics, Utah State University, Aug. 17-19, 1995.

"The dynamics of competition", G.J.Butler Memorial Conference on Differential Equations and Population Biology, University of Alberta, June 26-29,1996.

"Competitive exclusion and coexistence for competitive systems in ordered Banach spaces", session on monotone dynamical systems, 2nd World Congress of Nonlinear Analysts, Athens, Greece, July 10-17, 1996.

"A reaction-diffusion model of microbial competition", plenary talk, Conference on dynamical systems in biology and medicine, University of Veszprem, Veszprem, Hungary, July 17-20,1996.

"The dynamics of competition", plenary talk, Southeast Atlantic Regional Conference on Differential Equations, Emory University, October 18-19,1996.

"The effects of random motility on microbial growth and competition", Conference on Mathematical models in medical and health sciences, Vanderbilt University, Nashville, TN, May 28-31,1997.

"Theory of Competition", 6 hour lectures, session on "Mathematics Inspired by Biology", Centro Internazionale Matematico Estivo, Martina Franca, Italy, June 13-20, 1997.

“The effects of random motility on microbial growth and competition”, Colloquium, University of Rome, June 23, 1997.

“The effects of random motility on microbial growth and competition”, plenary talk, International Conference on Differential Equations with Applications to Biology, Dalhousie University, Halifax, Canada, July 25-29, 1997.

“The effects of random motility on microbial growth and competition”, plenary talk, International Conf. on Differential Equations, Universidad de Los Andes, Merida, Venezuela, Sept. 22, 1997.

“The effects of random motility on microbial growth and competition”, special session on nonlinear dynamics and applications, AMS southeast regional meeting, Atlanta, GA., October 17, 1997.

“A Model of wall growth in the plug flow reactor”, Mathematical Biology Seminar, Univ. Arizona, March 25, 1998.

“Mathematical Models of Microbial Competition for Nutrient and Living space in bioreactors”, The Second Palestinian International Conference on Mathematics, August 19-22, 1998, Palestine.

“Mathematical Models of Microbial Competition for Nutrient and Living space in bioreactors”, Alcala 1st Int. Conf. on Math. Ecology, Alcala de Henares (Madrid), Spain, Sept. 4-8, 1998.

“Mathematical Models of Microbial Competition for Nutrient and Living space in bioreactors”, plenary talk, Third Americas Conf. on Differential Equations and Nonlinear Analysis, Sept. 9-13.

“Perturbation of Global stability”, Colloquium talk, Univ. Texas San Antonio, Nov. 5, 1998.

”Microbial competition for nutrient and wall sites in plug flow”, invited talk, special session on ”Mathematics and Population Dynamics”, western regional meeting of AMS, Tucson, AZ, Nov. 15, 1998.

”A Mathematical Model of Microbial competition for nutrient and wall sites in plug flow: a model for the gut”, Nonlinear Differential Equations: A meeting in honor of Professor Alan Lazer on the occasion of his 60th Birthday, Univ. Miami, Jan. 9, 1999.

”A mathematical model of microbial competition for nutrient and wall sites in plug flow”, Colloquium, Purdue University, March 4, 1999.

”A mathematical model of microbial competition for nutrient and wall sites in plug flow”, Colloquium, Northern Arizona University, April 6, 1999.

”A mathematical model of microbial competition for nutrient and wall sites in plug flow: a model of the gut”, Colloquium, Univ. Autonoma Metropolitana-Iztapalapa, Mexico City, April 14, 1999.

”Applications of the theory of monotone dynamical systems to delay differential equations”, Colloquium, Univ. Nacional Auto. Mexico, Mexico City, April 16, 1999.

"A mathematical model of microbial competition for nutrient and wall sites in plug flow: a model of the gut", plenary talk, conference on Theory and Mathematics in Biology and Medicine, Amsterdam, June 29-July 3, 1999.

"Robust persistence and chain transitivity", Dynamical systems seminar, U. Minnesota, Sept. 21, 1999.

"A mathematical model of microbial competition for nutrient and wall sites in plug flow: a model of the gut", McKnight Seminar in the Math. Biosciences, U. Minnesota, Oct. 12, 1999.

"Uniform Persistence in Dynamical Systems", Applied Mathematical and Computational Sciences Colloquium, Univ. of Iowa, March 2, 2000.

"Robust Persistence", session on "Applications of Dynamical Systems to Biology", 3rd World Conf. of Nonlinear Analysts, Catania, Sicily, July 22, 2000.

"Robust Persistence", in session on Persistence in dynamics and biology, Pacific Rim Dynamical Systems Conf., Lahaina, Maui, Hawaii, August 10, 2000.

"Microbial Growth and competition for wall sites in tubular flow reactors", in special session, on PDE models in Population Biology and epidemiology, AMS meeting, Jan. 10-13, 2001, New Orleans.

"How many species can n limited resources support", Frontiers in Science lecture to College of Science faculty and grad students, Univ. Texas Arlington, Mar 2, 2001.

"Microbial Growth and competition for wall sites in tubular flow reactors", colloquium, Dept. Math. Univ. Texas Arlington, Mar.2, 2001.

"Robust Persistence", colloquium, Dept. Math., Universidad Autonoma de Yucatan, Merida, Yucatan, Mexico, Mar. 23, 2001.

"Colonization resistance in the gut and microbial surface colonization of bio-reactors: an exploration of the Freter Model", plenary talk, 22nd meeting of Canadian Applied & Industrial Mathematics Soc., Victoria, B.C., June 8, 2001.

"How many species can 2 essential resources support?", special session on Nonlinear Dynamics in Ecology and Epidemiology, at Internat. Conf. on Dynamics of continuous, discrete and impulsive systems, London, Ontario, July 27, 2001.

"Bacterial wall attachment in a flow reactor", in special session on Infinite dimensional dynamical systems and population biology, at Internat. Conf. on Dynamics of continuous, discrete and impulsive systems, London, Ontario, July 27, 2001.

"Bacterial wall attachment in a flow reactor", Colloquium talk, Memorial University of Canada, St. Johns, Newfoundland, July 23, 2001.

"How many species can 2 essential resources support?", Distinguished Lecturer award of the Atlantic Assoc. for Research in the Mathematical Sciences, International workshop on Dynamical Systems and their applications in Biology, Cape Breton, Nova Scotia, August 2, 2001.

"Competition in a 3D Flow Reactor with Wall Growth", PIMS Math. Bio. Seminar/Differential Equation Seminar, University of Alberta, Nov 2, 2001.

"How many species can n limited resources support", Colloquium talk, University of Alberta, Nov 1, 2001.

"Virus Dynamics: a global analysis", invited talk, special session on Mathematical Biology, regional meeting of AMS, Portland, Oregon, June 21, 2002.

"Competition for essential resources", invited talk, 5-th Americas Conference on differential equations and dynamical systems, Edmonton, Canada, July 10, 2002.

"Bacterial wall attachment in a flow reactor:mixed culture", DIMACS Workshop on Pathogenesis of Infectious Diseases: Host-Pathogen Dynamics, Rutgers Univ., Sept. 25, 2002.

"Microbial competition for nutrient and wall sites in plug flow", Workshop on transport in supply chains,traffic and biology, ASU, Feb.1 ,2003.

"Traveling waves in a bio-reactor model", Colloquium talk, Center for Dynamical Systems and Nonlinear Studies, Georgia Tech, Feb. 24, 2003.

"Traveling waves in a bio-reactor model", Colloquium talk, Miami University, Feb. 25, 2003.

"Traveling waves in a bio-reactor model", Colloquium talk, University of Southern California, Apr. 2, 2003.

"Competition in the Chemostat: some new results", invited talk, 4th G.J. Butler Memorial Conference on Differential Equations and Mathematical Biology, University of Alberta, June 17, 2003.

Biofilms in a flow reactor: mathematical models & applications, Colloquium talk, University of Louisiana at Lafayette, Oct. 20,2003.

Biofilms in a flow reactor: mathematical models & applications, Colloquium talk, Baylor University, Nov. 7, 2003.

Gene Transfer in Biofilms: a mathematical model, talk given at "Arizona Days 2004", Center for Nonlinear Studies, Los Alamos National Lab, January 30, 2004.

Gene Transfer in Biofilms: math models and implications, invited talk, International Symposium on Dynamical Systems Theory and its Applications to Biology and Environmental Sciences, Shizuoka University, Japan, March 14-17,2004.

Gene Transfer in Biofilms: math models and implications, DIMACS/BIOMAPS Seminar in Quantitative Biology and Epidemiology, Rutgers University, April 28,2004.

Monotone Maps: a review, Int. Conf. on Nonlinear Dynamics and Evolution Equations, July 6-10, 2004, Memorial University of Canada.

Gene Transfer in Biofilms: math models and implications, Canada-France Meeting of Mathematics, special session on mathematical biology, Toulouse France, July 12-15, 2004.

Gene Transfer in Biofilms: math models and implications, Int. Conf. for Mathematics in Biology and Medicine, Ann Arbor, Michigan, July 25-28, 2004.

Monotone Maps: a review, 9th International Conference on Difference Equations and Applications, Univ. Southern California, Los Angeles, Aug 2-6,2004.

Gene Transfer in Biofilms: math models and implications, II Seminario de Biomatemática, Universidad Nacional Mayor de San Marcos, Lima, Peru, August 12, 2004.

Asymptotically stable equilibria for monotone semiflows, Mississippi State-UAB Conference on Differential Equations, Computations, Simulations, Mississippi State University, May 13, 2005.

Nonmonotone systems decomposable into monotone systems with negative feedback, Colloquium talk, University of Helsinki, Finland, June 14, 2005.

Monotonicity in biological systems: positive and negative feedback, plenary lecture, International workshop on Differential Equations in Mathematical Biology, Le Havre, France, July 12, 2005.

Monotonicity in biological systems: positive and negative feedback, contributed talk, European Conference on Mathematical and Theoretical Biology, Dresden, Germany, July 21, 2005.

Mixed monotone difference equations, plenary talk, International Conference on Difference Equations, Special Functions & Applications, July 29, 2005, Munich University of Technology, Munich, Germany.

High dimensional dynamics of continuous and discrete systems reduced to low dimensional dynamics of mappings, invited talk, session: “the many branches of dynamical systems”, MathFest Program, annual MAA meeting, Albuquerque, New Mexico, August 4, 2005.

An overview of monotone dynamical systems, Colloquium, Math Biology Institute, Ohio State University, Feb. 28, 2006.

Monotone systems applied to gene regulatory networks, DIMACS Workshop on state-dependent delays in gene regulatory networks, Rutgers University, March 3, 2006.

Biofilms and the plasmid maintenance question, invite talk, special session on Continuum Modelling of Bacterial Biofilms, H. Eberl & J. Ward, Joint SIAM-SMB Conference on the Life Sciences, Raleigh N.C., Aug 1, 2006.

The Dynamics of Bacterial Infection, Innate Immune Response, and Antibiotic Treatment, Colloquium, Applied Mathematics, University of Arizona, Sept. 29, 2006.

Dynamical Systems in Biology, 3rd Symposium, Frontiers of Statistical, Mathematical, and Computational Sciences, George Washington University, Oct. 27, 2006.

The Dynamics of Bacterial Infection, Innate Immune Response, and Antibiotic Treatment, NCTS, Tsing Hua Univ., workshop on mathematical biology, Hsinchu, Taiwan, May 9, 2007.

Does Dormancy increase Fitness of Bacterial Populations in Time-Varying Environments?, NCTS, Tsing Hua Univ., workshop on mathematical biology, May 10, 2007.

Dynamical Systems in Biology, Colloquium, National Chung Hsing Univ., Taichung, Taiwan, May 11, 2007.

Non-monotone systems decomposable into monotone systems with negative feedback, invited talk, NCTS, Tsinghua Univ., dynamical systems workshop, Taiwan, May 14, 2007.

Dynamical Systems in Biology, Colloquium, National Central University, Taiwan, May 17, 2007.

The Dynamics of Bacterial Infection, Innate Immune Response, and Antibiotic Treatment,

EcoSummit2007, symposium on ecology, evolution and modeling of disease dynamics, Beijing, China May 25, 2007.

Dynamical Systems in Biology, Colloquium, University of Science and Technology, May 23, 2007, Beijing, China.

Dynamical Systems in Biology, 4-th Internat. Conf. on Math. Biology, plenary talk, Wuyishan, China, May 30, 2007.

Monotone dynamics in gene regulation, in minisymposium on dynamics of gene regulation, 6th Int. Congress on Industrial and Applied Math., July 16, 2007, Zurich, Switzerland.

Embedding systems in larger monotone systems versus comparison methods, invited hour talk, 12th Int. Conf. on Difference Eqns. and Applications, Lisbon Portugal, July 27, 2007.

Does Dormancy increase Fitness of Bacterial Populations in Time-Varying Environments?, Society of Math. Biol. annual meeting, minisymposium on chemostat and biodiversity, Aug 2, 2007.

Models of Virulent Phage Growth with application to Phage Therapy, plenary talk, conference on Mathematical Modeling and Analysis of Populations in Biological Systems, Univ. of Arizona, October 7, 2007.

Applications of monotone systems theory to systems of parabolic partial differential equations, workshop on "Recent progress on nonlinear elliptic and parabolic problems and related abstract methods", Banff Internat. Research Station, October 11, 2007.

Models of Virulent Phage Growth with application to Phage Therapy, Colloquium, Georgia Tech., February 25, 2008.

Models of Virulent Phage Growth with application to Phage Therapy, Colloquium, Pomona College, Apr. 16, 2008.

Models of Virulent Phage Growth with application to Phage Therapy, Conference on "Dynamics of structured populations", Banff International Research Station, Apr. 23, 2008.

Prevalent behavior of strongly order-preserving semiflows, AMS regional meeting, Claremont McKenna College, May 5, 2008.

Prevalent behavior of strongly order-preserving semiflows, Workshop on Mathematical tools for multi-scale biological processes, Montana State Univ., June 4, 2008.

Persistence in Semidynamical Systems, plenary talk, 14th ICDEA, Bahcesehir University, Istanbul, Turkey, July 24, 2008.

Remarks on the Theory of Persistence, invited talk, Conf. on Differential Equations and Applications in Ecology and Epidemiology, Purdue Univ., Dec. 10-12, 2008

<http://www.math.purdue.edu/calendar/conferences/deaee/>

Bacteriophage Infection Dynamics: Multiple Host Binding Sites NESCent Mathematical Models, Microbes & Evolutionary Diversification Meeting - July 17-18, 2009

Competition for Essential Resources and Diversity, session on Models and Microbes as Tools for Understanding Diversity, Ecological Society of Amer. annual meeting, Aug. 6, 2009.

Lyapunov exponents and uniformly weak normally repelling invariant sets, Plenary talk, International Symposium on Positive Systems: Theory and Applications, Valencia, Spain,

Sept. 3, 2009 <http://posta09.webs.upv.es/>
 Lyapunov Exponents and Persistence, The Second International Conference on Mathematical Modeling and Analysis of Populations in Biological Systems, Huntsville Alabama, Oct. 10, 2009. <http://brisk.math.uah.edu/conf/index.html>
 The Freter Model of Biofilm Formation, at the Mathematical Biosciences Institute CTW: Biofilms in Infectious Disease: Biology to Mathematical Models and Back Again (March 22-25, 2010) March 25, 2010.
 The Cucker-Smale model of flocking, 2 2-hour lectures, June 22,23, MTBI summer program, ASU 2010.
 Bacteriophage and Bacteria in Chemostat and Flow Reactor, session on “Bacterial Biofilms: Models, Analysis, and Simulation”, SIAM Conf. on Life Sciences, Pittsburgh, July 12, 2010.
 Bacteriophage and Bacteria in Chemostat and Flow Reactor, Applied Sciences Colloquium, ASU Polytechnic, Aug 30, 2010.
 Bacteriophage and Bacteria in Chemostat and Flow Reactor, Math Biology Seminar, ASU, Sept. 3, 2010.
 Dynamics of Bacterial Competition in Serial Transfer, special session on Continuous & Discrete Dynamical Systems, AMS regional meeting, UCLA, Oct. 9, 2010.
 Monotone Dynamical Systems: a quick tour, DIMACS Workshop on Perspectives and Future Directions in Systems and Control Theory, May 25, 2011.
 Persistence for Discrete-Time, Non-Linear, Matrix Population Models, Future Directions in Difference Equations, plenary talk, June 13, 2011, Vigo, Spain. <http://www.dma.uvigo.es/eliz/fdde.html>
 Spread of Viral Plaques, plenary talk, meeting on “Emerging Challenges at the Interface of Mathematics, Environmental Science and Spatial Ecology”, BIRS, Banff, Canada, July 6, 2011.
 Spread of Viral Plaque, ICIAM 2011 session on “Microbial Ecology”, July 18, 2011.
 Persistence of Bacteria and Phages in a Chemostat, ICIAM 2011 session on “Modeling of Ecological Systems”, July 21, 2011.
 Modeling Bacteriophage and Bacteria, MTBI summer program, ASU, July 29, 2011.
 Modeling Bacteriophage and Bacteria, plenary lecture, Summer School on Nonautonomous and Random Dynamical Systems in Life Sciences, Inzell, Germany, Aug. 1, 2011.
 Spread of Viral Plaque, plenary lecture, Summer School on Nonautonomous and Random Dynamical Systems in Life Sciences, Inzell, Germany, Aug. 2, 2011.
 Modeling Bacteriophage and Bacteria, invited seminar talk, Ecology and Evolutionary Biology, Cornell University, Oct. 31, 2011.
 Spread of Viral Plaque, Analysis, Dynamics, and Applications Seminar, Univ. Arizona, March 6, 2012.
 Modeling Microbial Populations in the Chemostat, Undergraduate Summer Research Two-week Program, MBI, Ohio State Univ., May 30, 2012.
 Lectures on Monotone Systems, Silesian Mathematical Summer School in Opava, June 11-15, 2012. Co-financed by the European Social Fund within the framework of the project

Development of Research Capacities of the Mathematical Institute of the Silesian University in Opava. Two hour-and-a half lectures per day for 4 days.

Spread of Viral Plaque, Bolyai Institute, University of Szeged, June 18, 2012.

Dynamical systems in biology: competitive and cooperative systems, MTBI, July 5, 2012.

Modeling Microbial Populations in the Chemostat, MTBI, July 6, 2012.

Dynamics of Bacterial Competition in Serial Transfer, Math. Biol. Seminar, ASU, Sept. 28, 2012.

Spread of Viral Plaque, Colloquium, Montana State University, Oct. 18, 2012.

Spread of Viral Plaque, invited talk, EVERYTHING DISPERSES TO MIAMI: THE ROLE OF MOVEMENT AND DISPERSAL IN SPATIAL ECOLOGY, EPIDEMIOLOGY AND ENVIRONMENTAL SCIENCE, Dec. 16, 2012.

Spread of Viral Plaque, plenary talk, International Conference on the Theory, Methods and Applications of Nonlinear Equations, Texas A&M Univ. Kingsville, Dec. 19, 2012.