

## Aaron A. King

Assistant Professor of Ecology & Evolutionary Biology and Mathematics

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### EDUCATION

Ph.D. (Applied Mathematics). University of Arizona, 1999.

Dissertation Title: *Hamiltonian Limits and Subharmonic Resonance in Models of Population Fluctuations*.

Advisor: Prof. W. M. Schaffer

M.A. (Mathematics). University of Hawai'i, 1992.

B.A. *summa cum laude* (Mathematics). Rice University, 1989.

### HONORS AND AWARDS

Biological Sciences Scholar, University of Michigan, 2005–.

National Science Foundation Mathematical Sciences Postdoctoral Fellowship, 2000–2003.

National Science Foundation Biological Informatics Postdoctoral Fellowship, 2000 (refused).

Flinn Foundation Postdoctoral Fellowship, 1999–2000.

Flinn Foundation Graduate Fellowship, 1997–1998.

National Science Foundation Graduate Research Fellowship, 1994–1997.

Flinn Foundation Scholarship, 1995–1997.

National Merit Scholarship, 1985–1989.

Full Scholarship to Rice University, 1986–1989.

Valedictorian, Andress High School Class of 1985.

### WORKING GROUPS

- Co-organizer of National Center for Ecological Analysis and Synthesis (NCEAS) Working Group on “Unifying approaches to statistical inference in ecology” (2007–2009).
- Invited participation in National Evolutionary Synthesis Center (NESCent) “Hackathon on Comparative Methods in R” (2007–2008).
- Invited participation in NCEAS Working Group on “Seasonality and the population dynamics of infectious diseases” (2003–2005).

### PEER-REVIEWED PUBLICATIONS

1. A. A. King, E. L. Ionides, M. Pascual, and M. J. Bouma (2008), “Inapparent infections and cholera dynamics”, *Nature* **454**:877–880.
2. C. Bretó, D. He, E. L. Ionides, and A. A. King (2008), “Time series analysis via mechanistic models” *Ann. Appl. Stat.*, in press.

3. D. Dimitrov, A. A. King, and T. G. Hallam (2008), "Modeling evolution and persistence of neurological viral diseases in wild populations". *Math. Biosci. Eng.*, in press.
4. E. L. Ionides, C. Bretó, and A. A. King (2008), "Modeling disease dynamics: Cholera as a case study", Chapter 8 in A. Biswas, S. Datta, J. Fine, M. Segal (eds.) *Statistical Advances in the Biomedical Sciences*.
5. E. L. Ionides, C. Bretó, and A. A. King (2006), "Inference for nonlinear dynamical systems" *Proceedings of the National Academy of Sciences of the U.S.A.* **103**:18438–18443.
6. Robert A. Desharnais, R. F. Costantino, J. M. Cushing, Shandelle M. Henson, Brian Dennis, and Aaron A. King (2006), "Experimental support of the scaling rule for demographic stochasticity" *Ecology Letters* **9**:537–547.
7. R. F. Costantino, Robert A. Desharnais, J. M. Cushing, Brian Dennis, Shandelle M. Henson, and Aaron A. King (2005), "Nonlinear population dynamics: The flour beetle *Tribolium* as an effective tool of discovery" *Advances in Ecological Research* **37**:101–141.
8. Aaron A. King (2005), "Phase plane", in Alwyn Scott (ed.), *Encyclopedia of Nonlinear Science*, pp. 712–714. Routledge, New York.
9. Marguerite Butler and Aaron A. King (2004), "Phylogenetic comparative analysis: a modeling approach for adaptive evolution", *The American Naturalist* **164**:683–695.
10. A. A. King, R. F. Costantino, J. M. Cushing, S. M. Henson, R. A. Desharnais, and B. Dennis (2004), "Anatomy of a chaotic attractor: subtle model-predicted patterns revealed in population data" *Proceedings of the National Academy of Sciences, U.S.A.* **101**:408–413.
11. Aaron A. King and Alan Hastings (2003), "Spatial mechanisms for coexistence of species with a shared natural enemy", *Theoretical Population Biology* **64**: 431–438.
12. Shandelle M. Henson, Aaron A. King, R. F. Costantino, J. M. Cushing, Brian Dennis, and Robert A. Desharnais (2003), "Explaining and predicting patterns in stochastic population systems", *Proc. R. Soc. Lond. B* **270**: 1549–1553.
13. A. A. King, R. A. Desharnais, S. M. Henson, R. F. Costantino, and J. M. Cushing (2002), "Random Perturbations and Lattice Effects in Chaotic Population Dynamics", *Science* **297**:2163.
14. S. M. Henson, R. F. Costantino, J. M. Cushing, Robert A. Desharnais, Brian Dennis, and Aaron A. King (2001), "Lattice Effects Observed in Chaotic Dynamics of Experimental Populations", *Science* **294**:602–605.
15. Aaron A. King and William M. Schaffer (2001), "The Geometry of a Population Cycle: A Mechanistic Model of Snowshoe Hare Demography", *Ecology* **82**:814–830.
16. W. M. Schaffer, B. S. Pederson, K. Moore, O. Skarpaas, A. A. King, and T. V. Bronnikova (2001), "Subharmonic resonance and multi-annual oscillations in northern mammals: a nonlinear dynamical systems perspective", *Chaos, Solitons, and Fractals* **12**:251–264.
17. J. M. Cushing, Shandelle M. Henson, Robert A. Desharnais, Brian Dennis, R. F. Costantino, and Aaron King (2001), "A Chaotic Attractor in Ecology: Theory and Experimental Data", *Chaos, Solitons, and Fractals* **12**:219–234.
18. Aaron A. King and William M. Schaffer (1999), "The Rainbow Bridge: Hamiltonian Limits and Resonance in Predator Prey Dynamics", *Journal of Mathematical Biology* **39**:439–469.

19. Aaron King and Alwyn Scott (1998), “The Dimensions of Creativity”, in S. R. Hameroff, A. W. Kaszniak, & A. C. Scott (eds.) *Toward a Science of Consciousness 2*, MIT Press, Cambridge, Mass.
20. A. A. King, W. M. Schaffer, J. Treat, C. Gordon, and M. Kot (1996), “Weakly Dissipative Predator-Prey Systems”, *Bulletin of Mathematical Biology* **58**:835–860.

Abstracts and preprints are available at <http://www.umich.edu/~kingaa/>.

#### MANUSCRIPTS SUBMITTED

1. A. A. King, S. Shrestha, E. T. Harvill, and O. N. Bjørnstad (2008), “Evolution of acute infections and the invasion-persistence trade-off” *Am. Nat.*, in revision.
2. J. A. Scales, A. A. King, and M. A. Butler (2008), “Running for your life or running for your dinner: What drives fiber-type evolution in lizard locomotor muscles?” *Am. Nat.*, in review.

#### TECHNICAL REPORTS

1. E. L. Ionides, C. Bretó, and A. A. King (2006), “Parameter estimation for nonlinear state space models”, Statistics Department Technical Report #438. University of Michigan, Department of Statistics.

#### APPOINTMENTS

- 2008– Senior Research Fellow, Fogarty International Center for Advanced Study in the Health Sciences, National Institutes of Health.
- 2005– Assistant Professor of Ecology & Evolutionary Biology and Mathematics, University of Michigan, Ann Arbor.
- 2004–2005 Research Assistant Professor of Mathematics, University of Tennessee, Knoxville.
- 2002–2005 Assistant Professor of Ecology & Evolutionary Biology, University of Tennessee, Knoxville.
- 2001–2002 Visiting Research Assistant Professor of Mathematics. University of California, Davis.
- 2000–2002 National Science Foundation Postdoctoral Research Fellow. Department of Environmental Science & Policy, University of California, Davis. Mentor: Alan Hastings.
- 1999–2000 Postdoctoral Research Associate. Program in Applied Mathematics, University of Arizona. Mentor: J. M. Cushing.
- 1998 Graduate Research Associate. Department of Ecology & Evolutionary Biology, University of Arizona.
- 1997–1998 Flinn Foundation Fellow. Program in Applied Mathematics, University of Arizona.
- 1994–1997 National Science Foundation Graduate Research Fellow. Program in Applied Mathematics, University of Arizona.
- 1993–1994 Adjunct Instructor of Mathematics, University of Arizona.
- 1993 Adjunct Instructor of Mathematics, Pima County Community College, Tucson, Arizona.
- 1991–1992 Graduate Teaching Assistant, Department of Mathematics, University of Hawai’i, Mānoa.

## RESEARCH GRANTS

- 2008-2011 National Oceanic and Atmospheric Administration Grant: “Cholera prediction: the role of the oceans and nonlinear disease dynamics” Oceans and Human Health Program. Award of \$943,168.
- 2005–2008 National Science Foundation, Division of Environmental Biology Grant: “A Direct Modeling Approach for Phylogenetic Comparative Analysis”. Systematics Program. Award of \$361,461.
- 2004–2008 National Science Foundation, Division of Biological Sciences Grant: “Collaborative Research: The interplay of extrinsic and intrinsic factors in epidemiological dynamics: cholera as a case study”. Ecology of Infectious Diseases Program. Award of \$942,000.
- 2004–2006 National Science Foundation, Division of Biological Sciences Grant: “Ecological Influences on Rabies Infections in Bats”. Ecology of Infectious Diseases Program. Award of \$1,496,000.
- 2000–2003 National Science Foundation Mathematical Science Postdoctoral Research Fellowship. Award of \$90,000.
- 2000–2002 National Science Foundation Biological Informatics Postdoctoral Research Fellowship (refused). Award of \$100,000.
- 1994–1997 National Science Foundation Graduate Research Fellowship.

## TEACHING GRANTS

- 2007–2012 National Science Foundation, Division of Mathematical Sciences Grant: ‘UBM-Institutional: SUBMERGE — Supplying Undergraduate Biology and Mathematics Education and Research Group Experiences to Students at the University of Michigan’ Interdisciplinary Training for Undergraduates in Biology & Mathematics Program. Award of \$905,000.

## INVITED LECTURES

1. “New insights into cholera dynamics: asymptomatic infections, rapid loss of immunity, and mode of transmission”, Seminar, National Center for Ecological Analysis and Synthesis, Santa Barbara, California (December 6, 2007).
2. “New insights into cholera dynamics: asymptomatic infections, rapid loss of immunity, and mode of transmission”, Seminar, Department of Biology, Case Western Reserve University, Cleveland, Ohio (October 17, 2007).
3. “Rigorous inference for partially-observed Markov processes”, Lecture, Mathematical Modeling and Analysis of Populations in Biological Systems Conference, Tucson, Arizona (October 5, 2007).
4. “Rapid loss of immunity is necessary to explain historical cholera epidemics”, Seminar, Applied and Interdisciplinary Mathematics Program, University of Michigan, Ann Arbor, Michigan (February 23, 2007).
5. “Rapid loss of immunity is necessary to explain historical cholera epidemics”, Seminar, Department of Epidemiology, University of Michigan, Ann Arbor, Michigan (January 24, 2007).

6. “Between-host consequences of within-host dynamics: the case of the *Bordetellae*”, Lecture, Bridging the Scales of Disease Dynamics 2006, Pacific Institute of Mathematical Sciences, University of British Columbia, Vancouver (September 29, 2006).
7. “Anatomy of a chaotic attractor: temporal patterns and lattice effects in population dynamics”, Seminar, W. K. Kellogg Biological Station (January 13, 2006).
8. “Rhythm and noise: Detection of temporal patterns in ecological data and what it tells us”, Keynote Lecture, TIMBER 2005, A Conference on Quantitative Biology, Appalachian State University, Boone, North Carolina (November 4, 2005).
9. “Rhythm and noise: Detection of temporal patterns in ecological data and what it tells us”, Seminar, Program in Applied and Interdisciplinary Mathematics, University of Michigan, Ann Arbor (October 28, 2005).
10. “Linking mechanistic models with epidemiological data: parameter estimation in the face of incomplete information”, Symposium Lecture, Ecological Society of America Annual Meeting, Montréal, Québec, (August 12, 2005).
11. “Linking mechanistic models with epidemiological data: parameter estimation in the face of incomplete information”, Symposium Lecture, SIAM Conference on Applications of Dynamical Systems, Snowbird, Utah (May 26, 2005).
12. “Discrete-state biological dynamics: Stochastic models and deterministic skeletons”, Lecture, Joint Mathematics Meetings, Atlanta, Georgia (January 8, 2005).
13. “Anatomy of a chaotic attractor: subtle model-predicted patterns revealed in population data”, Lecture, Joint Mathematics Meetings, Phoenix, Arizona (January 7, 2004).
14. “Chaos in a Bottle: Experimental Studies of Nonlinear Population Dynamics”, Lecture, University of Tennessee Chapter of the Society for Industrial and Applied Mathematics, University of Tennessee, Knoxville (November 5, 2003).
15. “Which deterministic skeleton? Multiple skeletons and lattice effects in stochastic population models”, Lecture, Ecological Society of America Annual Meeting, Savannah, Georgia, (August 7, 2003).
16. “The Hunt for Chaos” and “Patterns in Chaos”, Lectures, Rocky Mountain Mathematics Consortium Summer Conference, University of Wyoming, Laramie, Wyoming, (July 7–18, 2003).
17. “Some Hamiltonian problems in population dynamics”, Lecture, Differential Equations Seminar, University of Tennessee, Knoxville, Tennessee (October 28, 2002).
18. “Order in Real Data: Model-Predicted Temporal Patterns in Chaotic Population Data”, Lecture, Ecological Society of America Annual Meeting, Tucson, Arizona (August 4, 2002).
19. “From the Pendulum to the Lynx and the Hare”, Seminar, Department of Ecology & Evolutionary Biology, University of Arizona, (January 19, 1999).

#### CONTRIBUTED LECTURES

1. “Statistical inference using mechanistic models in continuous time: Measles as a case study”, Lecture, Ecology Society of America Annual Meeting, Milwaukee, Wisconsin (August 7, 2008)
2. “New insights into cholera dynamics: Rapid loss of immunity, transmission mode, and climate drivers”, Lecture, Ecology Society of America Annual Meeting, San Jose, California (August 9, 2007)

3. "A new view of cholera endemicity: routes of transmission and rapid loss of immunity", Lecture, Ecology of Infectious Diseases and American Society of Tropical Medicine & Hygiene, Atlanta, Georgia (November 21, 2006).
4. "Multiple skeletons and lattice effects in stochastic population models", Lecture, Alcalá Second International Conference on Mathematical Ecology, Alcalá de Henares, Spain (September 5–9, 2003).
5. "Spatial Mechanisms for Coexistence of Species Sharing a Common Natural Enemy", Lecture, Ecological Society of America Annual Meeting, Tucson, Arizona (August 4–9, 2002).
6. "Subtle Temporal Patterns in *Tribolium* Population Dynamics", Lecture, International Conference on Mathematical and Theoretical Biology, Hilo, Hawai'i (July 16–19, 2001).
7. "Host-parasitoid dynamics, apparent competition, and spatio-temporal pattern", Seminar, Institute for Theoretical Dynamics, University of California, Davis (May 9, 2001).
8. "Hamiltonian Limits and Subharmonic Resonance in Ecological Models: From the Pendulum to the Lynx and the Hare", Symposium Lecture, AMS Western Sectional Meeting, Tucson, Arizona (November 14, 1998).
9. "Subharmonic Resonance and Population Cycles", Seminar, Department of Mathematics, University of Arizona (April 1 & 8, 1998).
10. "Elucidating the Microcircuitry Underlying Polyphasic Response to Olfactory Stimulation", Lecture and Poster, Flinn Foundation Biomedical Initiative Symposium, Tucson, Arizona (May 9-10, 1997).
11. "Using Mathematics to Sniff Out the Brain's Olfactory Code", Lecture, Quantitative Modeling in Biology Seminar Series, University of Arizona, (February 26, 1997).
12. "Persistent Remnants of Hamiltonian Topology in Predator-Prey Dynamics", Lecture, Dynamics Days Arizona Conference (January 8-11, 1997).
13. "Mathematical Modeling as a Tool in Neurophysiology", Lecture, Foundation Biomedical Initiative Symposium, Scottsdale, Arizona (May 3-4, 1996).
14. "The Dimensions of Creativity", Lecture, Toward A Science of Consciousness II Conference (April 8-13, 1996).

#### TEACHING EXPERIENCE

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| 2008      | Ecology and Evolution of Infectious Diseases Workshop, Colorado State University, Ft. Collins, June 1–4.  |
| 2008      | Interrogating Data with Models, Graduate Course, Ecology and Evolutionary Biology, University of Michigan, Ann Arbor.                           |
| 2006      | Mathematical Ecology. Departments of Ecology & Evolutionary Biology and Mathematics, University of Michigan, Ann Arbor.                         |
| 2005–     | General Ecology. Program in Biology, University of Michigan, Ann Arbor.   |
| 2004–2005 | Mathematical Ecology. Departments of Ecology & Evolutionary Biology and Mathematics, University of Tennessee, Knoxville.                        |
| 2003–2004 | Mathematical Ecology. Departments of Ecology & Evolutionary Biology and Mathematics, University of Tennessee, Knoxville.                        |
| 2003      | Introduction to Modeling in Ecology, Evolution, and Behavior. Department of Ecology & Evolutionary Biology, University of Tennessee, Knoxville. |
| 2002      | Integral Calculus. Department of Mathematics, University of California, Davis.  |

- 2002 Ordinary Differential Equations. Department of Mathematics, University of California, Davis.
- 2000–2001 Guest lectures in course on Mathematical Methods in Population Biology, University of California, Davis.
- 1996 Calculus. Department of Mathematics, University of Arizona.
- 1993–1994 Calculus (with Laboratory). Department of Mathematics, University of Arizona.
- 1993 Two lower level mathematics courses. Pima County Community College, Tucson, Arizona.
- 1993 General Biology. Tucson Unified School District, Tucson, Arizona.
- 1991–1992 Trigonometry courses. Department of Mathematics, University of Hawai'i, Mānoa.
- 1991 Calculus. Department of Mathematics, University of Hawai'i, Mānoa.
- 1991–1992 English and Art History. Varsity International School, Honolulu, Hawai'i.

#### GRADUATE STUDENTS AND POSTDOCS SUPERVISED

Supervised the following students.

1. Yancy Lo (EEB, University of Michigan)
2. Sourya Shrestha (Applied Interdisciplinary Mathematics, University of Michigan)
3. Frank Wright, (M.A. in Mathematics, University of Tennessee)
4. Clay Cressler (EEB, University of Tennessee, University of Michigan)

Served on advisory committees for the following students.

1. Joseph Brown (EEB, University of Michigan)
2. Anindya Bhadra, (Statistics, University of Michigan)
3. Sarah Cobey (EEB, University of Michigan)
4. David Allen (EEB, University of Michigan)
5. Diego Ruiz-Moreno (EEB, University of Michigan)
6. Carles Bretó, (Ph.D. in Statistics, University of Michigan, 2007)
7. Tadashi Fukami (Ph.D. in EEB, University of Tennessee, 2003)
8. Sean McMahon (Ph.D. in EEB, University of Tennessee, 2006)
9. Paula Federico (EEB, University of Tennessee)
10. Marc Cadotte (Ph.D. in EEB, University of Tennessee, 2006)
11. Wandu Ding (Ph.D. in Mathematics, University of Tennessee, 2006)

#### PROFESSIONAL SOCIETIES

- Ecological Society of America.
- Society for Mathematical Biology.
- Society for Industrial and Applied Mathematics.
- American Association for the Advancement of Science.

#### SOFTWARE DEVELOPMENT

Developer and maintainer of the following software packages.

- *pomp*, an R package for statistical inference using mechanistic models (partially-observed Markov processes)
- *ouch*, an R package for model-based phylogenetic comparative analysis of quantitative traits

- *xloc*, a public-domain package for numerical continuation and bifurcation analysis
- *BifCurve*, a Mathematica package for numerical continuation and bifurcation analysis
- *NormalForm*, a Mathematica package for symbolic normal-form analysis of vectorfields
- *llama*, a C++ library of efficient applied mathematics algorithms
- *dlivr*, a package for numerical analysis of dynamical systems with a Matlab/Octave/Mathematica interface
- *arborize*, a TCL/Tk program for semiautomatic extraction of dimensions and connectivity of neurons from confocal laser microscopic data

These software packages can be downloaded at <http://www.umich.edu/~kingaa/>.

#### ACADEMIC SERVICE

Associate Editor for *Theoretical Population Biology*

Associate Editor for *Journal of Theoretical Biology*

Reviewer for: *Advances in Ecological Research*, *American Naturalist*, *Ecological Monographs*, *Ecology*, *Ecology Letters*, *Journal of Mathematical Biology*, *Journal of Theoretical Biology*, *Mathematical Biosciences*, *Oikos*, *Physical Review Letters*, *Physics Letters A*, *Proceedings of the National Academy of Sciences, U.S.A.*, *Proceedings of the Royal Society, Series A & B*, *Public Library of Science Biology*, *Public Library of Science Medicine*, *Public Library of Science One*, *Science*, *SIAM Journal on Applied Mathematics*, *Theoretical Population Biology*, *Trends in Ecology & Evolution*.

Departmental service:

- Graduate admissions committee, University of Michigan, 2006–2008.
- Undergraduate affairs committee, University of Tennessee, 2003–2004.
- Graduate Admissions Committee, University of Tennessee, 2002–2005.
- Departmental Library Representative, University of Tennessee, 2002–2005.
- Departmental Website Committee, University of Tennessee, 2004–2005.

Served on the “Nonlinear Dynamics in Biology” Research and Training Group Admissions Committee, 2001.

Panelist on “Nonlinear Dynamics in Biology” Research and Training Group panels: “Choosing a graduate school”, “Finding a postdoc”, “Balancing career and family concerns”, 2000–2001.

Served on the Board of Directors of the Tucson Waldorf School, 1999–2000.