

Seminar 30th Nov 2005

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Inbreeding depression in the wild: what we know and what we don't

Abstract: The insight that genetic processes can lead to unusual patterns in small populations is at least 240 years old. But to what extent these genetic processes affect naturally small populations has only been the subject of close attention in the past 30 or so years. I will first summarize what we know about one particular genetic process, inbreeding depression. Because I mainly work on birds I will illustrate my talk primarily with data from bird populations. Data from birds make it clear that severe inbreeding depression can occur in nature even in isolated island populations. Furthermore, I will present data that show that the degree of inbreeding depression can be strongly affected by the environmental conditions to which the birds are exposed. However, while evidence is accumulating that the magnitude of inbreeding depression in natural animal populations can be substantially modified by environmental conditions, I will argue that inbreeding depression is not necessarily always most pronounced when environmental conditions are poorest. I will put the results obtained from birds into a larger context and ask what we really know about inbreeding depression in the wild and what we currently fail to understand.

A list of key publications:

- Keller, L.F. and P. Arcese (1998): No evidence for inbreeding avoidance in a natural population of Song Sparrows (*Melospiza melodia*). *American Naturalist* 152 (3): 380-392.
- Keller, L.F. et al. 2001. Immigration and the ephemerality of a natural population bottleneck: Evidence from molecular markers. *Proc. R. Soc. Lond. B.* 268: 1387-1394.
- Keller, L.F. and D.M. Waller. 2002. Inbreeding effects in wild populations. *Trends in Ecology and Evolution* 17: 230-241.
- Keller, L.F. et al. 2002. Environmental conditions affect the magnitude of inbreeding depression in survival of Darwin's Finches. *Evolution* 56: 1229-1239.
- Reid, J.M. et al.. 2005. Hamilton & Zuk meet heterozygosity? Song repertoire size indicates inbreeding and immunity in song sparrows (*Melospiza melodia*). *Proc. R. Soc. Lond. B.* 272: 481-488.

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Citizenship: Swiss
Date of birth: December 31, 1966

Education:

Dec. 1996: Ph.D. Wildlife Ecology. Department of Wildlife Ecology, University of Wisconsin-Madison, USA.

Dec. 1991: M.Sc. Zoology. Institute of Zoology, University of Zürich, and Institute of Zoology, University of Basel, Switzerland.

There is no bachelor's degree in the Swiss educational system.

March 1985: Matura Type B, Realgymnasium Basel, Switzerland

Theses:

Ph.D. 1996 : 'Inbreeding in an insular population of Song Sparrows'. Advisor: Dr. Peter Arcese.

M.Sc. 1991: 'Environmental influences on nestling growth in the Great Tit (*Parus major L.*)'. Advisors: Prof. Hans Kummer (University of Zürich) and Dr. Arie J. van Noordwijk (University of Basel).

Employments:

September 2003 – present: Assistant Professor in Animal Evolutionary Biology, Zoological Museum, University of Zurich, Switzerland.

April 2000 – August 2003: Lecturer (assistant professor), Division of Environmental and Evolutionary Biology, University of Glasgow, Scotland.

Nov. 1997 – March 2000: Visiting Research Fellow, Department of Ecology and Evolutionary Biology, Princeton University, USA.

Jan. 1997 – Nov. 1997: Postdoctoral Research Fellow, Department of Wildlife Ecology, University of Wisconsin-Madison, USA.

Nov. 1992 – Dec. 1996: Research Assistant, Department of Wildlife Ecology, University of Wisconsin-Madison, USA.

1989 – 1991: Research Assistant, Institute of Zoology, University of Basel, Switzerland.

1989: Research Assistant, Swiss Ornithological Station, Sempach, Switzerland.

Teaching Experience:

Current: Taxonomy of Vertebrates. With Dr. J. Hegelbach, University of Zurich.

Current: Biology of Vertebrates. With Prof. H.-U. Reyer, University of Zurich.

Spring 2001-2003: Evolutionary Biology. With Dr. R. Page, University of Glasgow.

Spring 2001-2003: Applications of Ecological Principles. With Dr. D. Houston, University of Glasgow.

Spring 2001-2003: Behavioural Ecology. With Prof. P. Monaghan and Dr. N. Metcalfe, University of Glasgow.

Autumn 2000-2002: Population biology. With Drs. G. Ruxton and J. Lindström, University of Glasgow.

1996 – 1997: Conservation Biology. With Drs. D. Waller, T. Moermond, and S. Temple, University of Wisconsin.

1988-1989: Teaching Assistant, Statistics and Probability Theory Course, Department of Applied Mathematics, University of Zürich (Dr. A. Barbour).

Grants Received:

Swiss Agency for the Environment, Forests and Landscape (SAEFL), 2004-2007. To study the effects of inbreeding on the population dynamics of Alpine Ibex.

Leverhulme Research Grant, 2003-2006. To study the effects of gene flow on local adaptation in a parasitic nematode. To be used at University of Glasgow.

NERC Research Grant, 2002-2004. To study environmental modification of inbreeding depression in the Mauritius Kestrel. To be used at University of Glasgow.

NERC Research Grant, 2001-2002. To study the effects of gene flow on local adaptation in a parasitic nematode.

John Robertson Bequest, University of Glasgow. 2001. To study the evolutionary genetics of disease susceptibility in wild birds.

IBLS Research Award, University of Glasgow. 2001. To study the effects of gene flow on local adaptation in a parasitic nematode.

Roche Research Foundation Grant 1998, to acquire a Unix workstation dedicated to population genetic analyses.

Travel grant of the Swiss Academy of Sciences, 1998, to support evolutionary field research in the Galápagos Islands.

American Ornithologists' Union/NSF award, to attend the International Ornithological Congress 1998 in Durban, South Africa.

Postdoctoral Fellowship, Swiss Academy of Sciences and Swiss National Science Foundation, 1997-1999, to study inbreeding in Darwin's Finches.

Swiss National Science Foundation Grant 1993-1996, to study the evolutionary genetics of small and fragmented populations of birds (with S.C. Stearns).

Roche Research Foundation Grant 1992, to support research on inbreeding in song sparrows.

Honours and Awards Received:

P.L. Wright Distinguished Conservation Biologist, University of Montana, 2005.

Faculty Fellow at Forbes College, Princeton University, 1999 – 2000.

American Society of Naturalists Young Investigator Award 1999.

John Spurrell Graduate Scholarship 1995/1996, College of Agriculture and Life Sciences, University of Wisconsin-Madison.

Professional Activities:

Member of Editorial Boards: Animal Conservation (2002-2005), Biology Letters (2005-2008)

Memberships: American Ornithologists' Union, European Society for Evolutionary Biology, Schweizerische Zoologische Gesellschaft, Society for the Study of Evolution.

Reviewer for: *Journals:* Animal Behavior, Animal Conservation, Ardea, Auk, Biological Journal of the Linnean Society, Canadian Journal of Zoology, Condor, Conservation Biology, Ecology, Ecology Letters, Evolution, Genetics, Heredity, Journal of Animal Ecology, Journal of Avian Biology, Molecular Ecology, Nature, Proceedings of the Royal Society London, Science, Trends in Ecology and Evolution.

Granting Agencies: Leverhulme Trust (UK), National Environmental Research Council (UK), Royal Society of New Zealand, Swiss National Science Foundation.

Reviewed Publications:

- Petren, K., P.R. Grant, B.R. Grant and L.F. Keller. 2005. Comparative landscape genetics and the adaptive radiation of Darwin's finches: the role of peripheral isolation. *Molecular Ecology* 14: 2943-2957.
- Reid, J.M., P. Arcese, A.L.E.V. Cassidy, A.B. Marr, J.N.M. Smith, and L.F. Keller. 2005. Hamilton & Zuk meet heterozygosity? Song repertoire size indicates inbreeding and immunity in song sparrows (*Melospiza melodia*). *Proc. R. Soc. Lond. B.* 272: 481-488.
- Reid, J.M., P. Arcese, A.L.E.V. Cassidy, S.M. Hiebert, J.N.M. Smith, P.K. Stoddard, A.B. Marr, and L.F. Keller. 2005. Fitness correlates of song repertoire size in free-living song sparrows (*Melospiza melodia*). *American Naturalist* 165: 299-310.
- Grant, P.R., B.R. Grant, K. Petren, and L.F. Keller. 2005. Extinction behind our backs: the possible fate of one of the Darwin's finch species on Isla Floreana, Galápagos. *Biological Conservation* 122: 499-503.
- Reid, J.M., P. Arcese, A.L.E.V. Cassidy, S.M. Hiebert, J.N.M. Smith, P.K. Stoddard, A.B. Marr, and L.F. Keller. 2004. Song repertoire size predicts initial mating success in male song sparrows (*Melospiza melodia*). *Animal Behaviour* 68: 1055-1063.
- Grant, P.R., B.R. Grant, J.A. Markert, L.F. Keller, and K. Petren. 2004. Convergent evolution of Darwin's Finches caused by introgressive hybridization and selection. *Evolution* 58: 1588-1599.
- Markert, J.A., P.R. Grant, B.R. Grant, L.F. Keller, J.L. Coombs and K. Petren. 2004. Neutral locus heterozygosity, inbreeding, and survival in Darwins ground finches (*Geospiza fortis* and *G. scandens*). *Heredity* 92: 306-315.
- Grant, P.R., B.R. Grant, L.F. Keller, J.A. Markert, and K. Petren. 2003. Inbreeding and interbreeding in Darwin's Finches. *Evolution* 57: 2911-2916.
- Reid, J.M., P. Arcese, and L.F. Keller. 2003. Inbreeding depresses immune response in song sparrows (*Melospiza melodia*): direct and inter-generational effects. *Proc. R. Soc. Lond. B.* 1529: 2151-2158.
- Finney, S.K., M.P. Harris, L.F. Keller, D.A. Elston, P. Monaghan, and S. Wanless. 2003. Reducing the density of breeding gulls influences the pattern of recruitment of immature Atlantic puffins *Fratercula arctica* to a breeding colony. *J. Appl. Ecol.* 40: 545-552.
- Keller, L.F., P.R. Grant, B.R. Grant, and K. Petren. 2002. Environmental conditions affect the magnitude of inbreeding depression in survival of Darwin's Finches. *Evolution* 56: 1229-1239
- Keller, L.F. and D.M. Waller. 2002. Inbreeding effects in wild populations. *Trends in Ecology and Evolution* 17: 230-241. *ISI-Web of Science determined this to be one of the most cited recent papers in the field of Environment/Ecology (Sept. 2003).*
- Marr, A.B., L.F. Keller, and P. Arcese. 2002. Heterosis and outbreeding depression in descendants of natural immigrants to an inbred population of song sparrows (*Melospiza melodia*). *Evolution* 56: 131-142.
- Keller, L.F., P.R. Grant, B.R. Grant, and K. Petren. 2001. Heritability of morphological traits in Darwin's Finches: misidentified paternity and maternal effects. *Heredity* 87: 325-336.

- Keller, L.F. K.J. Jeffery, P. Arcese, M.A. Beaumont, W.M. Hochachka, J.N.M. Smith, and M.W. Bruford. 2001. Immigration and the ephemerality of a natural population bottleneck: Evidence from molecular markers. *Proc. R. Soc. Lond. B.* 268: 1387-1394.
- Jeffery, K.J., L.F. Keller, P. Arcese, and M.W. Bruford (2001): The development of microsatellite loci in the song sparrow, *Melospiza melodia* and genotyping errors associated with good quality DNA. *Molecular Ecology Notes* 1: 11-13.
- Grant, P.R., B.R. Grant, L.F. Keller, and K. Petren. 2000. Effects of El Niño events on Darwin's finch productivity. *Ecology* 81(9): 2442-2457.
- Nager, R.G., L.F. Keller, and A.J. van Noordwijk (2000): Understanding natural selection on traits that are influenced by environmental conditions. *In: T. Mousseau et al. (eds.). Adaptive genetic variation in the wild.* Oxford University Press, Oxford.
- Naef-Daenzer, B. and L.F. Keller (1999): Foraging performance of great and blue tits (*Parus major* and *P. caeruleus*) in relation to caterpillar development, and its consequences for nestling growth and fledging weight. *Journal of Animal Ecology* 68: 708-718.
- Keller, L.F. and P. Arcese (1998): No evidence for inbreeding avoidance in a natural population of Song Sparrows (*Melospiza melodia*). *American Naturalist* 152 (3): 380-392.
- Keller, L.F. (1998): Inbreeding and its fitness effects in an insular population of Song Sparrows (*Melospiza melodia*). *Evolution* 52: 240-250.
- Arcese, P., L.F. Keller, and J.R. Cary (1997): Why include a behaviorist in your conservation team? *In: J. R. Clemmons and R. Buchholz, editors. Behavioral Approaches To Conservation in the Wild.* Cambridge University Press, Cambridge.
- Smith, J.N.M., M.J. Taitt, C.M. Rogers, P. Arcese, L.F. Keller, A.L.E.V. Cassidy, and W.M. Hochachka (1996): A metapopulation approach to the population biology of Song Sparrows. *Ibis* 138:120-128.
- Keller, L.F., P. Arcese, J.N.M. Smith, W.M. Hochachka, and S.C. Stearns (1994): Selection against inbred song sparrows during a natural population bottleneck. *Nature* 372:356-357.
- Keller, L.F. and A.J. van Noordwijk (1994): Effects of local environmental conditions on nestling growth in the Great Tit (*Parus major* L.). *Ardea* 82: 349-362.
- Keller, L.F. and A.J. van Noordwijk (1993): A method to isolate environmental effects on nestling growth, illustrated with examples from the Great Tit (*Parus major* L.). *Functional Ecology* 7:493-502.
- Hellriegel, B., U. Leugger, L. Keller, and H. Zandt (1993): Education and science for maintaining biodiversity. *Biodiversity Letters* 1: 131-133.
- Kummer H., M. Brandt, M. Furter, L. Keller and M. Meier (1991): Nutritional exploitation of dead trunks: Another function of cypress knees (*Taxodium distichum*)? *Trees* 5: 122-123.

Books:

- Smith, J.N.M. L.F. Keller, A.B. Marr, and P.Arcese (eds.). 2005. *Biology of small populations: the song sparrows of Mandarte Island.* Oxford University Press.

Other Publications:

- Keller, L.F., P. Arcese, and J.N.M. Smith (1998): Factors affecting post-fledging survival and settlement patterns in the Song Sparrow. *In: Adams, N.J. and R.H. Slotow (ed.). Proc. 22 Int. Ornithol. Congr., Durban.* Ostrich 69: 76.

- Anthony, N., G. Gelembiuk, D. Ganzer, R. French-Constant, and L.F. Keller (1997): Conservation Genetics of the endangered Karner Blue Butterfly (*Lycaeides melissa samuelis*). Preliminary report to the U.S. Fish and Wildlife Service.
- Keller, L.F. (1994): Phenotypic Plasticity of Nestling Growth in the Great Tit (*Parus major*) in Response to Local Environmental Conditions. *Journal fuer Ornithologie* 135(3):344.
- Keller, L.F. (1991): Environmental influences on nestling growth in Great Tits. *Revue Suisse de Zoologie* 98:712.