# Russell Scott Lande

**Royal Society Research Professor at Imperial College London**

## 2011 Balzan Prize for Theoretical Biology or Bioinformatics

*For pioneering contributions to the development and application of theoretical population biology, including the modern development of the theory of quantitative genetics, and the study of stochastic population dynamics.*

**Institution Administering Research Funds:** Imperial College London

**Adviser for the Balzan General Prize Committee**: H. Charles J. Godfray

## Theories of Quantitative Character Evolution and Stochastic Population Dynamics

With the second part of his Balzan Prize, Russell Lande is supporting young researchers at the postdoctoral and graduate student levels. Two experienced postdoctoral researchers are employed through Imperial College London, Silwood Park Campus, modeling the joint evolution of mating systems, flowering phenology and inbreeding depression in plants. Both are to be based at their home institutions in France, Dr. Emmanuelle Porcher at the Muséum national d'Histoire naturelle and Dr. Céline Devaux at Université Montpellier 2, doing collaborative research supervised by Professor Lande, with frequent visits to Silwood Park by them and to their home institutions by Professor Lande.

The Centre for Conservation Biology (CCB) organized a workshop entitled *Stochastic demography in fluctuating environments: theory and empirical patterns* from 23-27 April 2012. The workshop was aimed at young scientists in the initial stages of their scientific career and focused on models for describing the demography of populations in fluctuating environments, methods for estimation of parameters from data and presentations of empirical examples that illustrate the practical application of this quantitative approach for understanding dynamics of populations. Central topics covered were the concepts of demographic and environmental stochasticity, density-

dependence in age-structured populations, techniques for estimating key parameters in age-structured models, spatial synchrony in population fluctuations, population viability analyses and community dynamics.

A major part of the workshop was comprised of introductory lecturers by Prof. Steinar Engen, Prof. Russell Lande and Prof. Bernt-Erik Sæther. The aim of these lectures was to give an overview of the theories in stochastic population dynamics and demography, to show their significance for general understanding of principles explaining patterns in fluctuations of natural populations and to demonstrate how these models could be parameterized using data from different model systems. The second part of the course consisted of exercises in practical applications of the models in analyses of data using a multitude of computer programmes mainly developed by researchers at CCB. These practicals were supervised by Professor Jarle Tufto and Researcher Vidar Grøtan. The final part of the course consisted of short presentations in which the participants presented their own research.

The venue for the course was Lovund Rorbuhotell on the island of Lovund in northern Norway. This rather isolated island was chosen because it provided the participants with knowledge concerning one of the major study areas for field projects at CCB. All together 42 persons (37 invited participants and 5 lecturers) participated in the workshop. 16 of the participants were Scandinavian, 19 came from rest of Europe, 1 from the USA and 1 from Asia. *Lecturers* - Russell Lande, United Kingdom; Steinar Engen, Norway; Bernt-Erik Sæther, Norway; Vidar Grøtan, Norway; Jarle Tufto, Norway. *Invited participants* - Adriana Plicanti, Italy; Aline M Lee, Norway; Agata Czapracka, Poland; Alva Curtsdotter, Sweden; Anders Wikstrom, Sweden; Anna Nilsson, Sweden; Arne Schröder, Sweden; Ayco Tack, The Netherlands/Finland; Brancila Raluca Ioana, Romania; Chris Sutherland United Kingdom/Sweden; Daisy Brickhill, United Kingdom; Deborah Pardo, France; Diala Abu Awad, France; Edwige Bellier, France/Norway; Erik Blystad Solbu, Norway; Helena Johansson, Sweden; Henna Fabritius, Finland; Henrik J. de Knegt, The Netherlands/Finland; Håkon Holand, Norway; Karen Lesley Szostek, Germany; Linda Kaneryd, Sweden; Marcin Tobolka, Poland; Markku Karhunen, Finland; Nele Schuwirth, Switzerland; Peter Hellström, Sweden; Piotr Tryjanowski, Poland; Shouli Li, China/Finland; Simona Imperio, Italy; Sonja Leidenberger, Germany/Sweden; Stephanie Jenouvrier, France/USA; Stine Svalheim Markussen, Norway; Tanjona Ramiadantsoa, Madagascar/Finland; Thomas Cameron, United Kingdom/Sweden; Thomas Kvalnes, Norway; Thor Harald Ringsby, Norway; Uli Steiner, Switzerland/France/USA.

Based on the feedback received from the participants during the course, it was clear that they considered it a huge success. Thus, this type of course may be replicated on a later occasion, using the same organizational concept.

**Research publications**

Research was conducted with Dr. Celine Devaux, who was hired as a consultant for two summers (likely to be extended to a third one), and with Dr. Emmanuelle Porcher, who was hired as an employee of Imperial College London for two years beginning September 2012. Results to date include one published paper, listed below with its abstract, two submitted papers under review, listed by authors and title, and three manuscripts in advanced stages of preparation (not listed). The research focuses on developing quantitative theories of the evolution of plant mating systems, particularly mixed self-fertilization and outcrossing, as influenced by pollination ecology and the evolution of inbreeding depression.

- Porcher E, Lande R. 2013. Evaluating a simple approximation to modeling the joint evolution of self-fertilization and inbreeding depression. Evolution. 67: 3628–3635.

  A comprehensive understanding of plant mating system evolution requires detailed genetic models for both the mating system and inbreeding depression, which are often intractable. A simple approximation assuming that the mating system evolves by small infrequent mutational steps has been proposed. We examine its accuracy by comparing the evolutionarily stable selfing rates it predicts to those obtained from an explicit genetic model of the selfing rate, when inbreeding depression is caused by partly recessive deleterious mutations at many loci. Both models also include pollen limitation and pollen discounting. The approximation produces reasonably accurate predictions with a low or moderate genomic mutation rate to deleterious alleles, on the order of $U = 0.02–0.2$. However, for high mutation rates, the predictions of the full genetic model differ substantially from those of the approximation, especially with nearly recessive lethal alleles. This occurs because when a modifier allele affecting the selfing rate is rare, homozygous modifiers are produced mainly by selfing, which enhances the opportunity for purging nearly recessive lethals and increases the marginal fitness of the allele modifying the selfing rate. Our results confirm that explicit genetic models of selfing rate and inbreeding depression are required to understand mating system evolution.

- Devaux C, Lande R, Porcher E. 2014. Pollination ecology and inbreeding depression control individual flowering phenologies and mixed mating. Evolution. (revision in review).
- Devaux C, Lepers C, Porcher E. 2014. Pollinator constraints on the ecology and evolution of plant mating systems. Journal of Evolutionary Biology. (in revision).