Mathematical modelling of infection dynamics

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AGBU, UNE, Armidale, Australia

Andrea Doeschl-Wilson & Osvaldo Anacleto

The Roslin Institute & Royal (Dick) School of Veterinary Studies, University of Edinburgh, UK

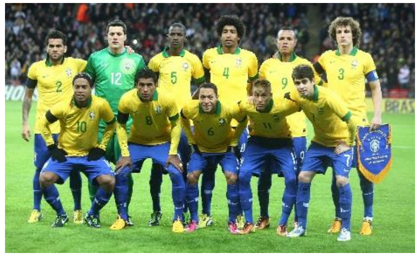
Who are we?

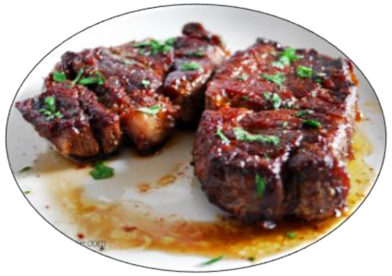
Andrea Doeschl-Wilson

- Current position: Group Leader in Mathematical modelling in genetically heterogeneous populations (Genetics & Genomics, Roslin Institute)
- Research Background:
  - MSc Pure Mathematics (Germany) – Dynamical systems theory
  - PhD Applied mathematics (Canada) – Modelling braided river dynamics
  - Research Scientist in a pig breeding company – 'Blue sky team': Mathematical modelling in quantitative genetics
  - Research Fellow in Scottish Agricultural College: mathematical modelling applied to animal science; focus on infectious disease modelling since ~2007

Andrea Doeschl-Wilson, Genetics & Genomics, The Roslin Institute and R(D)SVS, University of Edinburgh, Scotland, UK
Andrea.Wilson@roslin.ed.ac.uk

Who are we?





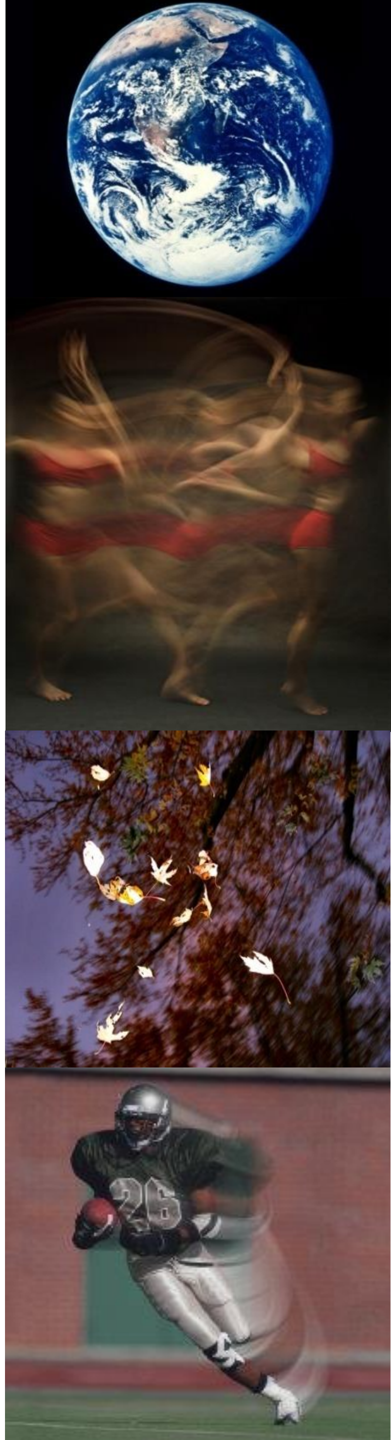
Osvaldo Anacleto

- Current position: Research Fellow (Genetics & Genomics, Roslin Institute)
- Research Background:
  - MSc Statistics (Brazil)
  - PhD Statistics (UK) – Bayesian models for traffic flow
  - Research & Development Specialist for a bank in Brazil
  - Lecturer (Brazil)
  - Statistical Consultant (Brazil)

Osvaldo Anacleto, Genetics & Genomics, The Roslin Institute and R(D)SVS, University of Edinburgh, Scotland, UK
Osvaldo.Anacleto@roslin.ed.ac.uk

Underpinning philosophy

- The world is made up of non-linear and dynamic processes
- Infection is a highly complex, dynamic phenomenon arising from many processes that interact over time
- In order to understand or predict the behaviour of this complex system we need to describe the underlying dynamics
- Mathematical modelling is an extremely powerful tool to study such complex dynamical systems



What will you learn in this course?

By the end of the course you will

- Have a good understanding what mathematical models can / cannot do in infectious disease research
- Be familiar with various types of models and modelling tools
- Know how to build, code, analyse and use mathematical models
- Know how to estimate model parameters from data using likelihood and Bayesian statistics

- Know the basic mathematical toolset to start your own modelling project
- Know how to write and run R-scripts

Some tips

1. **Don’t panic if you struggle with the mathematics**
    - Focus on the main message rather than the mathematical detail
    - Skip the analytical sections in the tutorials
2. **You don’t need to fully understand the R-code provided**
    - We expect you to be able to run the R-scripts we provided (help provided)
    - It is more important to know WHAT the code is doing (see comments in code) than HOW it was programmed
3. **ASK QUESTIONS & INTERACT**

Course outline

Day 1: Introduction to mathematical modelling and infectious disease dynamics in livestock

Lecture 1: Introduction to mathematical modelling (A. Wilson)

Lecture 2: Infectious disease fundamentals (A. Wilson)

Lecture 3: Examples of infectious disease models for livestock (A. Wilson)

Tutorial 1: Designing a mathematical model for bovine Tuberculosis

Tutorial 2: Introduction to R

Course outline

Day 2: Modelling epidemics

Lecture 4: Mathematical essentials (A. Wilson)

Lecture 5: Deterministic models for homogeneous populations (A. Wilson)

Tutorial L5: Deterministic models for homogeneous populations

Lecture 6: Deterministic models in heterogeneous populations (A. Wilson)

Tutorial L6: Deterministic models for heterogeneous populations

Lecture 7: Stochastic & individual based epidemiological models (A. Wilson)

Tutorial L7: Stochastic models

Course outline

Day 3: Modelling within-host infection dynamics

Lecture 8: Empirical vs mechanistic models of within-host infection dynamics (A. Wilson)

Tutorial L8: Exploring empirical & mechanistic models of within-host infection dynamics

Lecture Mathematical Essentials 2:

Introduction to probability distributions

Course outline

Day 4: Statistical Inference

Lecture 9: Introduction to Statistical Inference: the frequentist approach and its application to stochastic epidemic models (O. Anacleto)

Tutorial L9: Frequentist inference for proportions & stochastic epidemic models

Lecture 10: Introduction to Bayesian inference & conjugate models (O. Anacleto)

Tutorial L10: Bayesian inference for the beta-binomial model

Lecture 11: Introduction to Bayesian inference using MCMC: Gibbs Sampling and Metropolis Hastings algorithms (O. Anacleto)

Tutorial L11: Markov chains

Lecture 12: Applications of Bayesian inference using MCMC (O. Anacleto)

Tutorial L12: Analysis of a hierarchical non-linear model for PRRS data