# EEB1210H Advanced Statistics – Fall 2023
## Department of Ecology & Evolutionary Biology

### Course Instructor

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### Location and Time

Tuesday from 9:30 (sharp) to 12:30; ESC 2144 or zoom
(https://utoronto.zoom.us/j/86156107574 Passcode: stats)

### Course Description

Biologists need to use statistical methods to test their hypotheses. Given the increasing complexity of experiments carried out by biologists, they need however to understand the limitations of these statistics and how to select the appropriate statistics for their needs, and how to interpret them properly both statistically and biologically. The goal of this advanced course in statistics is to teach biologists how to choose and use statistics so that they can address relevant biological questions and test them with the appropriate methods. Specifically, an overview of advanced notions about regression analysis and ANOVA will be presented. The course is lecture-based with assignments designed to develop awareness about the misuse of statistics.

### Course Objectives

By the end of the course, graduate students should be able to:

- understand the utility and pitfalls of statistics and their appropriate application to biological problems;
- analyse their data with the appropriate statistics and interpret the results adequately;
- read, understand, and critically evaluate papers and their use of statistics.

### Topics and Timetable

| 2023 | Topics | Labs |
|---|---|---|
| Sept 12-Wk1 | • Review of the various types of statistical approaches: parametric, non-parametric, Bayesian, randomization tests<br>• Experimental design, Power analysis, Effect size | Homework DUE on Sept 19: Your questions/objectives and potential data |
| Sept 19-Wk2 | • *Chi*-Square-test, *G*-test<br>• Correlation, partial correlation<br>• Linear regression and Residual analysis | Homework DUE |
| Sept 26-Wk3 | • Causality 201-Path Analysis<br>• Multiple regression<br>• Model selection criteria<br>• Generalized Linear Models (GLM) | |
| Oct 3-Wk4 | • Generalized Linear Mixed Models (GLMM)<br>• Non-linear regression, Smoothing<br>• Generalized Additive Models (GAM)<br>• Regression Tree Methods; Clustering | Lab 1: Regression |
| Oct 10 and 17 | No Class | Lab 1 DUE |
| Oct 24-Wk5 | • ANOVA<br>• Nested ANOVA<br>• Factorial ANOVA/Multiple comparison tests | Lab 2: ANOVA |
| Oct 31-Wk6 | • ANCOVA<br>• Split-plot models/Repeated measures<br>• MANOVA | |
| Nov 7-Wk7 | • Meta-analysis/Survival analysis<br>• Multivariate/Ordination methods | Lab 2 DUE |
| **Nov 21-Wk8** | • **Student presentations (10 minutes MAX)** | Term-paper DUE |

**Evaluation**

**1. Lab 1:** Regression methods (10%)
→ I do not want a printout of the figures.
→ The marks are for the statistical and biological interpretations of the results obtained.

**2. Lab 2:** ANOVA (10%)
→ I do not want a printout of the figures
→ The marks are the statistical and biological interpretations of the results obtained.

**3. Term project = Report** (60%): Write the "methods section" of your potential data analysis explaining which statistics you should use to answer your hypotheses/objectives: Compare at least two different statistical methods stressing the assumptions of each selected statistical methods as well as their pros and their cons from a statistical/methodological perspective and from an ecological/evolutionary/biological perspective.

- Maximum 6 pages **single-interlined**
  - Half-page presenting the objectives of the study
  - Half-page presenting the data
  - Four pages explaining (assumptions; the goals of each method; how the methods address your objectives; comparing the statistical methods-pros and cons)
  - One page for references (of the methods and examples of applications)

**4. Term project = Presentation** (20%): Each student will present a 10-minute talk summarizing: The objective(s) of their project; The (potential) data; The selected methods that should be used to assess/test your hypotheses.

**Useful References**


→ Gotelli NJ, AM Ellison. 2012. *A Primer of Ecological Statistics.* 2nd edition. Sinauer.
→ **Lepš J, P Šmilauer. 2020. *Biostatistics with R. An introduction guide for field biologists*. Cambridge Uni. Press.**
→ Whitlock M, D Schluter. 2015. *Analysis of Biological Data*. 2nd ed. Roberts and Company Publishers.
→ van Emden HF. 2008. *Statistics for Terrified Biologists*. Wiley-Blackwell.

•James G, Witten D, Hastie T, Tibshirani. 2013. *An Introduction to Statistical Learning: with Applications in R*. Springer.
•Pardo S, Pardo M. 2018. *Statistical Methods for Field and Laboratory Studies in Behavioral Ecology*. Chapman and Hall/CRC.
•Zuur *et al*. 2009. *Mixed Effects Models and Extensions in Ecology with R*. Springer.
ºEdwards AM, Auger-Méthé M. 2019. Some guidance on using mathematical notation in ecology. *Methods in Ecology and Evolution* 10:92-99.
ºElith J *et al*. 2008. A working guide to boosted regression trees. *Journal of Animal Ecology* 77:802-813.
ºGreen P, MacLeod CJ. 2016. SIMR: an R package for power analysis of generalized linear mixed models by simulation. *Methods in Ecology and Evolution* 7:493-498.
ºGurevitch J *et al*. 2018. Meta-analysis and the science of research synthesis. *Nature* 555(7695):175-182.
ºHarrison XA *et al*. 2018. A brief introduction to mixed effects modelling and multi-model inference in ecology. *PeerJ* 6:e4794.
ºPedersen EJ *et al*. 2019. Hierarchical generalized additive models in ecology: an introduction with mgcv. *PeerJ* 7:e6876.


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