Studying Evolutionary Ecology 1: Experimentation

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Biol 417: Evolutionary Ecology

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Review

Last week we covered the scope of evolutionary ecology.

We also covered some basic evolutionary principles.

This week we will cover how we can actually study evolutionary ecology.

Design- vs. Model-based Inference

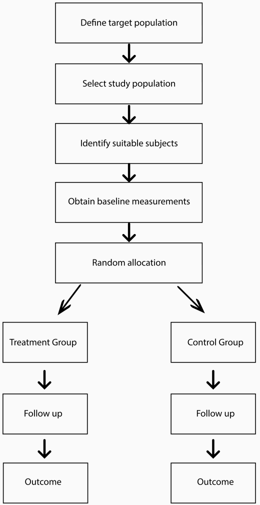
The Scientific Method

Science is a process of learning about nature. As scientists, we weigh competing ideas about how the world works (hypotheses) against observations (data).

The process of making scientific inference can be split into two broad categories: design-based and observation-based.

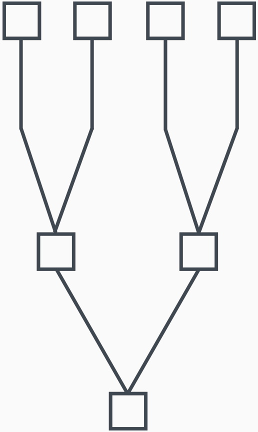
Design-based inference

- In design-based inference, most of the focus is on experimental design (e.g., ensuring the sample population is representative, the appropriate controls are included, etc...).
- Goal is to be able to demonstrate that 'x causes y'.
- Data are typically analysed by comparing means and variances across groups (e.g., ANOVAs, t-tests, etc...).



Worklow of design-based inference

- Devise a hypotheses
- Devise an experiment with outcomes that will clearly accept or reject the hypothesis.
- Carry out the experiment so as to get a clean result.
- Recycle the procedure to refine the remaining possibilities (Platt, 1964).



Core of design-based inference is confronting single hypotheses with data.

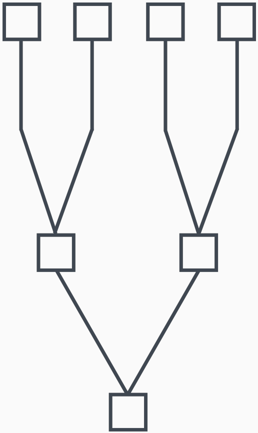
Rqmts. of design-based inference

Platt's decision tree is based on:

i) Clear, distinct hypotheses.

ii) Unambiguous outcomes.

iii) A relationship between statistical significance and biological relevance.



Experimentation in Evolutionary Ecology

What if you want to study how predator prey interactions have shaped species' traits?

Problem:

Predator-prey dynamics have already played out and what we see is the end result.

Solution:

Introduce species to new predators.

Reznick et al. (1990)

Source stream:

Poecilia reticulata

Length: 2-6 cm

Crenicichla alta

Max length: 16 cm

Preys on adult guppies

Introduction stream:

Rivulus hartii

Max length: 10 cm

Preys on juvenile guppies

Reznick et al. (1990) cont.

12 years later in the introduced population:

- Males and females were larger.
- Females produced fewer, larger offspring.
- Individuals allocated less energy to reproduction.
- When individuals were removed from the stream and reared in a lab, these changes were heritable persisted for generations.

Genetic benefits of immigration

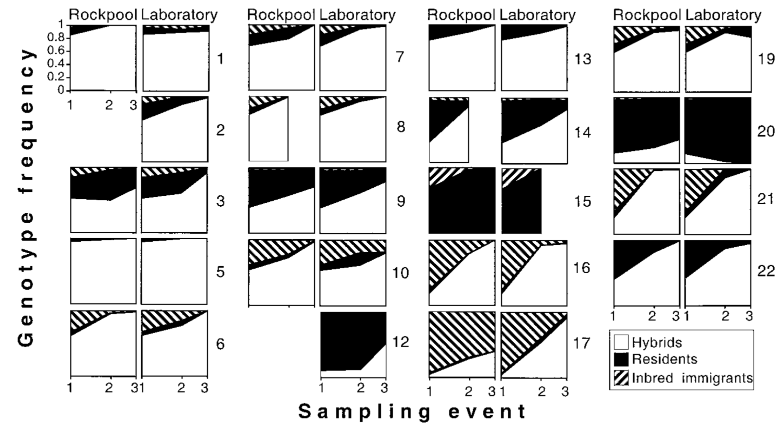
What if you want to study the genetic benefits of immigration and gene flow?

Problem:

You need to control immigration rates, quantify the benefits, and control against environmental confounds.

Solution:

Ebert et al. (2002)



— Ebert *et al.* (2002)

Species acquisition rates

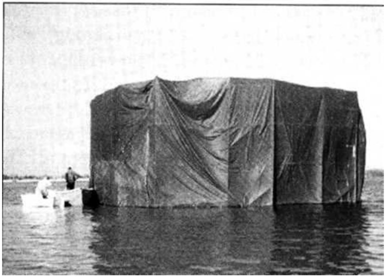
What if you want to study the rates at which different environments acquire new species?

Problem:

Most natural systems are probably near carrying capacity and blank slates are rare.

You can't easily create a natural ecosystem in a lab and expect natural immigration.

Solution:



Simberloff's defaunation experiment on Mangroves

Simberloff & Wilson (1970)

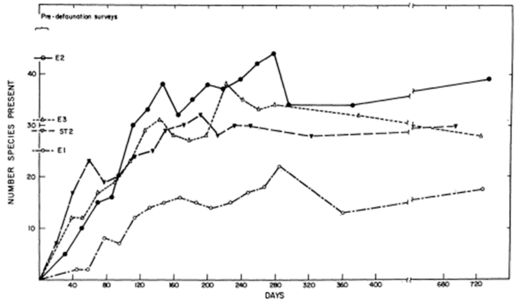


FIG. 1. The colonization curves of four small mangrove islands in the lower Florida Keys whose entire faunas, consisting almost solely of arthropods, were exterminated by methyl bromide fumigation. The figures shown are the estimated numbers of species present, which are the actual numbers seen plus a small fraction not seen but inferred to be present by the criteria utilized by Simberloff and Wilson (1969) and Simberloff (1969). The number of species in an inverse function of the distance of the island to the nearest source of immigrants. This effect was evident in the predefaunation censuses and was preserved when the faunas regained equilibrium after defaunation. Thus, the near island E2 has the most species, the distant island E1 the fewest, and the intermediate islands E3 and ST2 intermediate numbers of species.

— Simberloff & Wilson (1970)

Limitations of design-based inference in Evolutionary Ecology

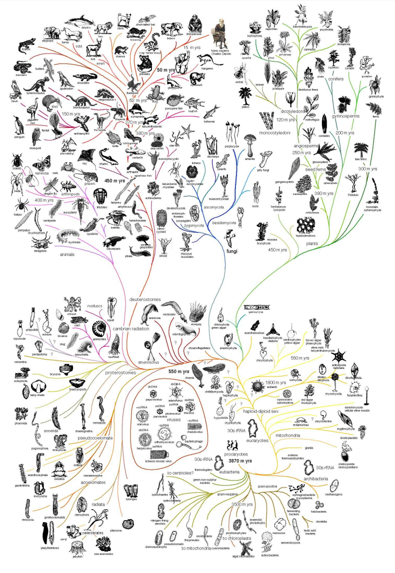
Limitations of design-based inference

Evolutionary processes have long time-scales.

Humpback whales (*Megaptera novaeangliae*) can live for 50+ years. Source: David Valencia

Bristlecone pines (*Pinus longaeva*) live for thousands of years. Source: wired.com

Long time-scales



Source: Chris King

Limitations of design-based inference

Evolutionary processes have long time-scales.

Many ecological systems have very poor reproducibility.

Poor reproducibility

Source: Tom and Pat Leeson

Limitations of design-based inference

Evolutionary processes have long time-scales.

Many ecological systems have very poor reproducibility.

How can you design a controlled experiment in a wild population?

Limitations of design-based inference

What if you're interested in studying evolution from a species conservation perspective?

Source: Wikipedia

In 1988 the wild pop. of black footed ferrets (*Mustela nigripes*) was down to 18 ind.

What if a power analysis says you need 20 animals?

Experimentation and Evol. Ecol.

Experimentation, paired with design-based statistical inference, provides a powerful tool for understanding the mechanisms that drive evolutionary ecological phenomena.

Climbing the scientific 'tree of progress' via experimentation is an inherently slow process.

Not all questions/systems lend themselves to experimentation.

Next Lecture

Next lecture we will learn about the Comparative Method and how it provides a complementary approach to experimental ecology.

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