Reproduce with whom?
Emergence of reproductive isolation in ecological speciation

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Reproductive strategies from genes to societies
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Outline

1. Introduction
2. Speciation on a regulated landscape
3. Role of spatial heterogeneity
4. Conclusion
Why speciate?

- **Darwin:**
  - Speciation is driven by the advantage of being different.
  - No clue on reproductive isolation.
- **Allopatric (Mayr) speciation:**
  - No way for divergent evolution in a panmictic population.
  - Populations must be geographically separated first!
- **Ecological (competitive, adaptive, etc.) speciation:**
  - Reproductive isolation is a consequence of divergent selection.
  - Parsimony: ecological possibility for diversification drives diversification.

Mallet: Mayrs view of Darwin: was Darwin wrong about speciation? (2008)
Why adaptation leads to reproductive isolation?

How does emergence of reproductive isolation is affected by spatial structure?
Introduction

Questions

Why adaptation leads to reproductive isolation?

How does emergence of reproductive isolation is affected by spatial structure?
Why are there so many kinds of animals?

Background: different pictures in ecology and evolution:

Species occupy different niches.

Species occupy different peaks of landscape.

Conceptual clarification is needed!
Regulated landscape

Competition: I eat your food and therefore reduce your fitness.

Competition and evolution to avoid competition are meaningless on a landscape which do not take into account the biotic feedback.

Meszéna (2005); Meszéna, Gyllenberg, Jacobs & Metz et al. (2005)
Is there a limit for similarity?

Lotka-Volterra competition *a la* MacArthur & Levins (1967)
Gaussian carrying capacity & competition kernel.

Except the immediate vicinity of continuous coexistence:
Discretization! Segregation by niche width!

Gyllenberg & Meszéna (2005); Szabó & Meszéna (2006)
Evolutionary branching for clonal organism

MacArthur & Levins ecology + mutation; clonal inheritance

Branching, i.e. evolutionary discretization!

Gertitz, Metz, Kisd &, Meszéna, (1997)
Speciation with multilocus genetics

Modified from Dieckmann & Doebeli (1999)

Multilocus traits:

- Ecological trait: 2 x 32 loci
- Mating trait: 2 x 16 loci

Two alleles per locus (0, or 1), additive, random recombination. Assortative mating according to the ecological trait.

Meszéna & Dieckmann: Three-phase transitions to reproductive isolation (2019)
Three phases speciation process

Three phases

- First: fast to the middle, widened trait distribution
- Second: slow, gradual transition to bimodality
- Third: fast completion of segregation
Three phases

- First: fast increase of assortativity
- Second: minimal additional change
- Third: fast further increase of assortativity
Three-pase speciation: Additive variance

Three phases

- First: no significant change of variance
- Second: accelerating loss of genetic variance
- Third: seems to be initiated by the loss of genetic variance
Feedback structure

Population

Allelic variance

Ecological trait

Phenotype distribution

Mating trait

Selection

Ecological fitness

Sexual fitness (male success)

Ecological trait

Allelic variance

Phenotype distribution

Mating trait

Sexual fitness (male success)

Ecological fitness

+
Ecology of spatial structure: Ways of niche segregation

Parallelism between resource and habitat segregation!
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Role of spatial heterogeneity

Fitness and coexistence in a two-patch environment

Fitness and coexistence on the large spatial scale!

Meszéna, Czibula & Geritz (1997); Szilágyi & Meszéna (2009)
Reproductive isolation in a two patch, two resource model

Model setup

Pure resource segregation:

Disadvantage of ecological heterozygote selects for assortativity!
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Role of spatial heterogeneity

Spatial segregation

Patches differ in environmental condition and resource distribution.

Decreased migration rate modifies evolution!
Why adaptation leads to reproductive isolation?

- Essence of speciation is not the accidentally arising incompatibilities.
- Reproductive isolation is essentially an adaptation to a multi-niche environment. (Accidents may help.)

How does emergence of reproductive isolation is affected by spatial structure?

- Speciation is rarely expected to be strictly sympatric.
- Spatial heterogeneity may help to initiate evolution for assortativity, but may inhibit reaching complete reproductive isolation.
Conclusion

Why adaptation leads to reproductive isolation?

- Essence of speciation is *not* the accidentally arising incompatibilities.

- Reproductive isolation is essentially an adaptation to a multi-niche environment. (Accidents may help.)

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Conclusion

Theory-Based Ecology: A Darwinian approach

Is there such thing, as theory-based ecology?

At least, we have a book on it...

Enjoy!!!
Thanks

Theory Based Ecology
- Liz Pásztor
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- Gabriella Magyar

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Thanks for your attention!