Sympatric, or allopatric?

Adaptive emergence of reproductive isolation in different ecological situations

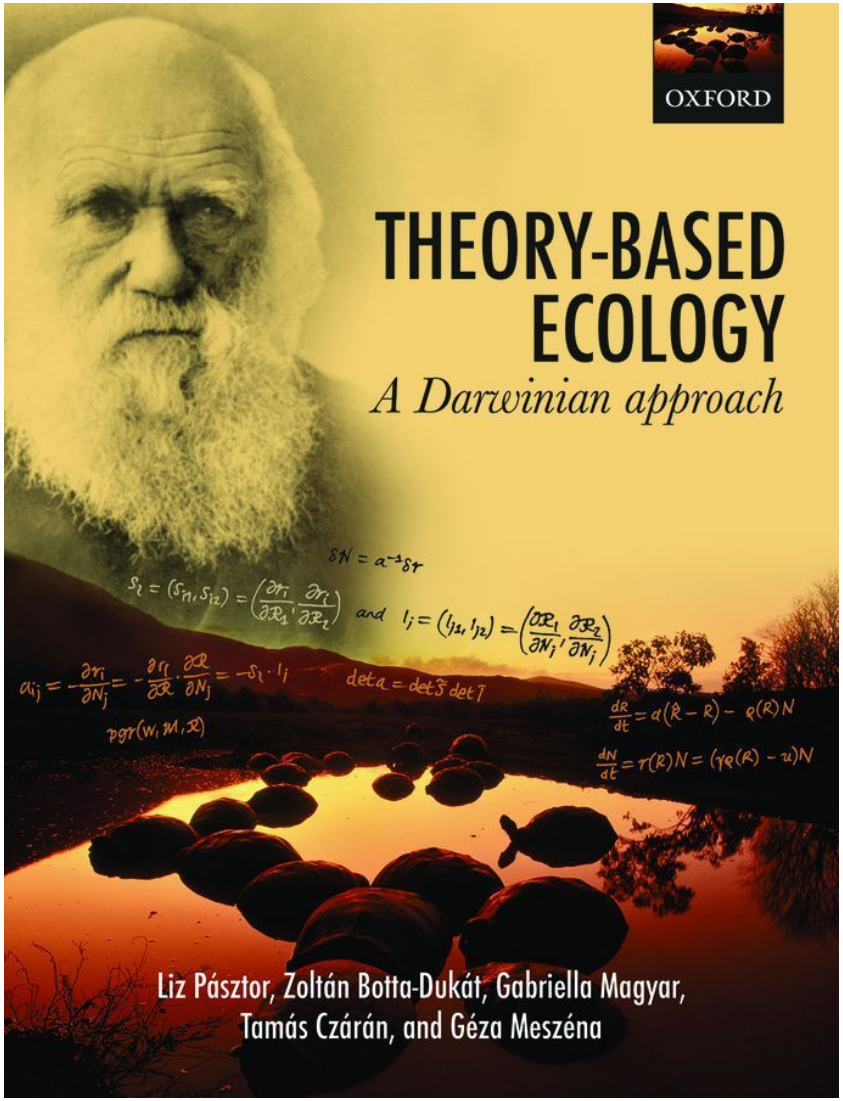
Géza Meszéna with Benjamin Márkus & Kristóf Törkenczy

Eötvös University, Budapest

MPDEE'18, Leicester, 2018

Outline

Theory-Based Ecology: A Darwinian approach



Principles

1. Exponential growth
2. Growth regulation
3. Inherited variability
4. Finitness – stochasticity
5. Competitive exclusion
6. Coexistence
7. Constraints – trade-offs

Speciation debate

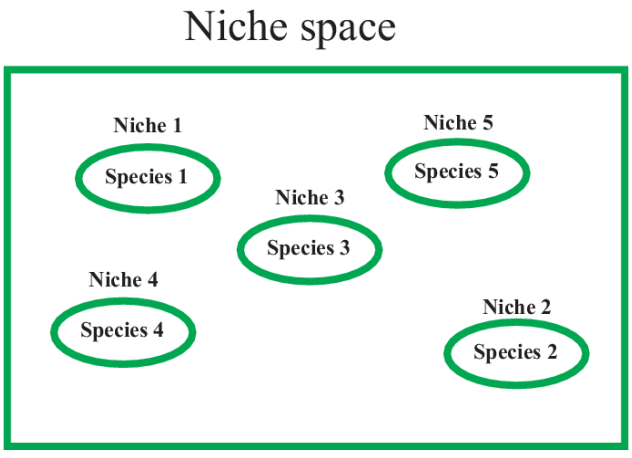
1. Darwin: It is advantageous to be different. Continuity from variability within species to different species.
2. Allopatric theory (Mayr): externally imposed allopatry is the *only* possible way to initiate speciation.
3. Empirical results:
   - Sympatric speciation *is* possible
   - Role of ecological selection is established
   - Existence of gene flow during speciation is established
4. Emergence of competitive/adaptive/ecological theory of speciation.

Question:

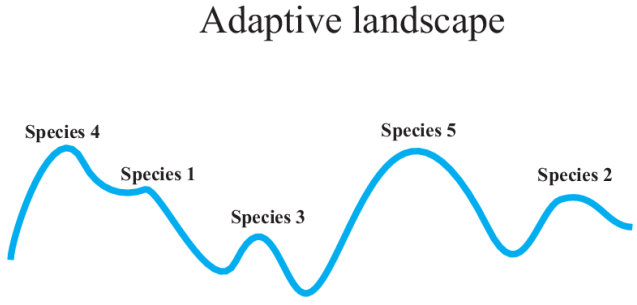
If allopatry is not compulsory,
is it still true that spatial segregation helps speciation?

Why are there so many kinds of animals?

Conflicting pictures: ecology vs. evolution



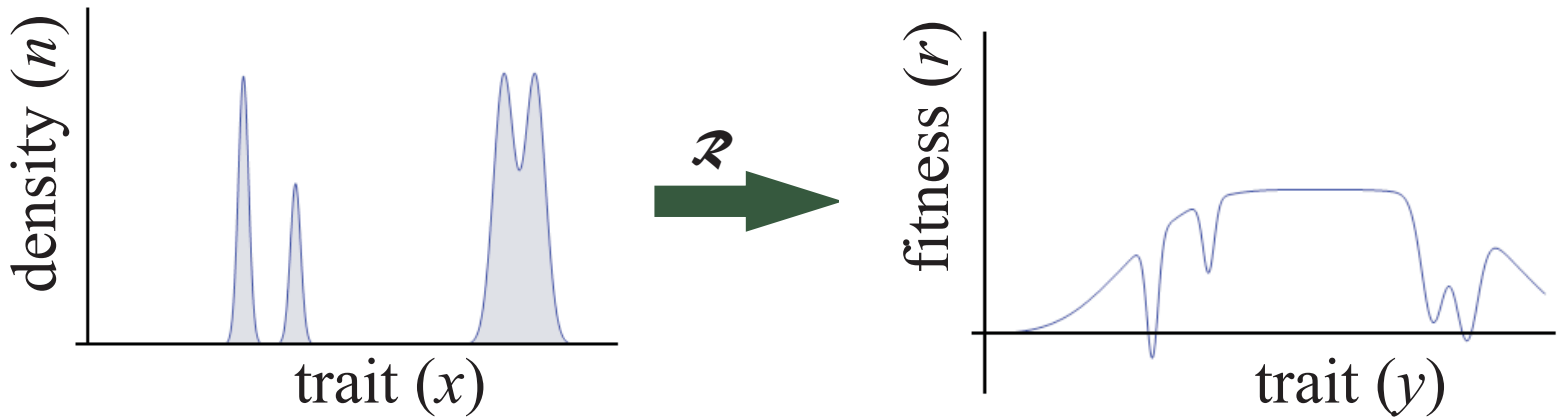
Species occupy different *niches*.



Species occupy different *peaks of landscape*.

Tension: "fittest wins" vs. "coexistence with reduced competition"

Regulated landscape

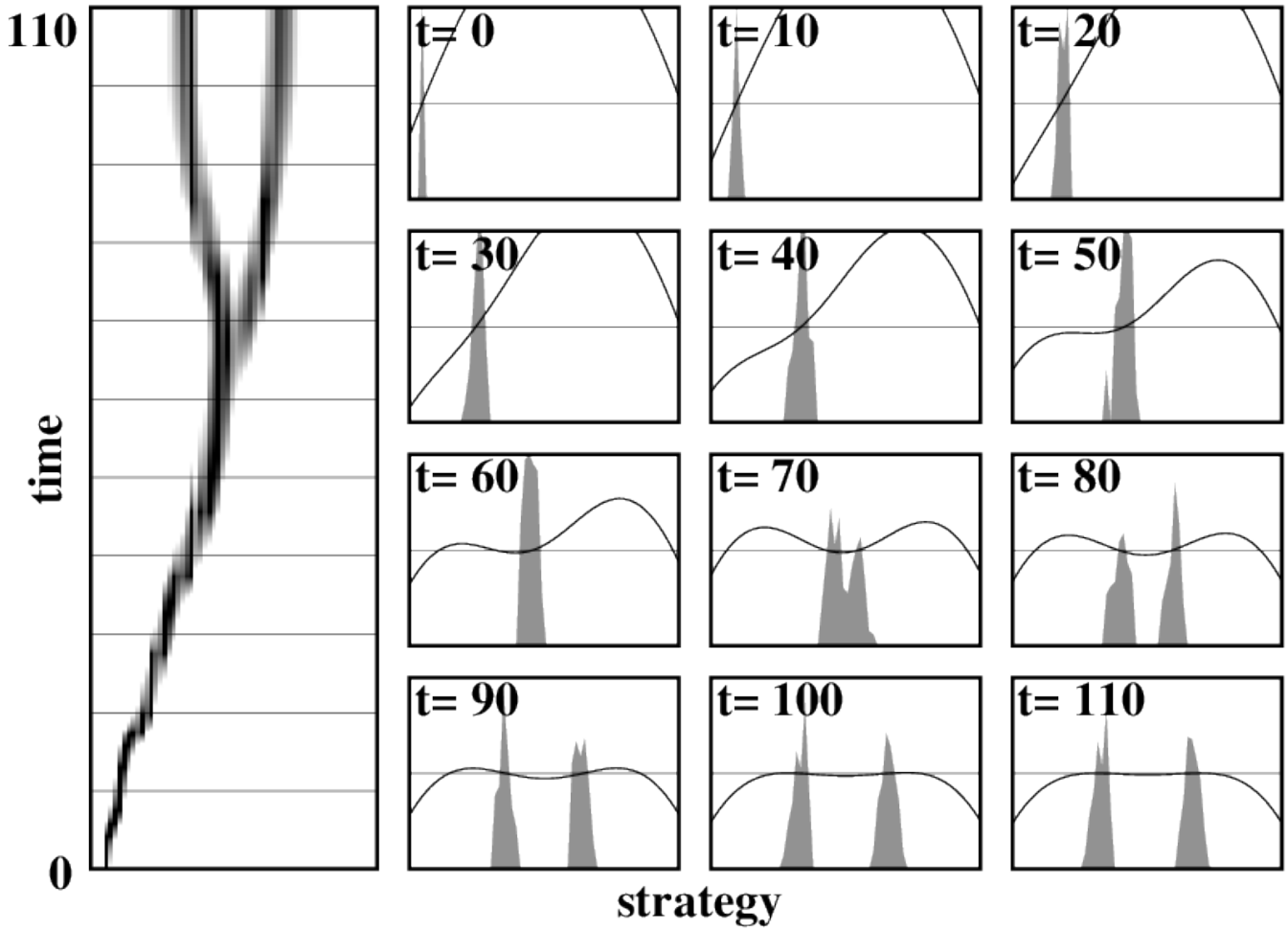


Strength of competition:

$$a(x,y) = -\frac{\delta r(y)}{\delta n(x)} = -\frac{\delta r(y)}{\delta \mathcal{R}} \frac{\delta \mathcal{R}}{\delta n(x)}$$

Strength of competition (reduced competition) makes evolutionary sense only on a *regulated* landscape!

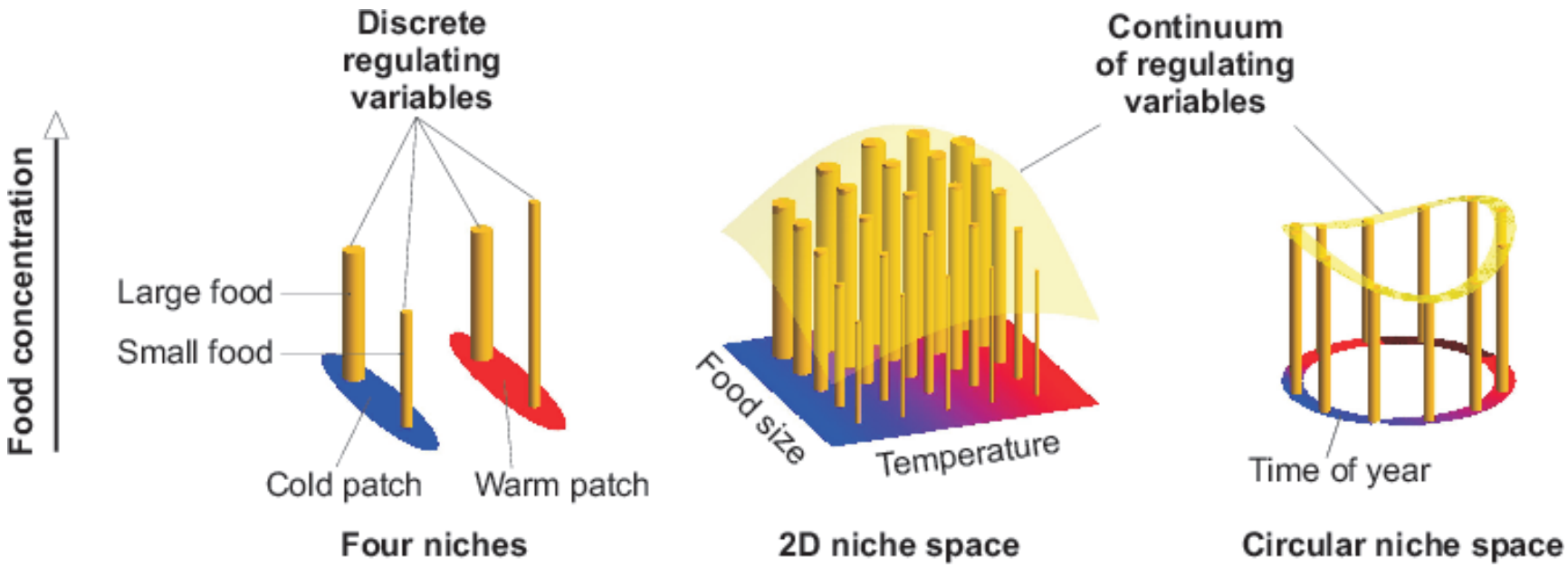
Evolutionary branching



Reproductive isolation in the sexual case?

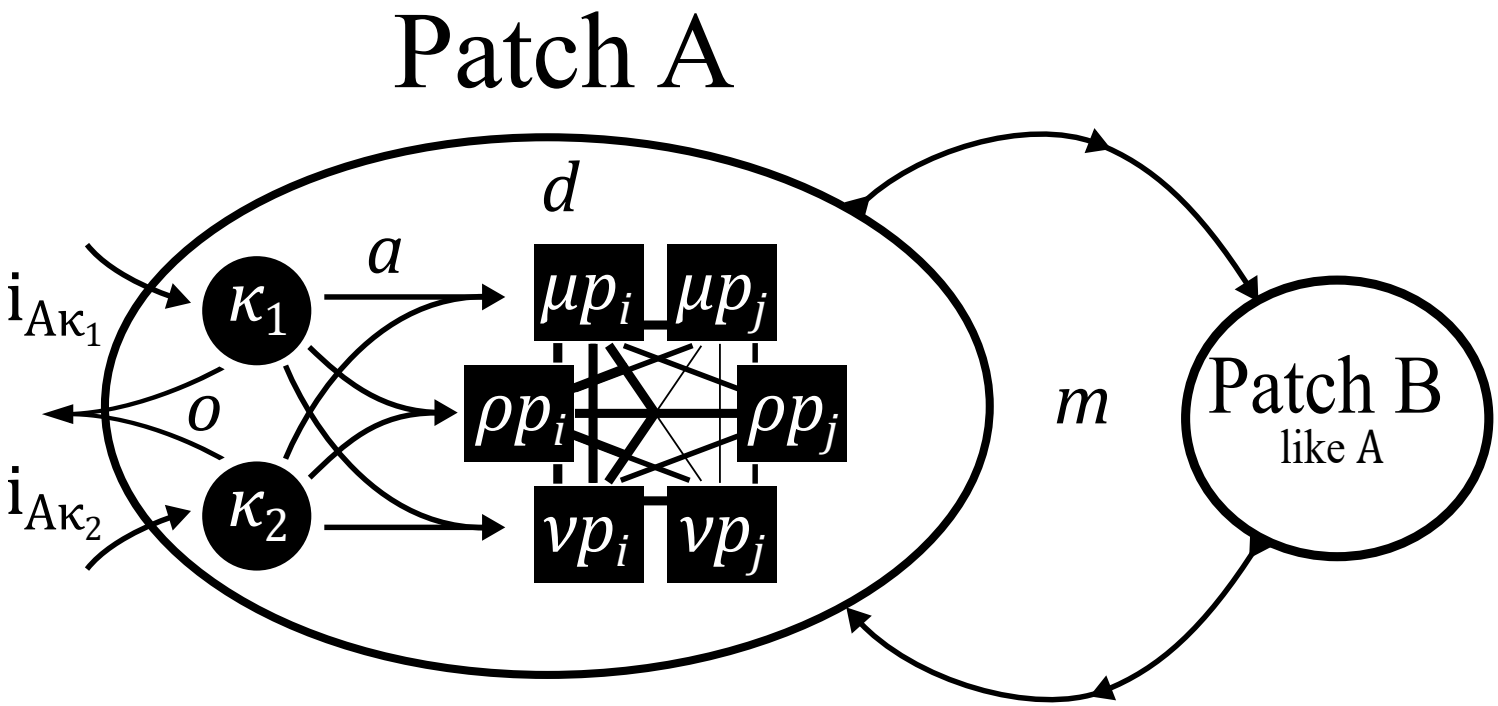
The underlying niche space: set of regulating variables

Varieties for niche space:



Niche space: set of regulating variables.
Not necessarily an Euclidean space of a few dimension!

Model structure

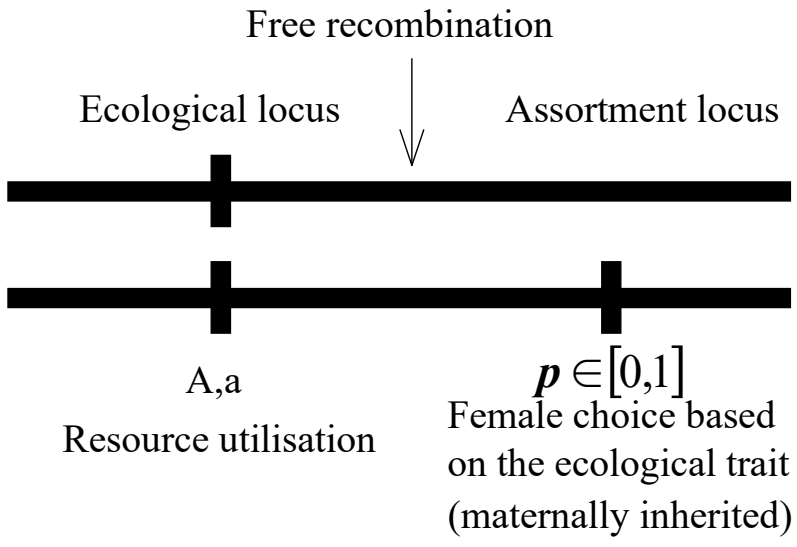


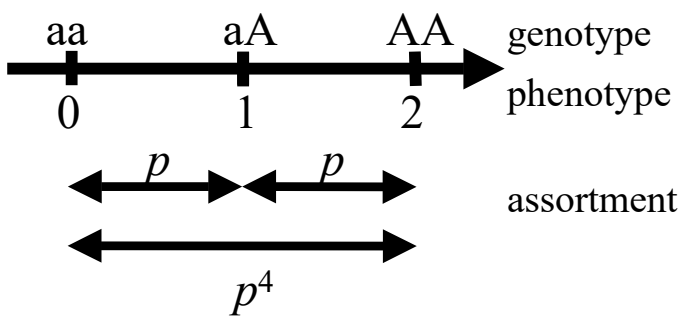
resources:
κ_1, κ_2

genotypes:
μ=aa,ρ=Aa,ν=AA

assortment:
p_i,p_j

Genetic makeup





Working of the model

Dynamics:

Tilman-type resource competition in the patches, Holling I.

Resource is fast.

Study:

Adaptive dynamics of the assortment character.

Background:

Population of an assortment allel is structured with respect to

- ecological genotype
- patch

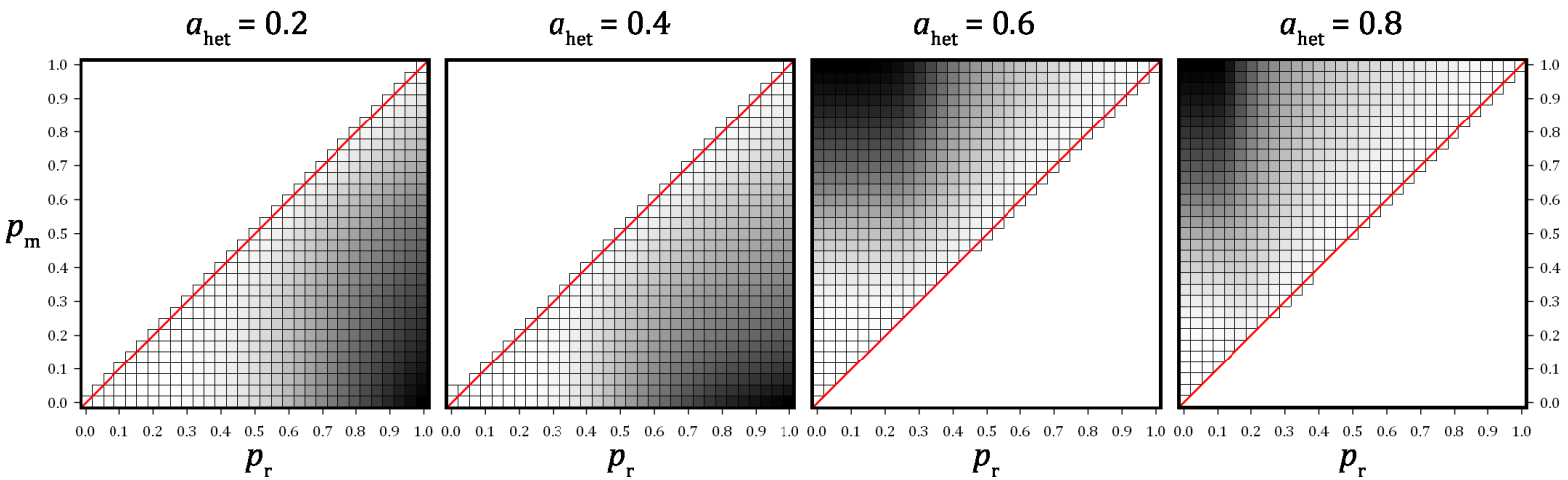
Hint:

It is good to increase the production of the ecological genotype with higher reproductive value from the point of view of the assortment allel.

Pure resource segregation

Heterozygote disadvantage

Heterozygote advantage

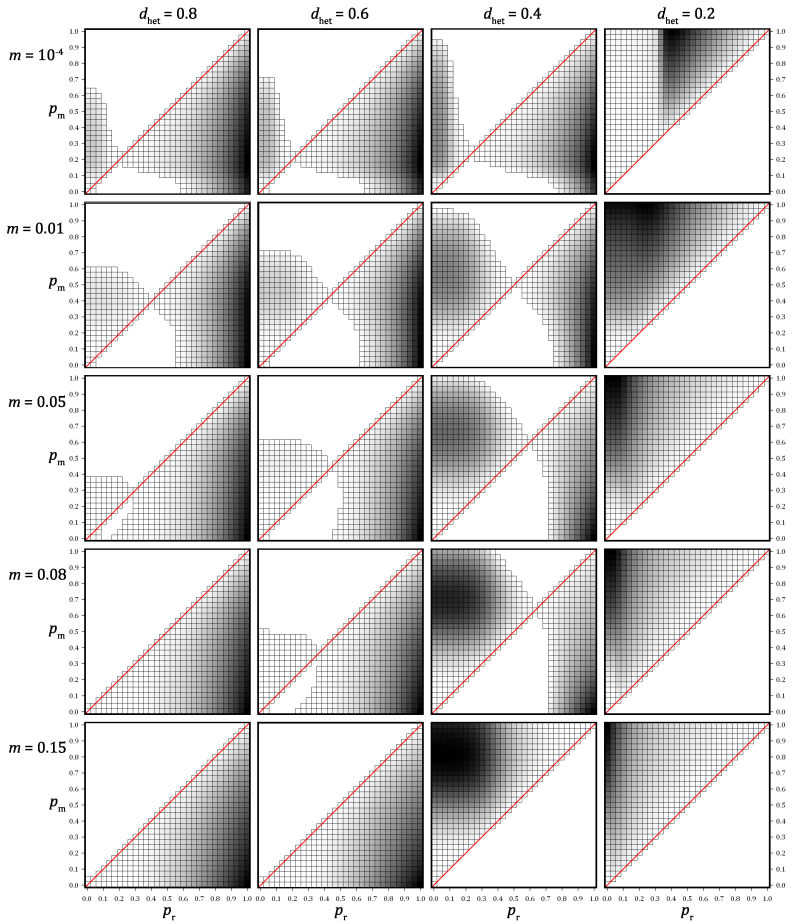


Selection for isolation

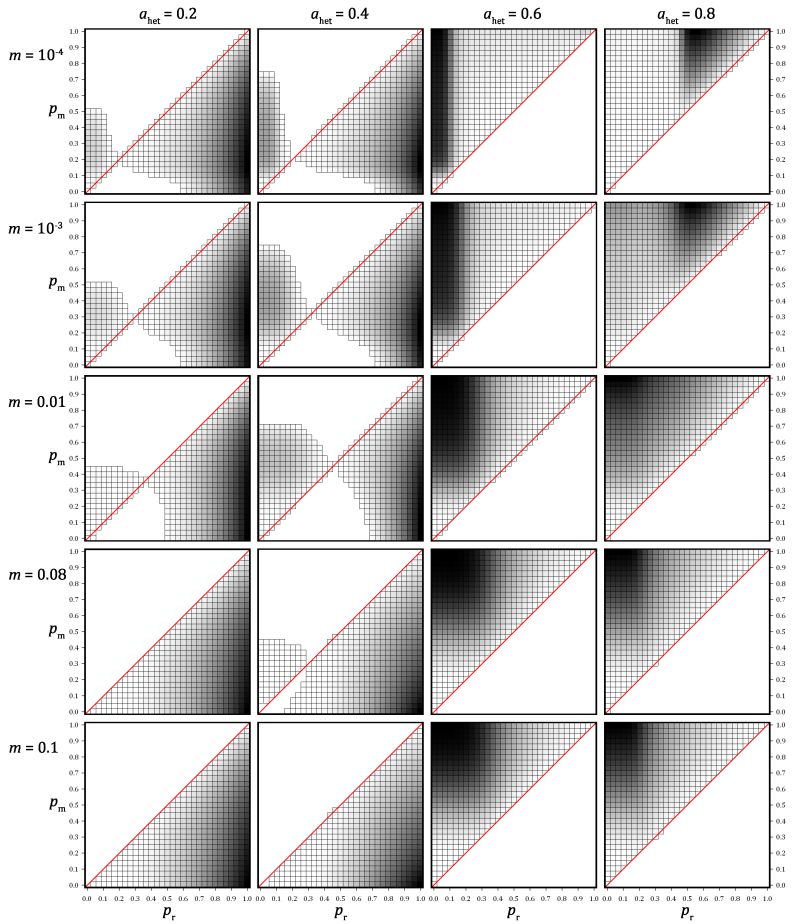
Selection for random mating

Two different patches

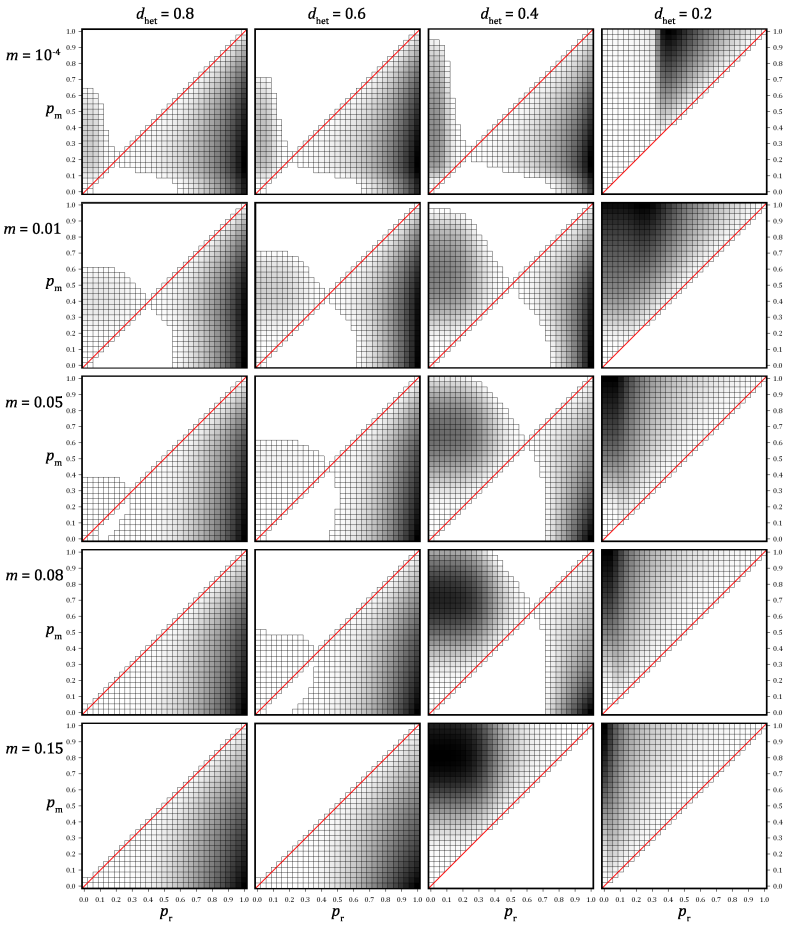
Different temperatures



Different resource contents



Two patches with different temperatures



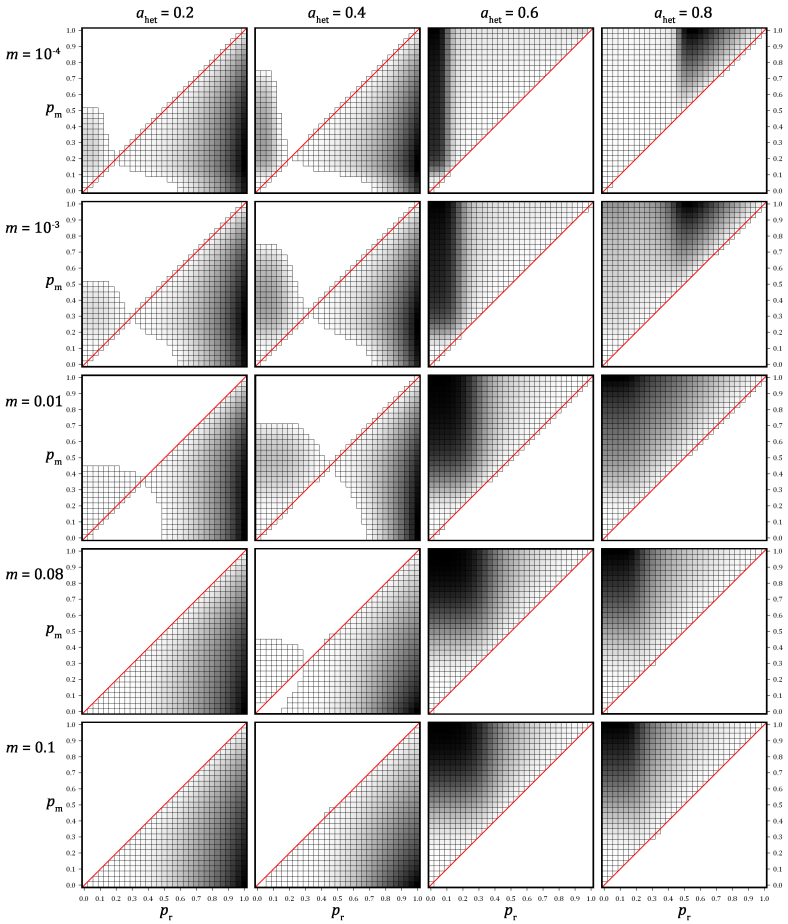
Restricted migration:

allows emergence of at least a partial segregation even at moderate heterozygote advantage.

Reason:

Heterozygote should be disadvantageous, as compared to the *weighted* average of homozygotes.

Two patches with different resource content

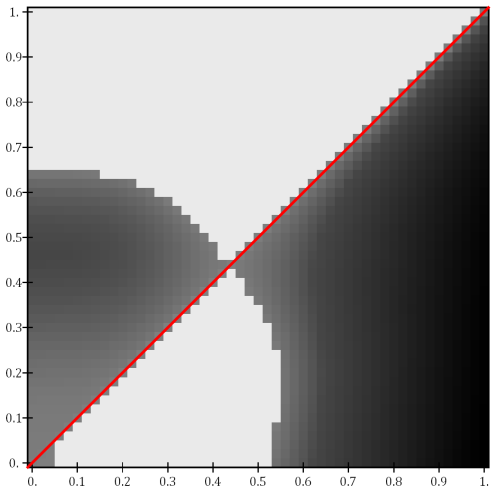


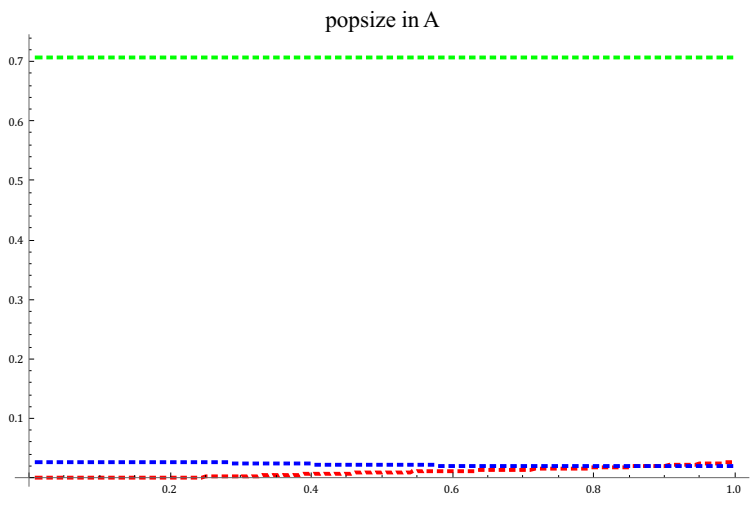
We do NOT see here the same!!

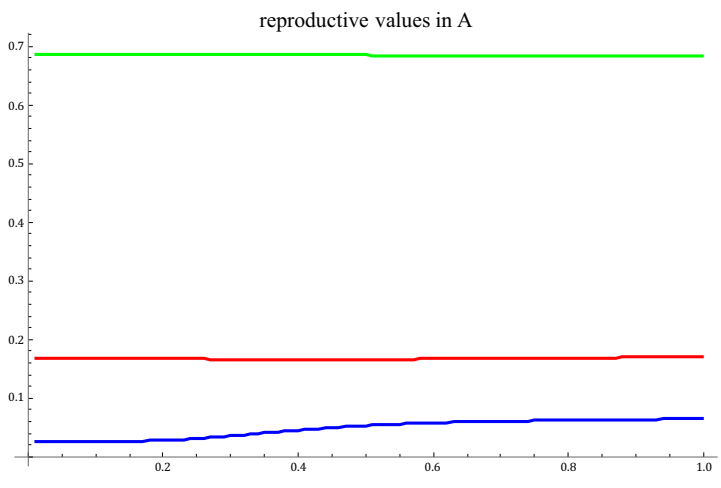
Reason:

No "fitness" difference between the homozygotes!

Why the singular point?







Conclusions

1. Adaptive emergence in speciation is natural in many cases.
2. Restricted migration (i.e. para/allopatry) does matter.
3. However, it's effect is not simple and unequivocal.
4. Para/allopatry may, or may not help initialisation of speciation.
5. Completion of reproductive isolation is made more difficult by spatial segregation. (Sexual selection could help, not shown)

TakeHome

Speciation is an inherent part of evolution on a regulated landscape, and not something additional, caused by accidental speciation mechanisms.

Thanks for the coworkers!

- Benjmin Márkus
- Kristóf Törkenczy
- Freddy Christiansen (Aarhus University)
- Ulf Dieckmann (IIASA)
- Liz Pásztor (Eötvös University, Budapest)
- András Szilágyi (Eötvös University, Budapest)

Thanks for your attention!