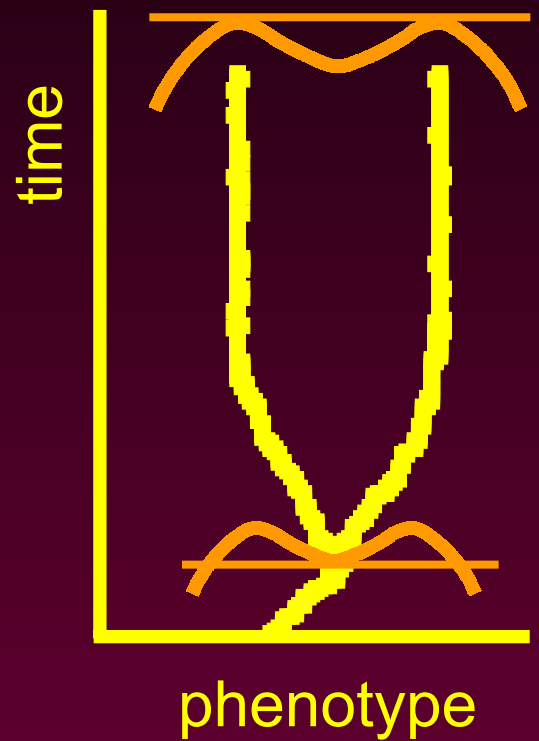
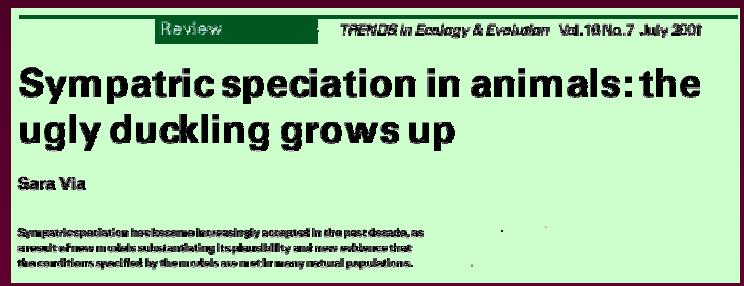
# From disruptive selection to the origin of species




**evolution to a fitness minimum: disruptive selection**

**AD: evolutionary branching**

***(non-allopatric) speciation???***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**Sympatric speciation in animals: the ugly duckling grows up**

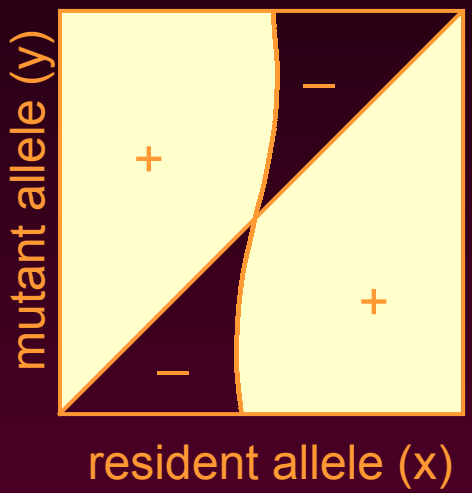
Sara Via

Sympatric speciation has become increasingly accepted in the past decade, as a result of new models substantiating its plausibility and new evidence that the conditions specified by the models are met in many natural populations.

# Evolutionary branching is common in clonal models

| | |
|---|---|
| ***Resource competition*** | ● Christiansen & Loeschcke 1980 ● Abrams et al. 1993 ● Metz et al. 1996 ● Meszéna & Metz 1996 ● Dieckmann & Doebeli 1999 ● Day 2000 ● Day 2001 ● Drossel & McKane 2000 |
| ***Asymmetric competition*** | ● Abrams et al. 1993 ● Geritz et al. 1999 ● Kisdi 1999 ● Jansen & Mulder 1999 ● Kisdi & Geritz 2001 |
| ***Predation*** | ● Abrams et al. 1993 ● Doebeli & Dieckmann 2000 |
| ***Host-parasite systems*** | ● Boots & Haraguci 1999 |
| ***Mutualism*** | ● Doebeli & Dieckmann 2000 ● Law et al. 2001 |
| ***Spatial heterogeneity*** | ● Brown & Pavlovic 1992 ● Meszéna et al. 1997 ● Geritz et al. 1998 ● Kisdi & Geritz 1999 ● Geritz & Kisdi 2000 ● Kisdi 2001 ● Mathias & Kisdi 2002 |
| ***Temporal fluctuations*** | ● Kisdi *in prep.* |
| ***Metapopulations*** | ● Cohen & Levin 1991 ● Doebeli & Ruxton 1997 ● Parvinen 1999 ● Mathias et al. 2001 ● Kisdi 2002 ● Parvinen in press |
| ***Mating systems*** | ● Hoekstra 1980 ● Metz et al. 1992 ● Cheptou & Mathias 2001 ● De Jong & Geritz 2001 ● Maire et al. 2001 |
| ***Sexual selection*** | ● Van Doorn & Weissing 2001 |
| ***Prebiotic replicators*** | ● Meszéna & Szathmáry 2001 |

# One locus, many alleles: Genetic polymorphism



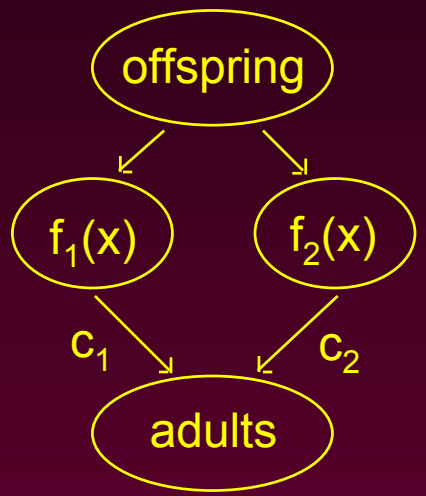

Invasion fitness of a rare mutant allele *y*
= invasion fitness of a rare phenotype $(x+y)/2$

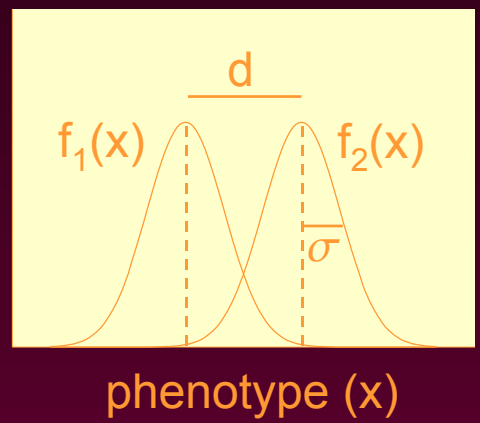
Evolutionary branching with clonal inheritance
= evolutionary branching of alleles
= genetic polymorphism

Evolution in a polymorphic population:
clonal and diploid sexual cases are different

# Two-patch soft selection model (Levene-model)

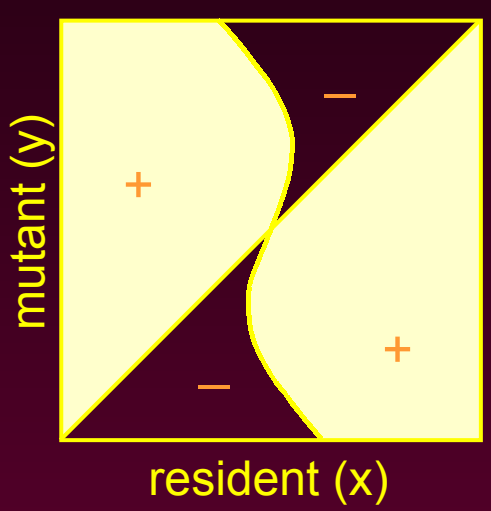
- random dispersal to two patches
- within-patch selection
- within-patch competition: fixed number of emerging adults

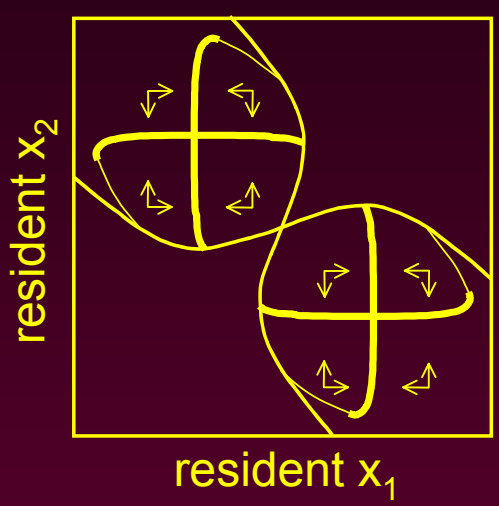


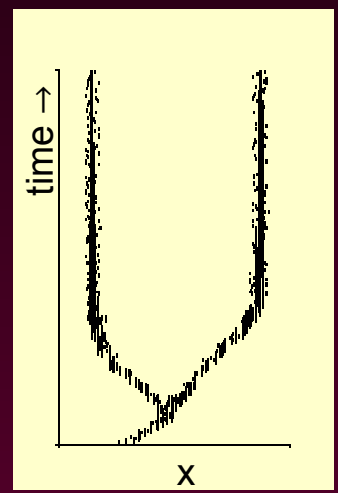



# Two-patch soft selection model (Levene-model)

Clonal version

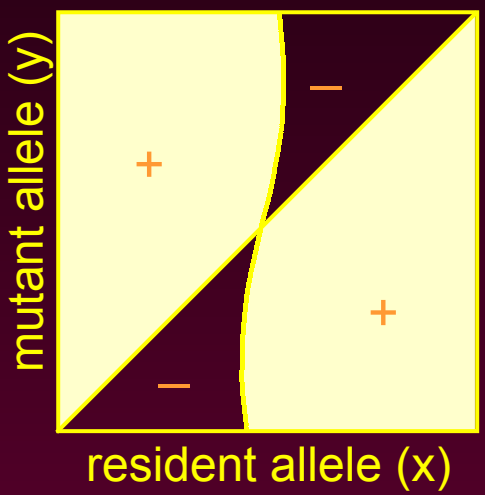


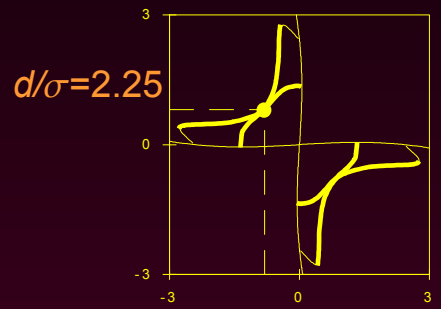



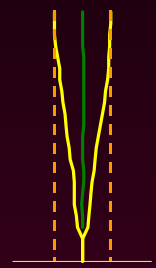



# Two-patch soft selection model (Levene-model)

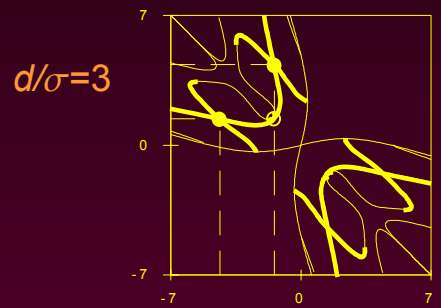
Diploid version

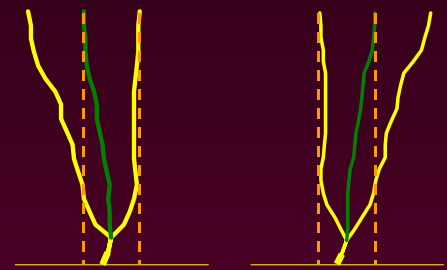


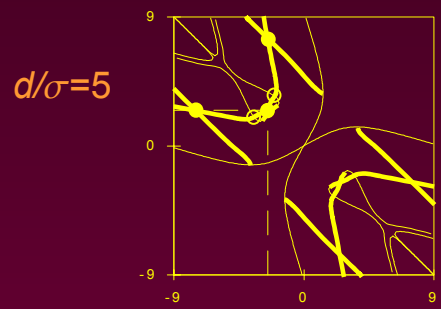



symmetric



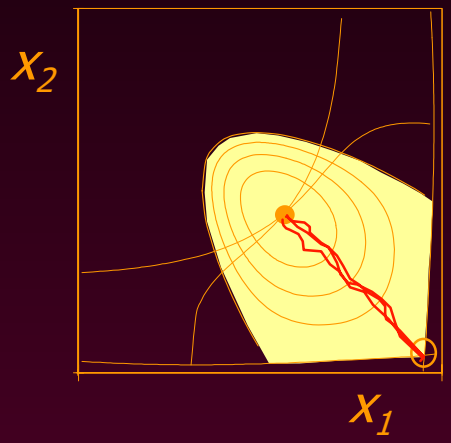
asymmetric



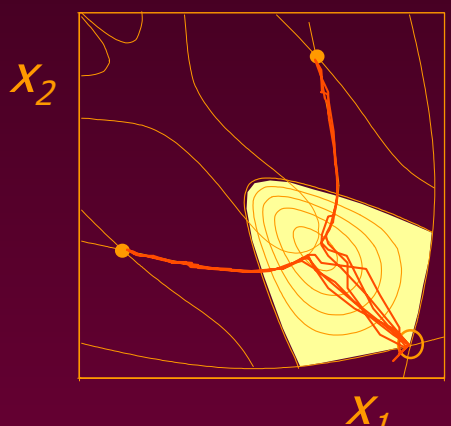

symmetric + asymmetric

# Selection against hybrids (Levene-model)

symmetric




asymmetric




Selection against intermediate phenotypes
= selection against heterozygotes

→ Evolution of dominance
full dominance ≡ clonal dynamics

→ Evolution of assortative mating

heterozygote disadvantage
evolutionary trajectory
○ branching point
● evolutionarily stable polymorphism

# The evolution of assortative mating

- **Mate choice depends on the ecological trait**
  e.g. body size (benthic-limnetic sticklebacks)

Branching = speciation

- **"One-allele" mechanisms**
  e.g. less dispersal: local mating with similar individuals

Branching = speciation

- **"Two-allele" mechanisms**
  mating is based on an independently segregating trait
  e.g. flowering time in plants

  ??? may be under disruptive selection
  (*Mimulus guttatus* metal-tolerant race)


**recombination between the ecological and the mating locus -- strong selection / tight linkage needed**

# Speciation

Biological species concept: Reproductive isolation

Ecological stability: Niche differentiation

Speciation by sexual selection yields ecologically identical sister species. If it happens at a branching point, subsequent divergence ensures differentiation

# Multilocus genetics: Directional evolution

**Quantitative Genetics (with separate species):**

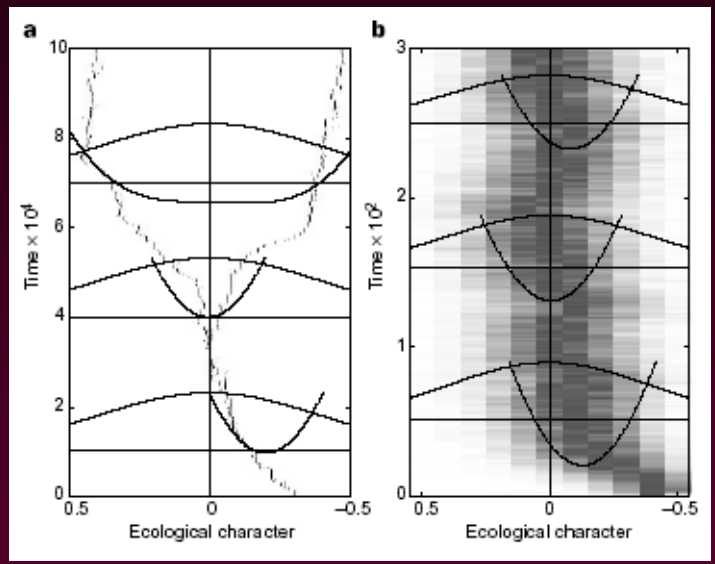
$$\Delta \bar{z}_i = V_{Ai} \left. \frac{\partial W(z; \bar{z}_1, \ldots, \bar{z}_n)}{\partial z} \right|_{z=\bar{z}_i}$$

**Canonical Equation of Mutation-Limited Evolution:**

$$\frac{dx_i}{dt} = \frac{1}{2} \mu_i \sigma_i^2 \hat{N}_i(x_1, \ldots, x_n) \left. \frac{\partial s_{x_1, \ldots, x_n}(y)}{\partial y} \right|_{y=x_i}$$

# Multilocus genetics: Branching?

clonal model multilocus model



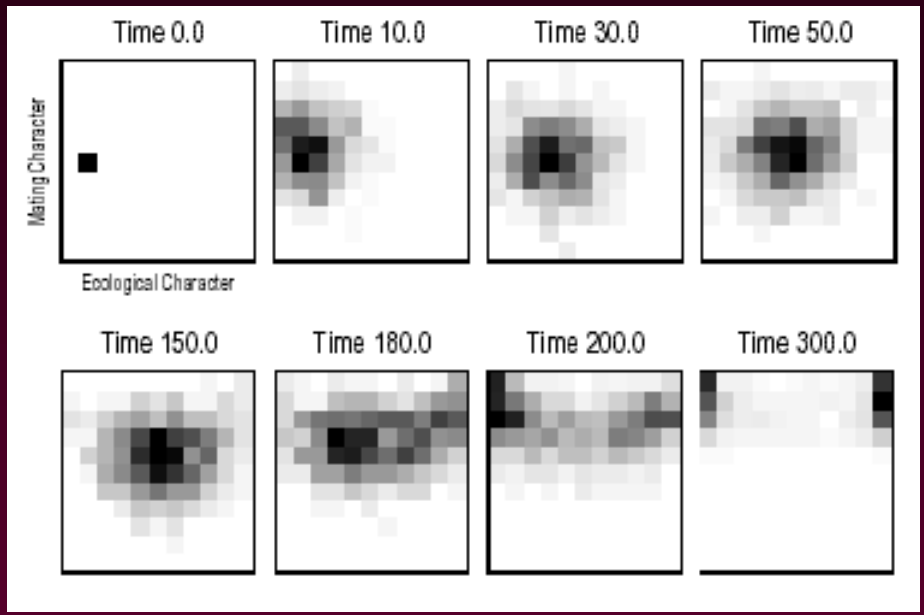

Lotka-Volterra resource competition model

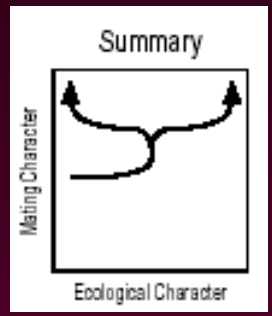
recombination between the ecological loci prevents branching

assortative mating needed for evolutionary branching itself (and then it is speciation)

# Multilocus genetics & assortative mating

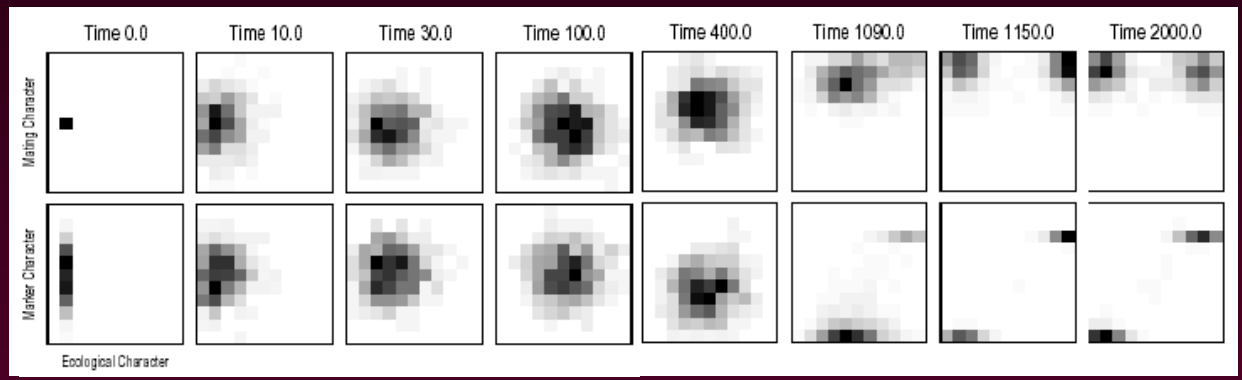
I. Mate choice based on the ecological trait

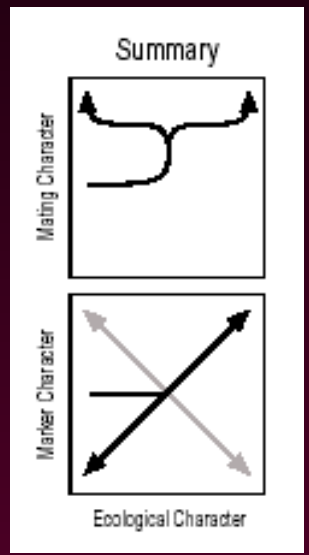


# Multilocus genetics & assortative mating

II. Mate choice based on a neutral marker character



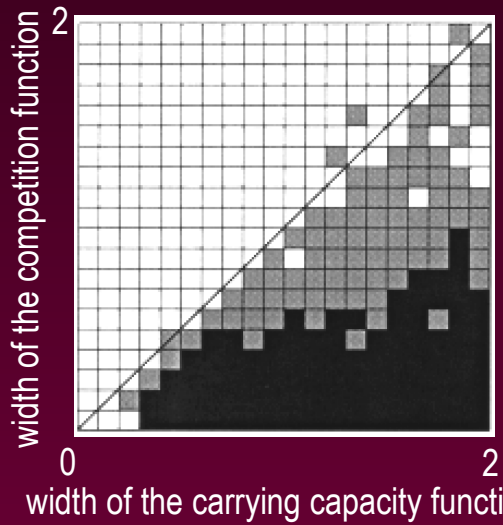



# Multilocus genetics & assortative mating

Mate choice based on a neutral marker character
- grim expectation from classic models:


Weak selection at the branching point - no linkage
No linkage - mating is not assortative by the ecological trait
No assortative mating - no branching

Finite population size: initial linkage by genetic drift - it works




assortative mating based on the ecological trait

assortative mating based on a marker trait
(linkage disequilibrium necessary)


Adaptive Dynamics

evolution to fitness minima is common

Evolution of diversity

within-species genetic polymorphism
speciation

# References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