Individual-level causes and population-level consequences of variation in fitness in an Alpine rodent

Timothée Bonnet

Department of evolutionary biology and environmental studies (IEU)

University of Zurich[UZH]

- Erik Postma

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- Lukas Keller
- Barbara Tschirren
- Arpat Ozgul
- Marc Kéry
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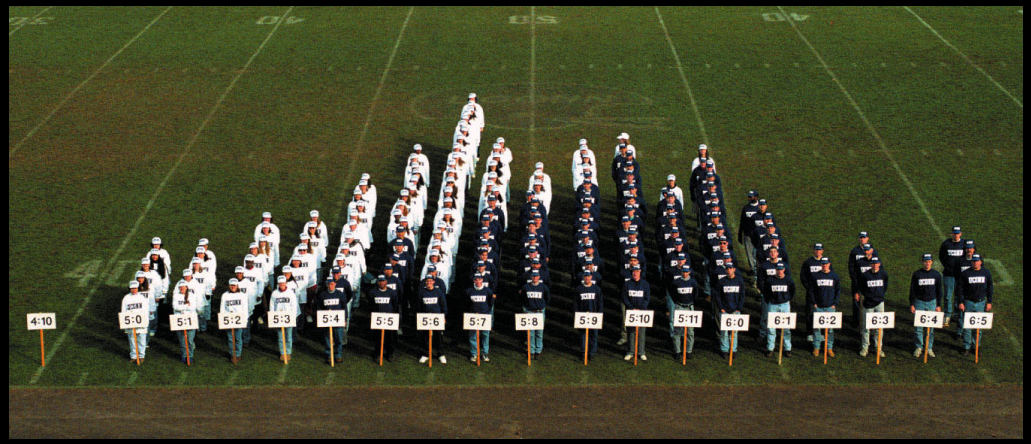
- Eelke Jongejans
- Pirmin Nietlisbach
- Philipp Becker
- Judith Bachmann

Phenotypic variation within population



Phenotypic variation within population

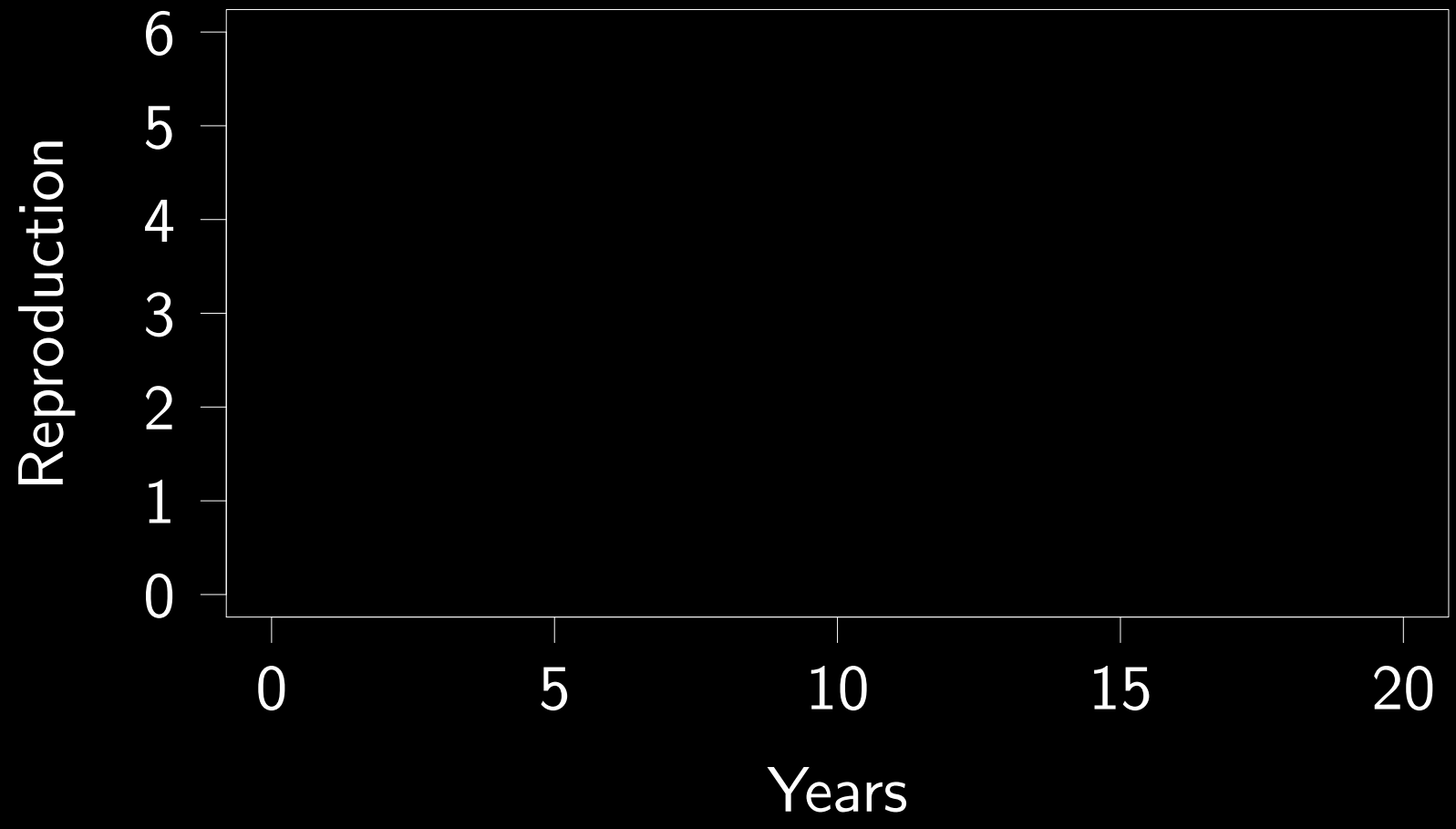
Fitness variation



What is fitness?

The expected relative contribution of an individual to the next generation

Chance or fate? Why do survival and fertility vary?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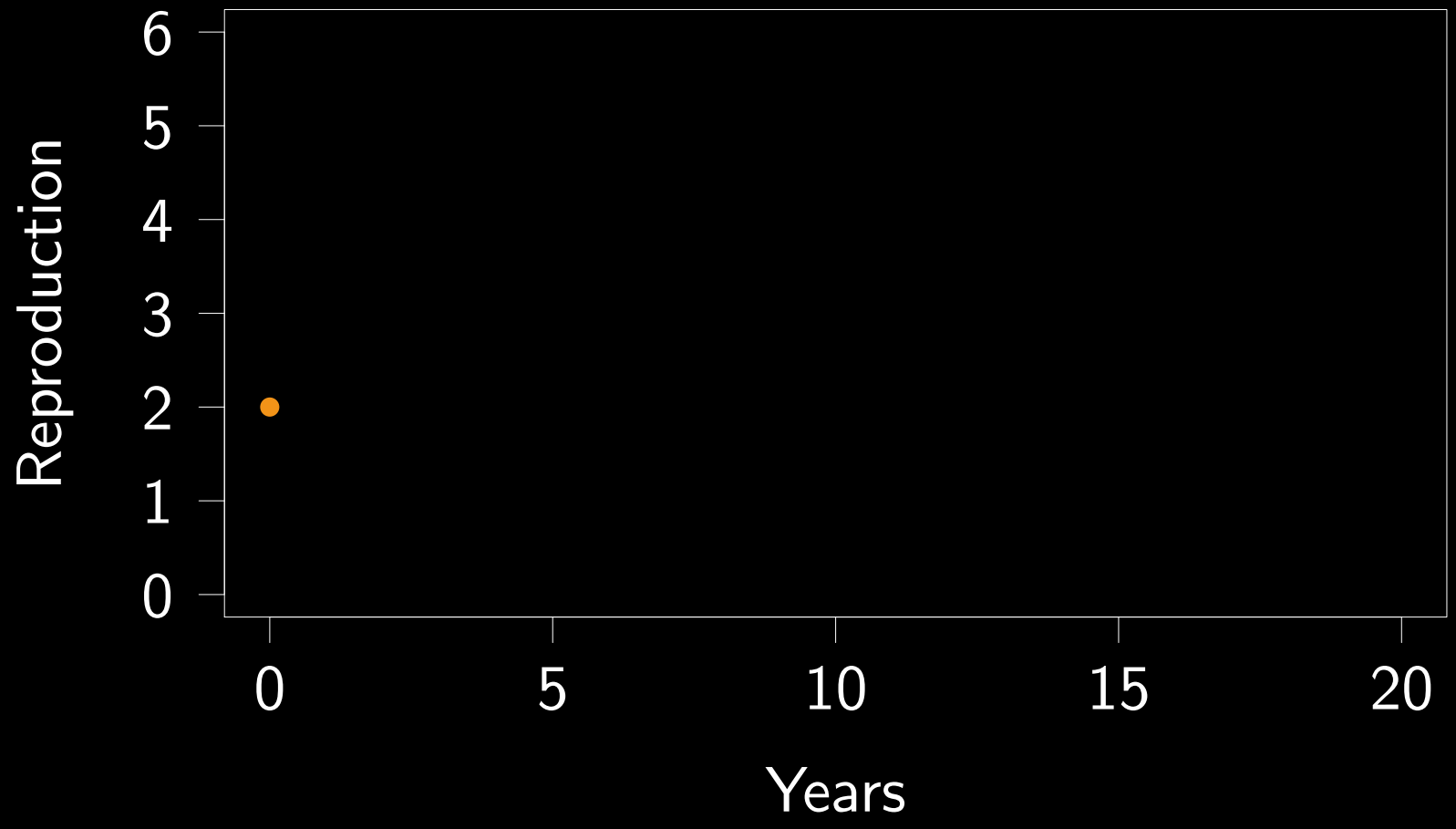
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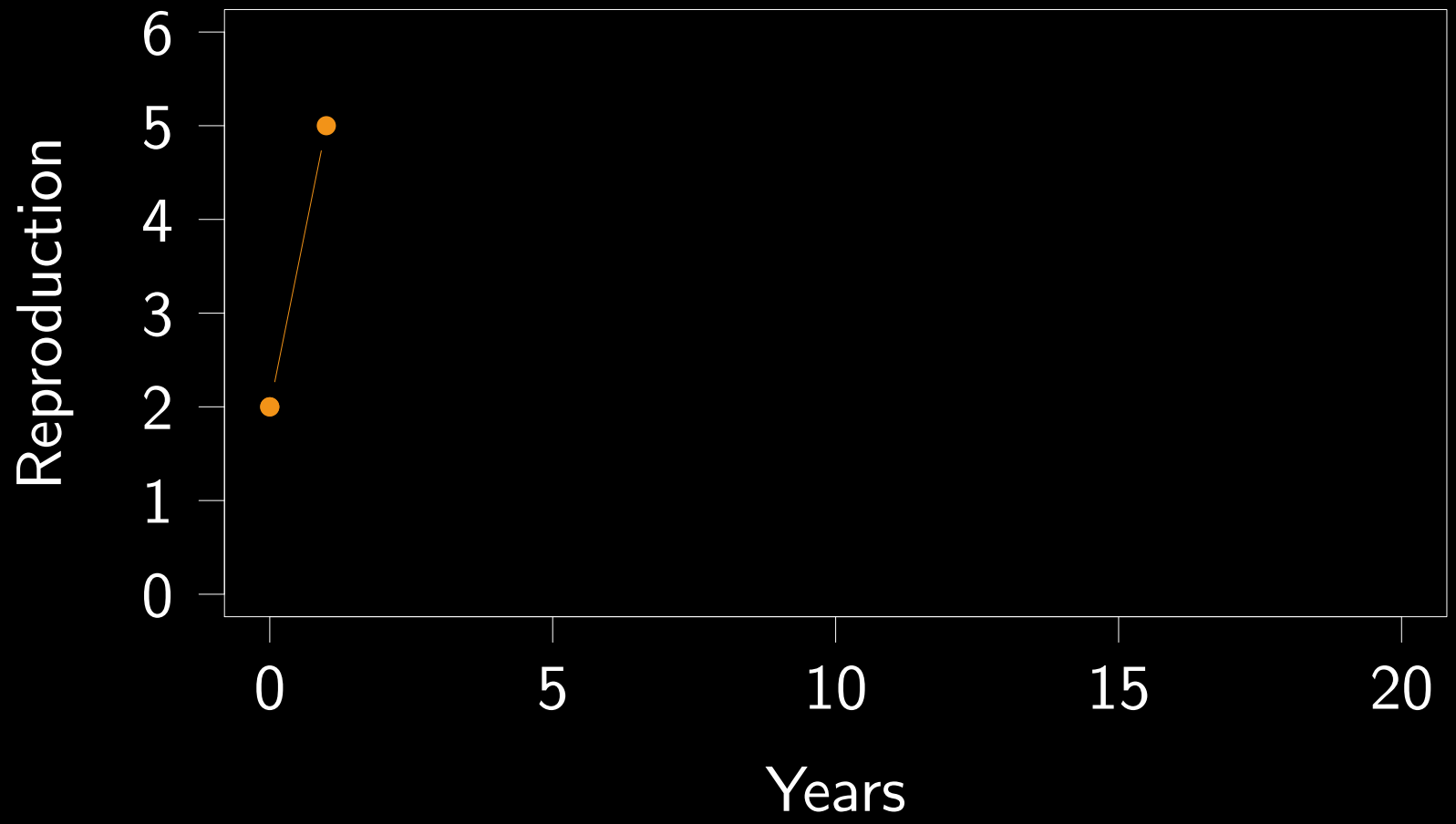
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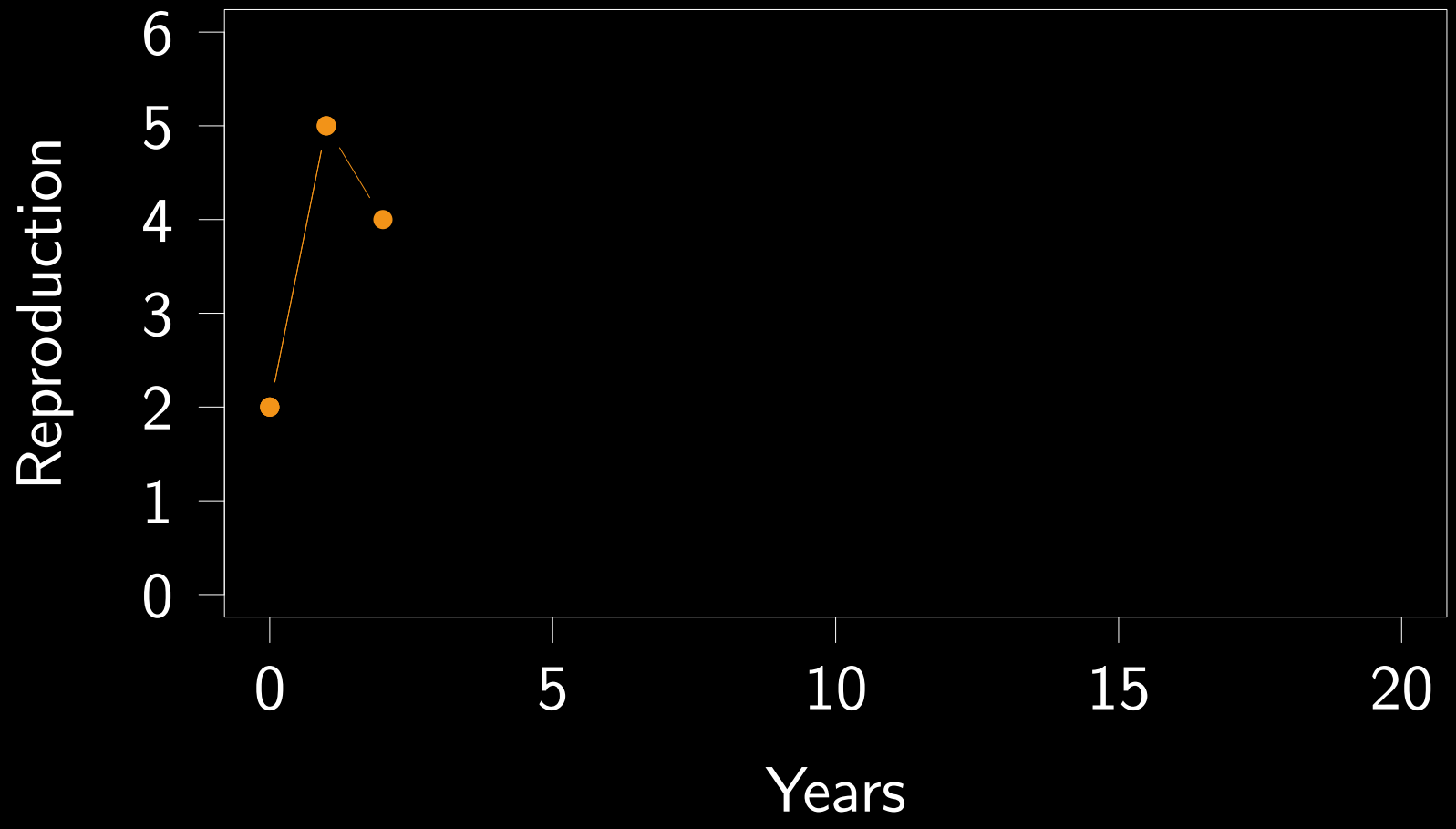
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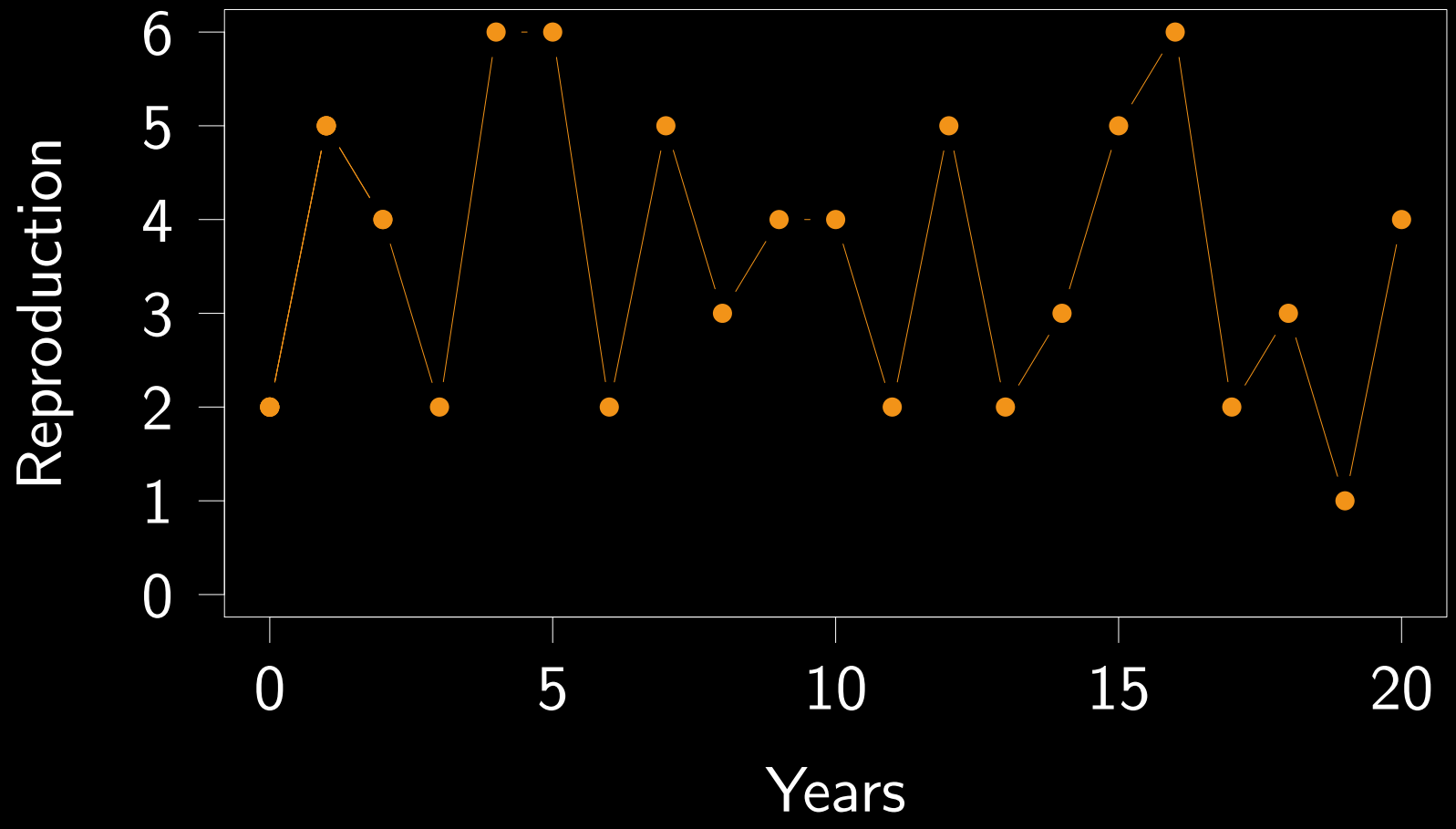
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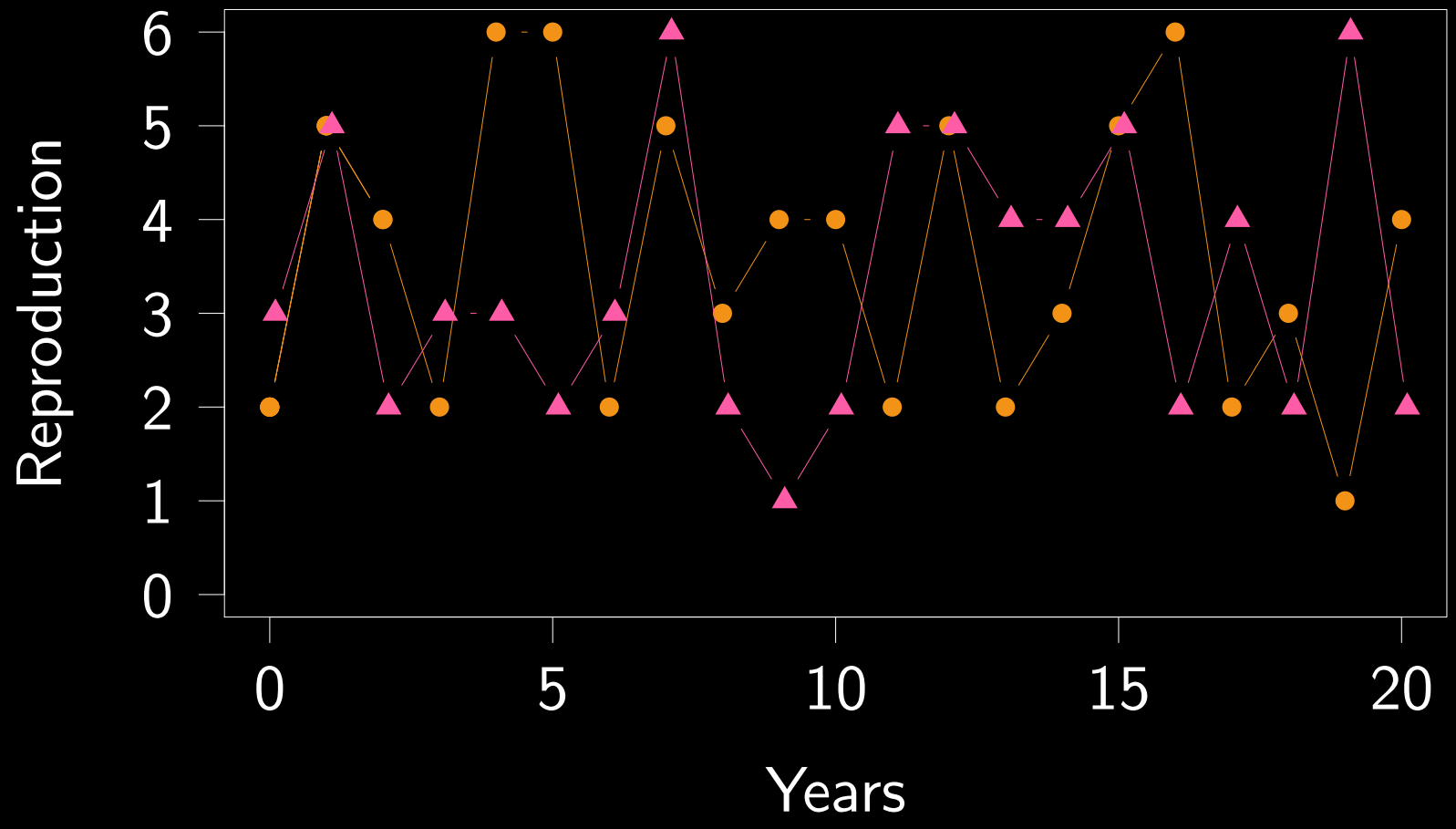
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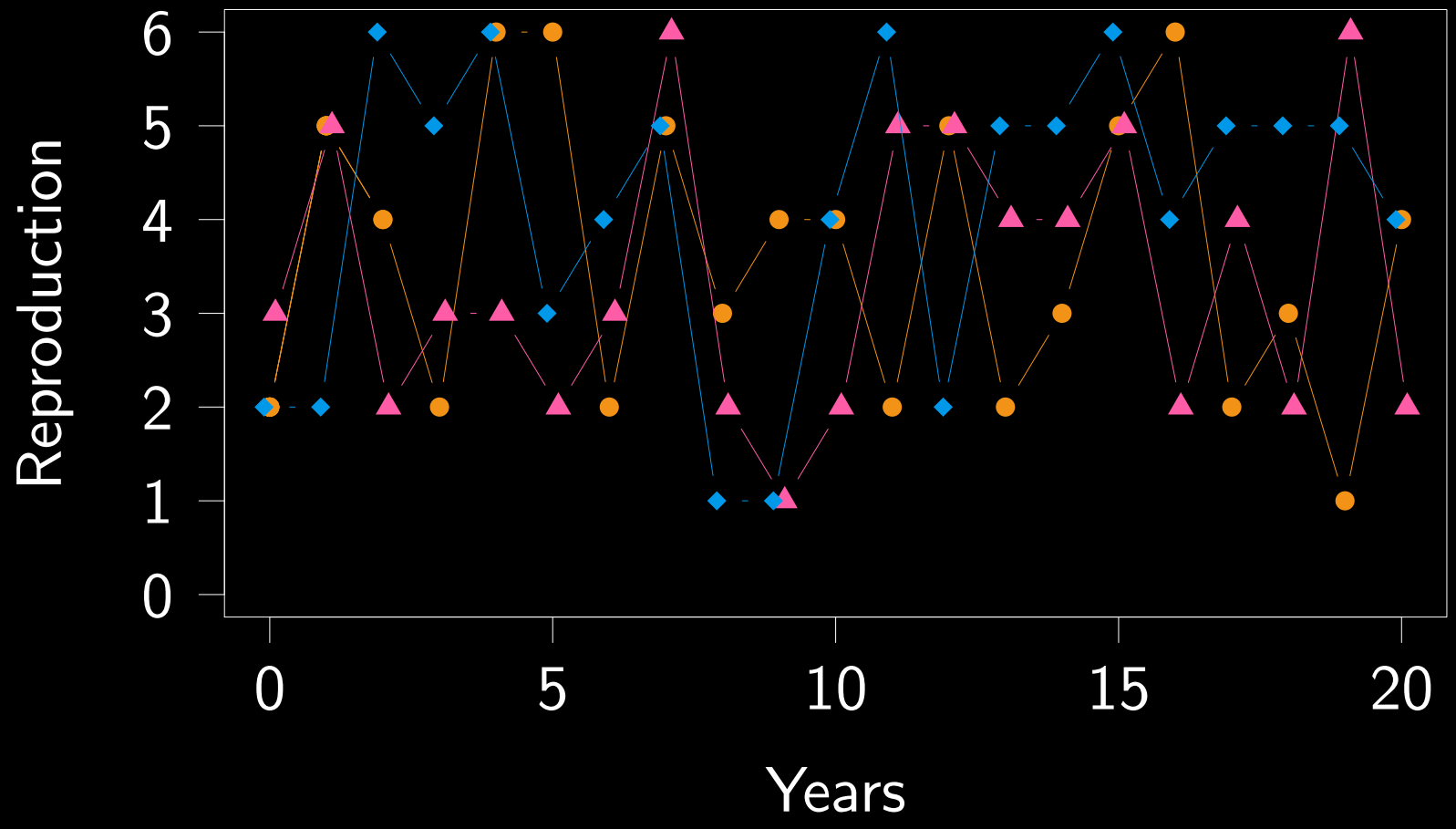
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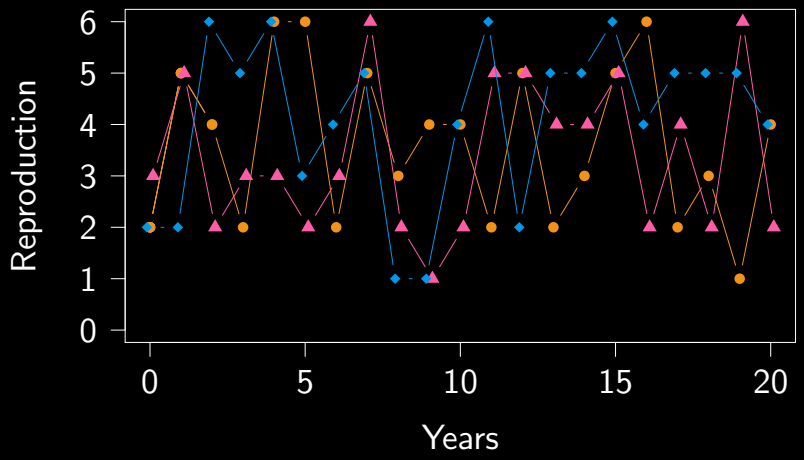
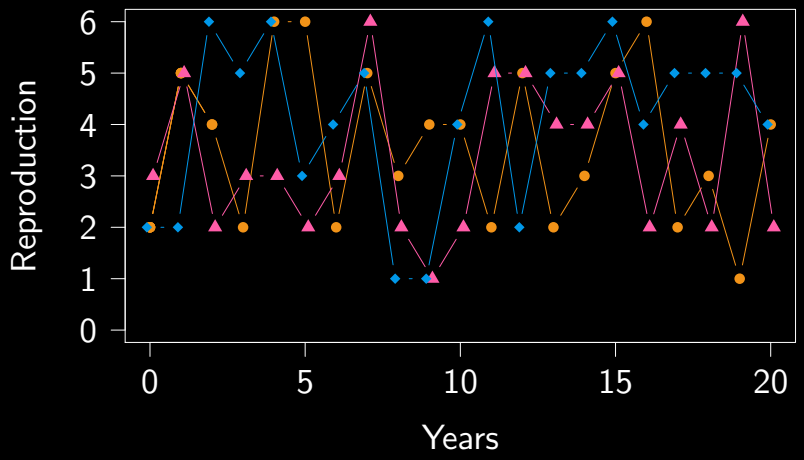
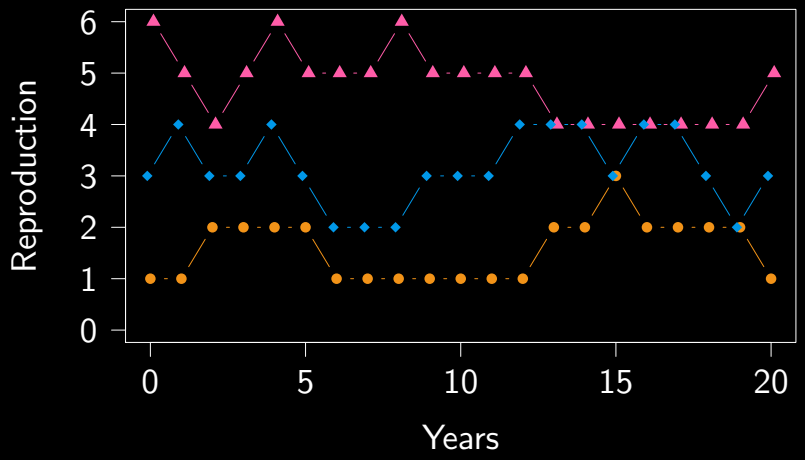
One dice theory



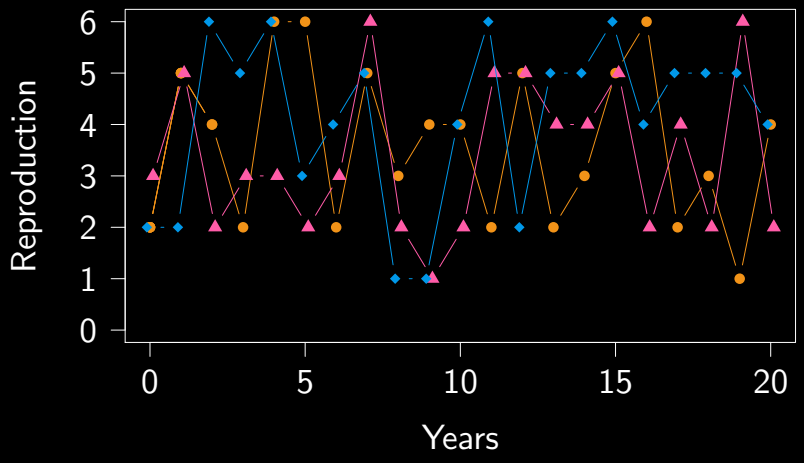
One dice theory



Real pattern



One dice theory



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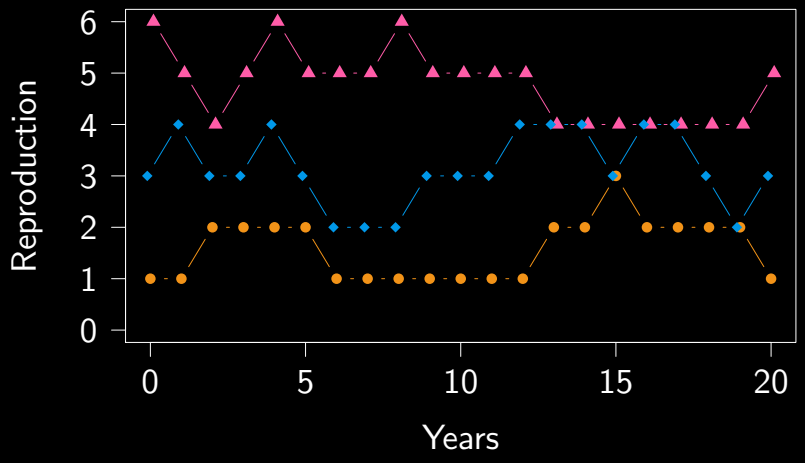
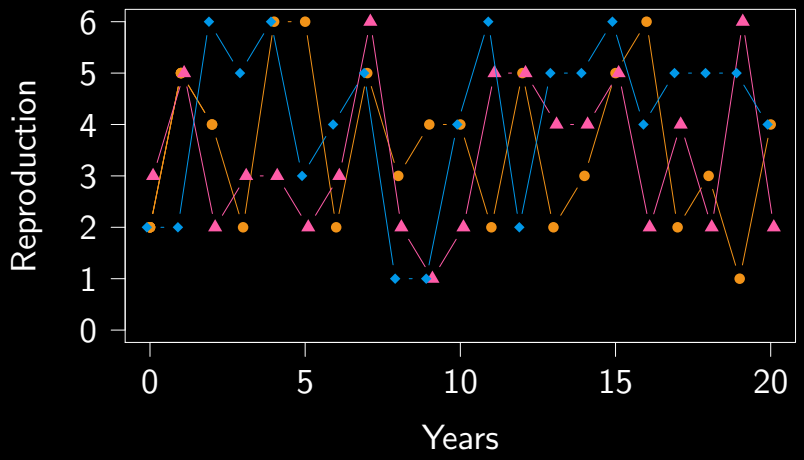


?

Individuals

are different

One dice theory



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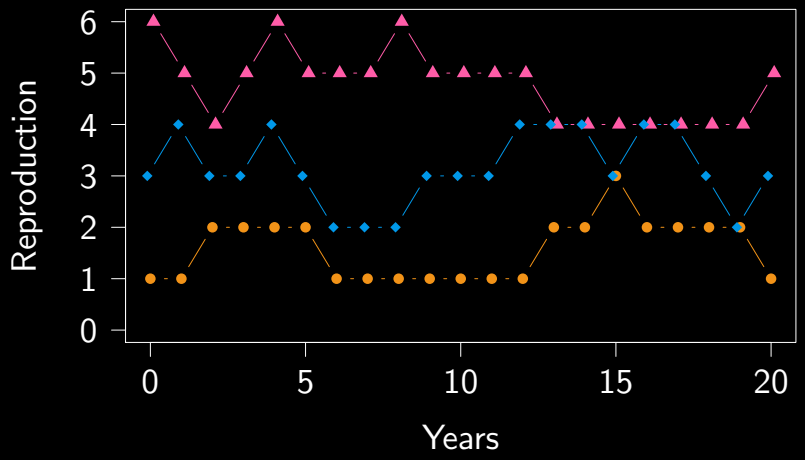
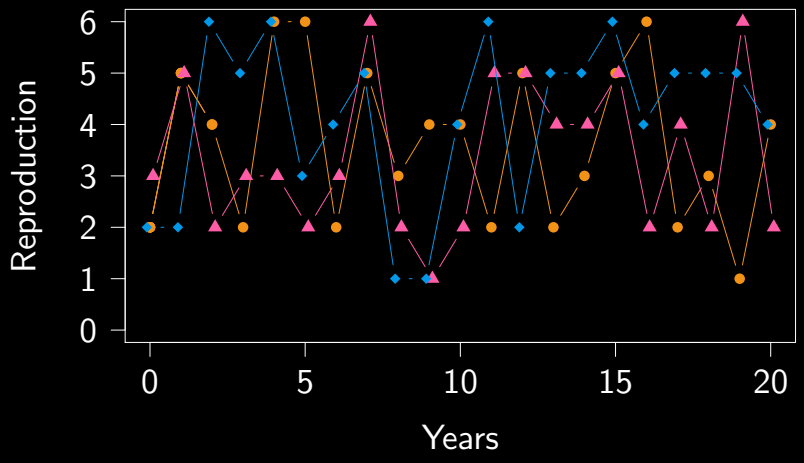


?

Individuals are different

Stages are different

One dice theory



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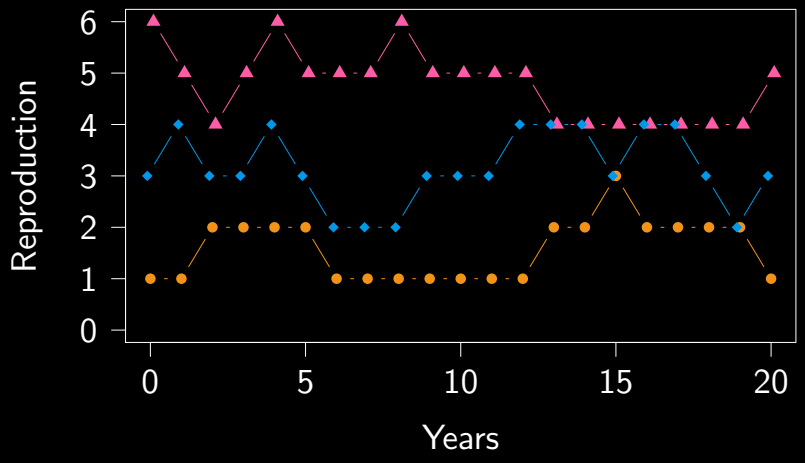
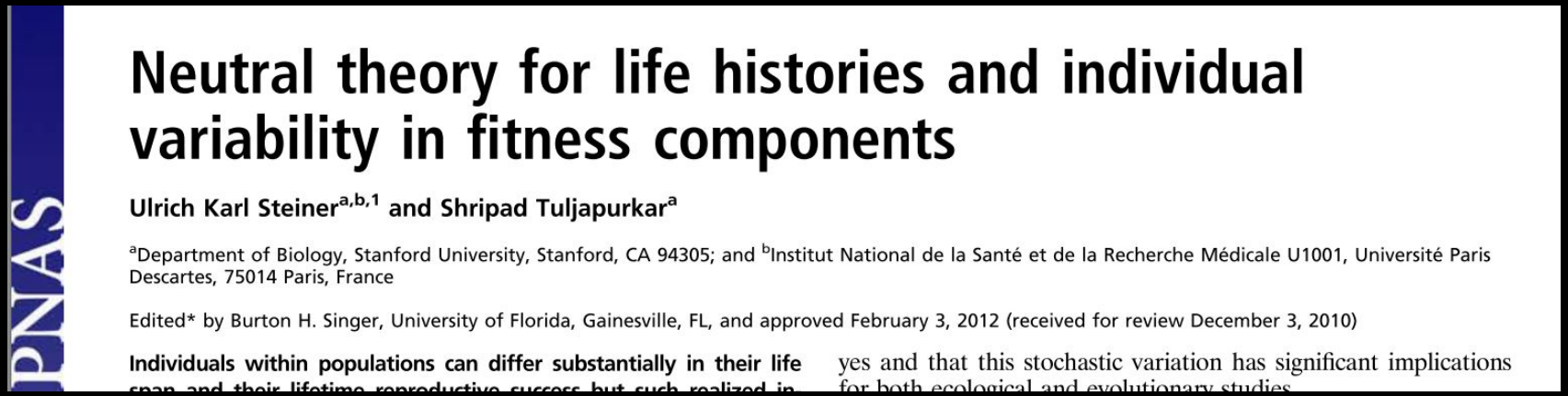


?

Individuals are different → Selection/Evolution

Stages are different → Neutrality

The neutral theory



PNAS

Neutral theory for life histories and individual variability in fitness components

Ulrich Karl Steiner[a,b,1] and Shripad Tuljapurkar[a]

[a]Department of Biology, Stanford University, Stanford, CA 94305; and [b]Institut National de la Santé et de la Recherche Médicale U1001, Université Paris Descartes, 75014 Paris, France

Edited* by Burton H. Singer, University of Florida, Gainesville, FL, and approved February 3, 2012 (received for review December 3, 2010)

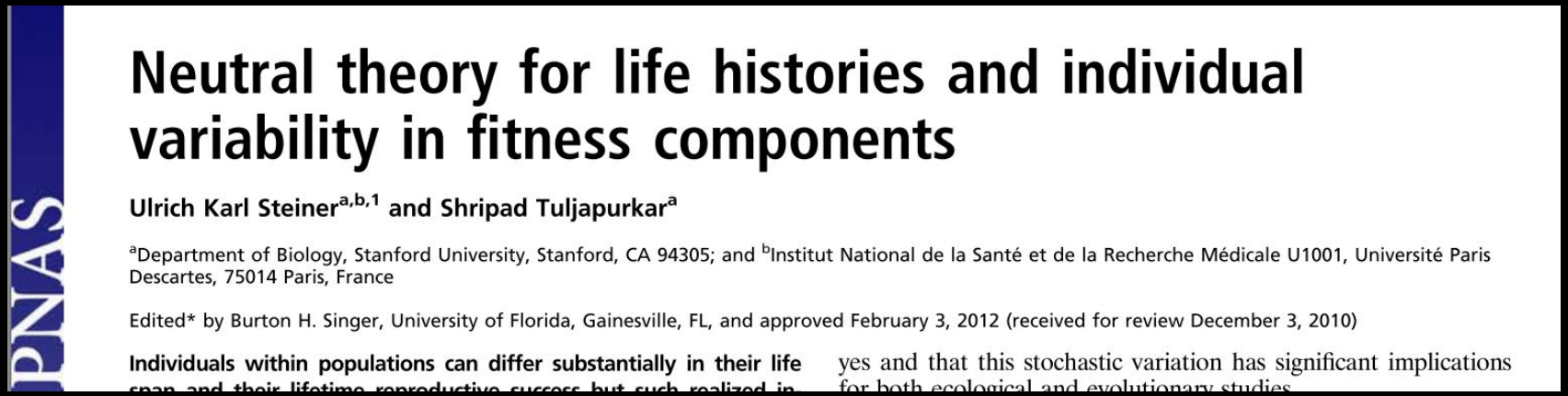
Individuals within populations can differ substantially in their life yes and that this stochastic variation has significant implications

Neutral matrix method

	next year		
	1	2	3
1	0.9	0.08	0.02
2	0	0.7	0.3
3	0	0.2	0.8

No variation in fitness among individuals

The neutral theory



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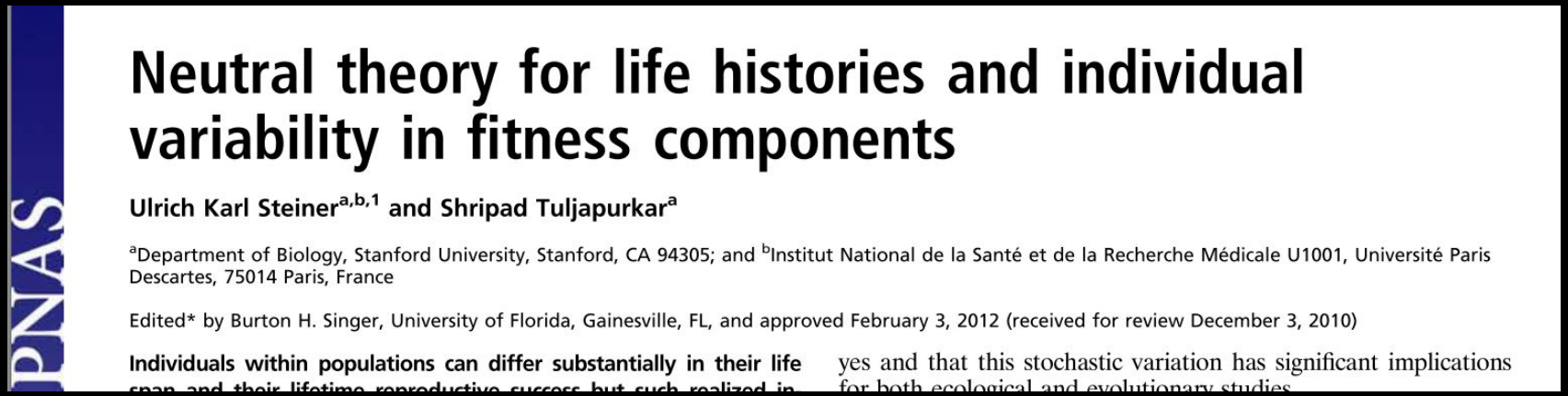

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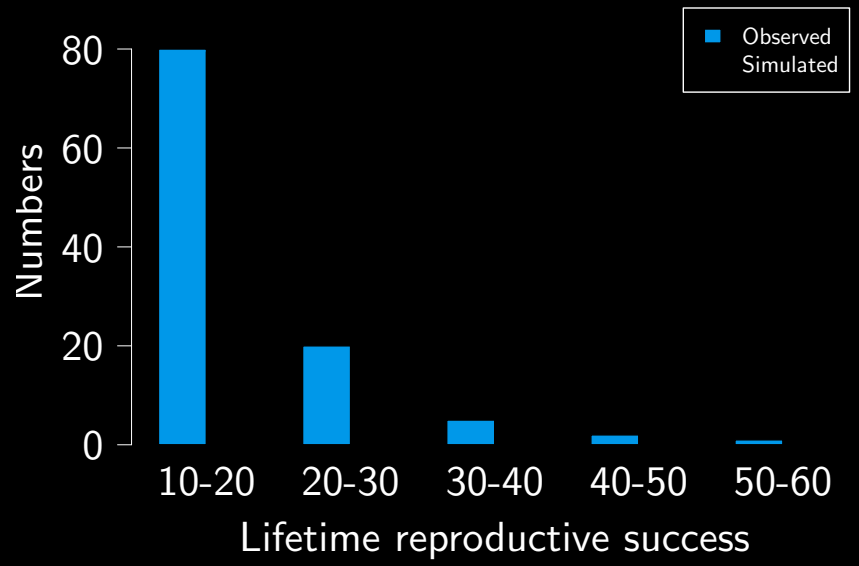

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Individuals within populations can differ substantially in their life yes and that this stochastic variation has significant implications for both ecological and evolutionary studies

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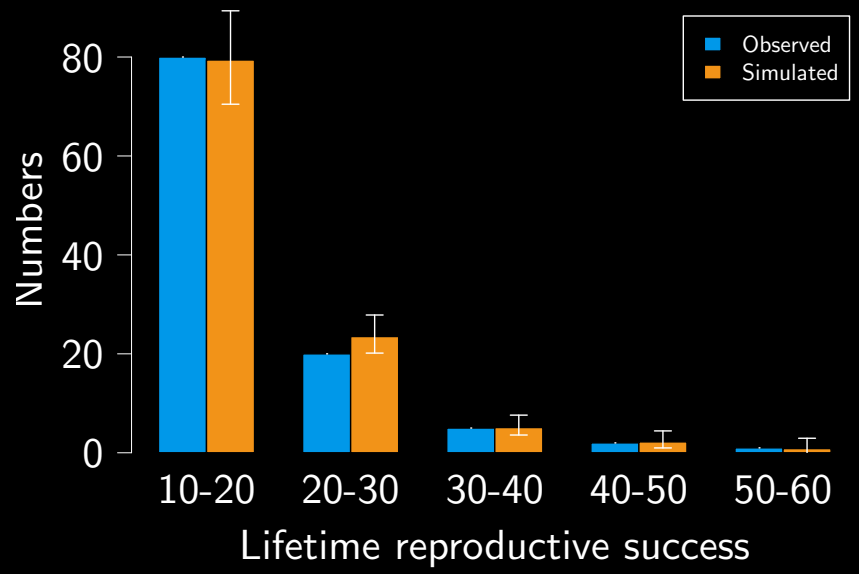


No variation in fitness among individuals

Conflicting results

Neutral matrix method

Mixed model method & Quantitative genetics

Conflicting results

Neutral matrix method

- No significant differences between individuals

Mixed model method & Quantitative genetics

Journal of Animal Ecology

British Ecological Society

Journal of Animal Ecology 2010, **79**, 436–444 doi: 10.1111/j.1365-2656.2009.01653.x

Dynamic heterogeneity and life history variability in the kittiwake

Ulrich K. Steiner[1]*, Shripad Tuljapurkar[1] and Steven Hecht Orzack[2]

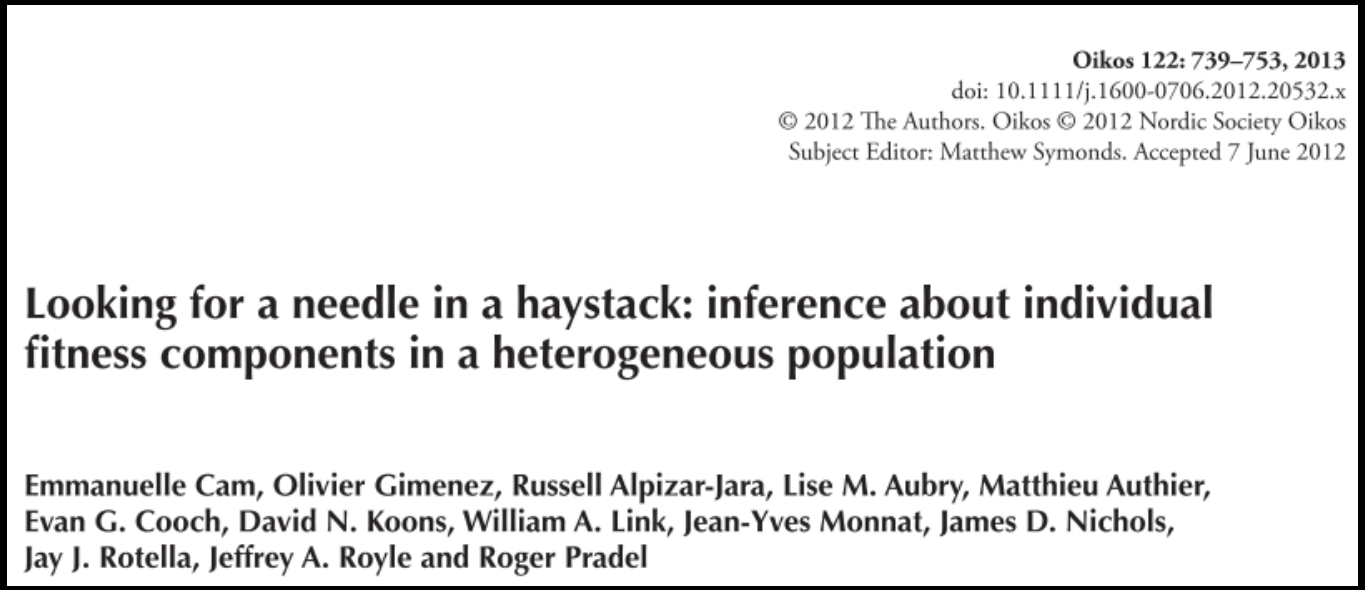
Conflicting results

Neutral matrix method

- No significant differences between individuals

Mixed model method & Quantitative genetics

- Individual performances are



Oikos 122: 739–753, 2013
doi: 10.1111/j.1600-0706.2012.20532.x

Subject Editor: Matthew Symonds. Accepted 7 June 2012

Looking for a needle in a haystack: inference about individual fitness components in a heterogeneous population

Emmanuelle Cam, Olivier Gimenez, Russell Alpizar-Jara, Lise M. Aubry, Matthieu Authier, Evan G. Cooch, David N. Koons, William A. Link, Jean-Yves Monnat, James D. Nichols, Jay J. Rotella, Jeffrey A. Royle and Roger Pradel

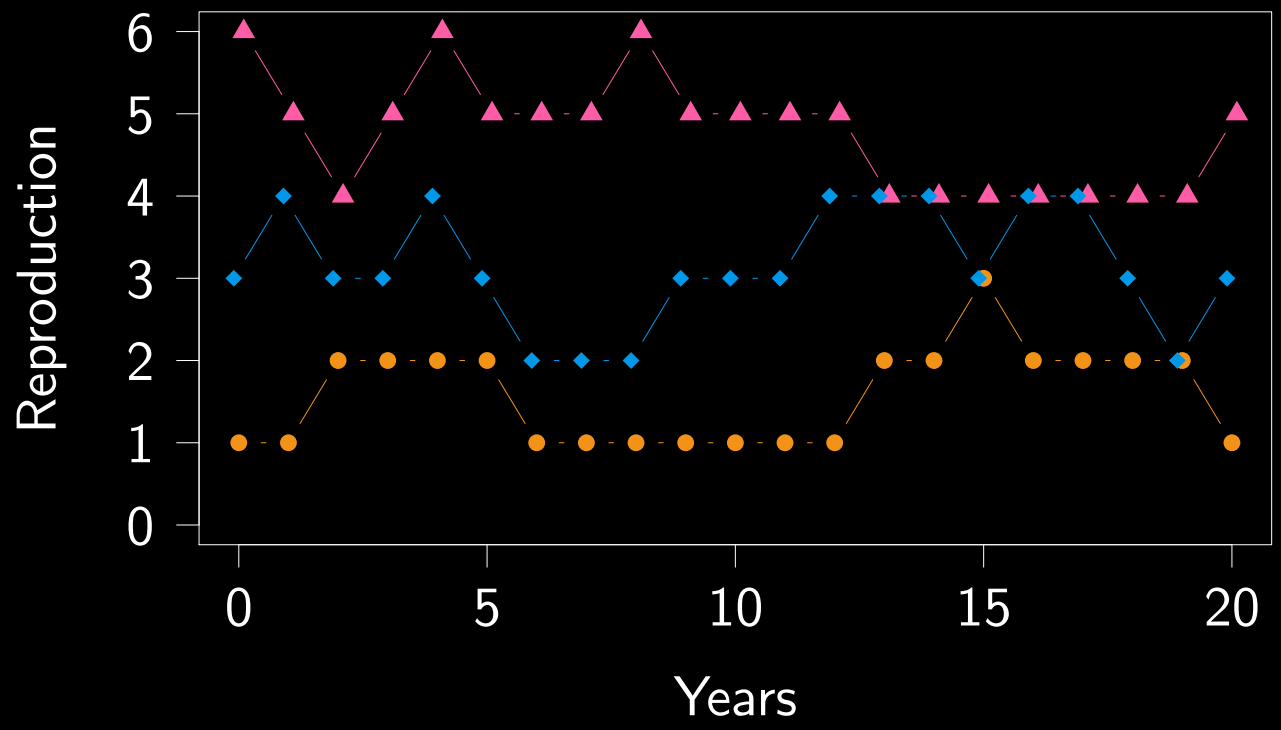
Conflicting results

Neutral matrix method

- No significant differences between individuals
- . . . because of stage structure

Mixed model method & Quantitative genetics

- Individual performances are repeatable



Conflicting results

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Mixed model method & Quantitative genetics

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Conflicting results

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Mixed model method & Quantitative genetics

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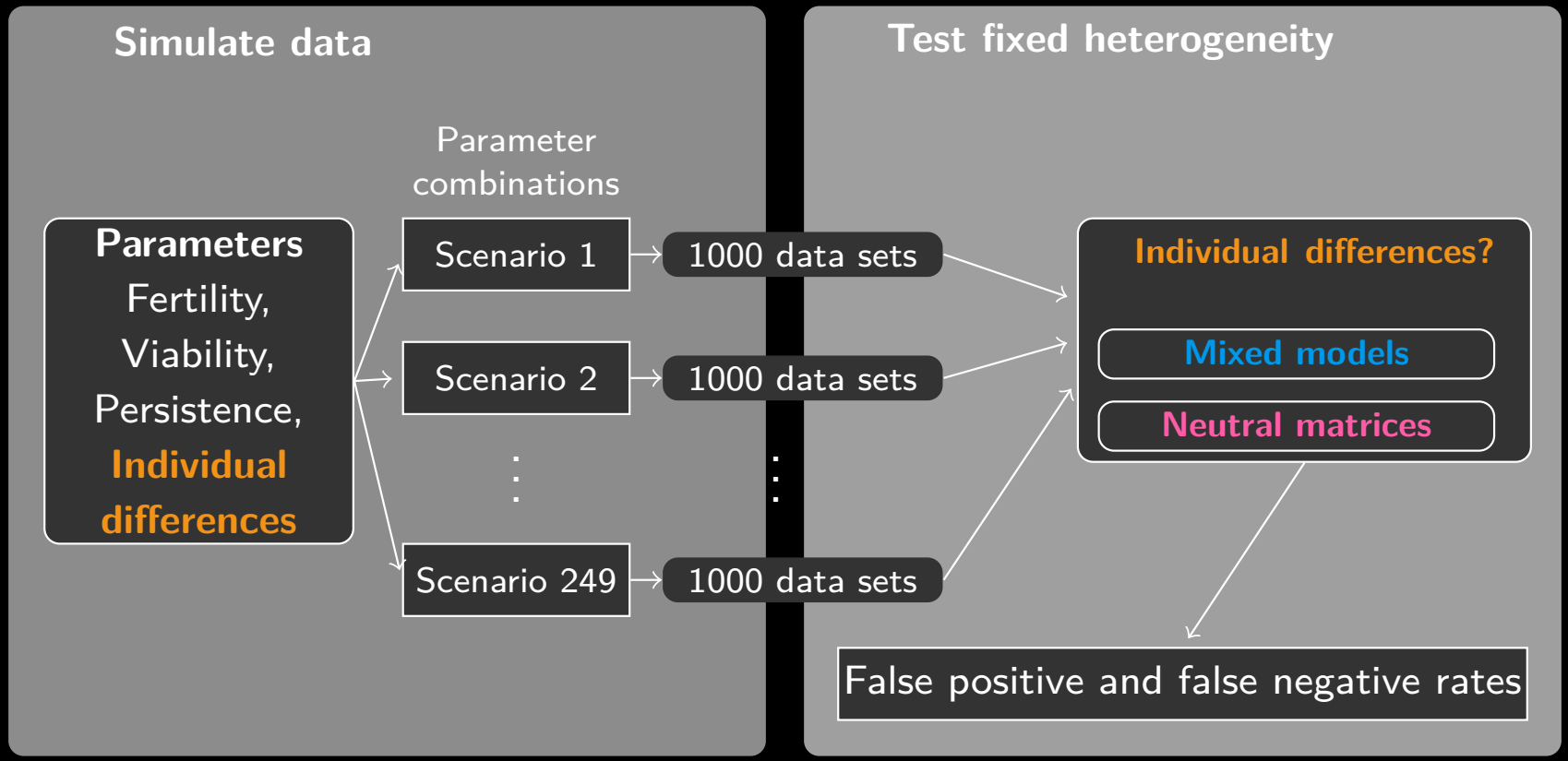
- . . . fitness traits are heritable
- . . . eh?

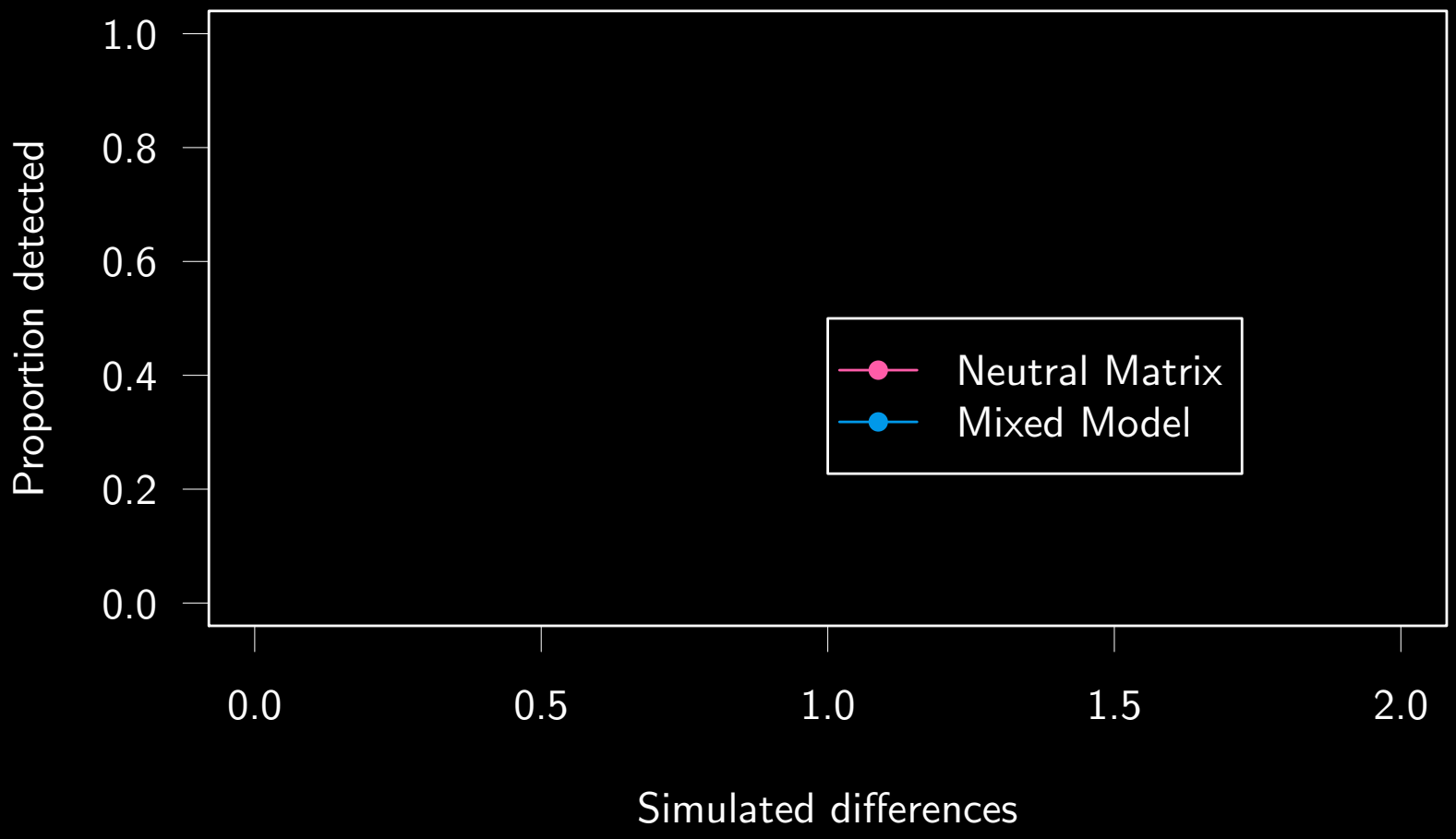
Why?

- **Neutral matrix method** =**false negative**?
- **Mixed model method** =**false positive**?

Method


Simulate data
Test fixed heterogeneity
Parameter combinations
Parameters
Fertility,
Viability,
Persistence,
Individual differences
Scenario 1
Scenario 2
Scenario 249
1000 data sets
1000 data sets
1000 data sets
Individual differences?
Mixed models
Neutral matrices
False positive and false negative rates

Results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1.5
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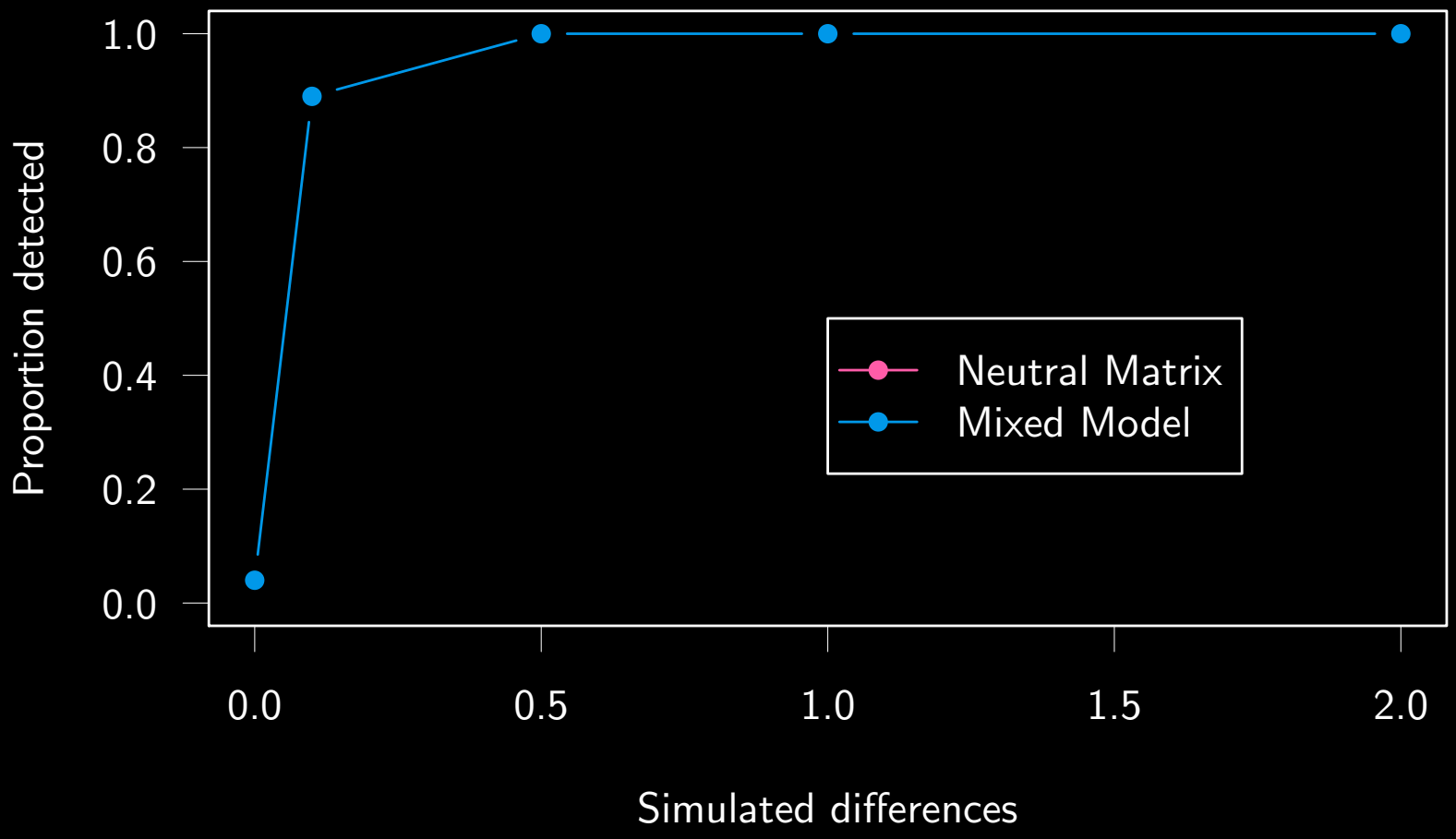
Simulated differences
Neutral Matrix
Mixed Model

Results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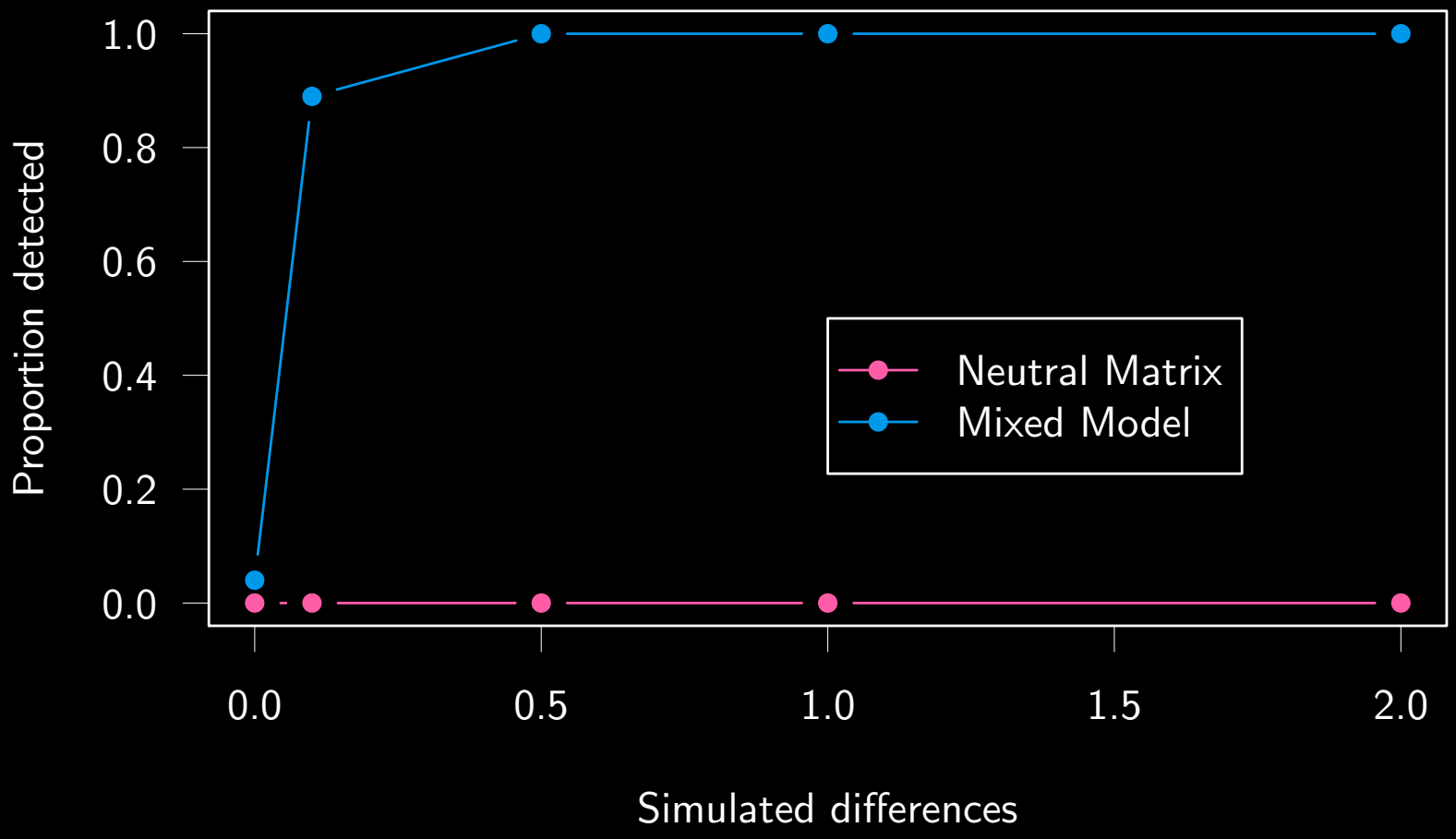
Results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Mixed Model

Conclusion

Why conflicting methods?

Conclusion

Why conflicting methods?

- **Neutral matrix method** =**false negative**? **YES**
- **Mixed model method** =**false positive**? **NO**

Conclusion

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$\rightarrow$ Individual differences in fitness components are common

Conclusion

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Implications

Conclusion

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$\rightarrow$ Individual differences in fitness components are common

Implications

- Phenotypic variation in fitness $\rightarrow$ opportunity for selection

Conclusion

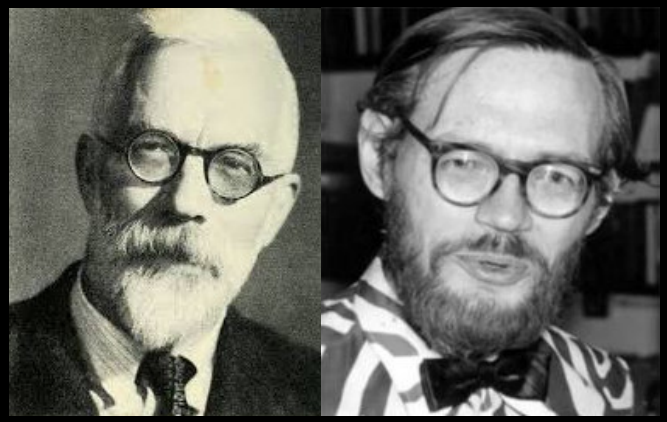
Why conflicting methods?

- **Neutral matrix method** =**false negative**? **YES**
- **Mixed model method** =**false positive**? **NO**

→ Individual differences in fitness components are common

Implications

- Phenotypic variation in fitness → opportunity for selection
- Heritability of fitness = **evolution**



R.A. Fisher **G. Price**

VOL. 187, NO. 1 THE AMERICAN NATURALIST JANUARY 2016

Successful by Chance? The Power of Mixed Models and Neutral Simulations for the Detection of Individual Fixed Heterogeneity in Fitness Components

Timothée Bonnet* and Erik Postma

Evolution in a changing world

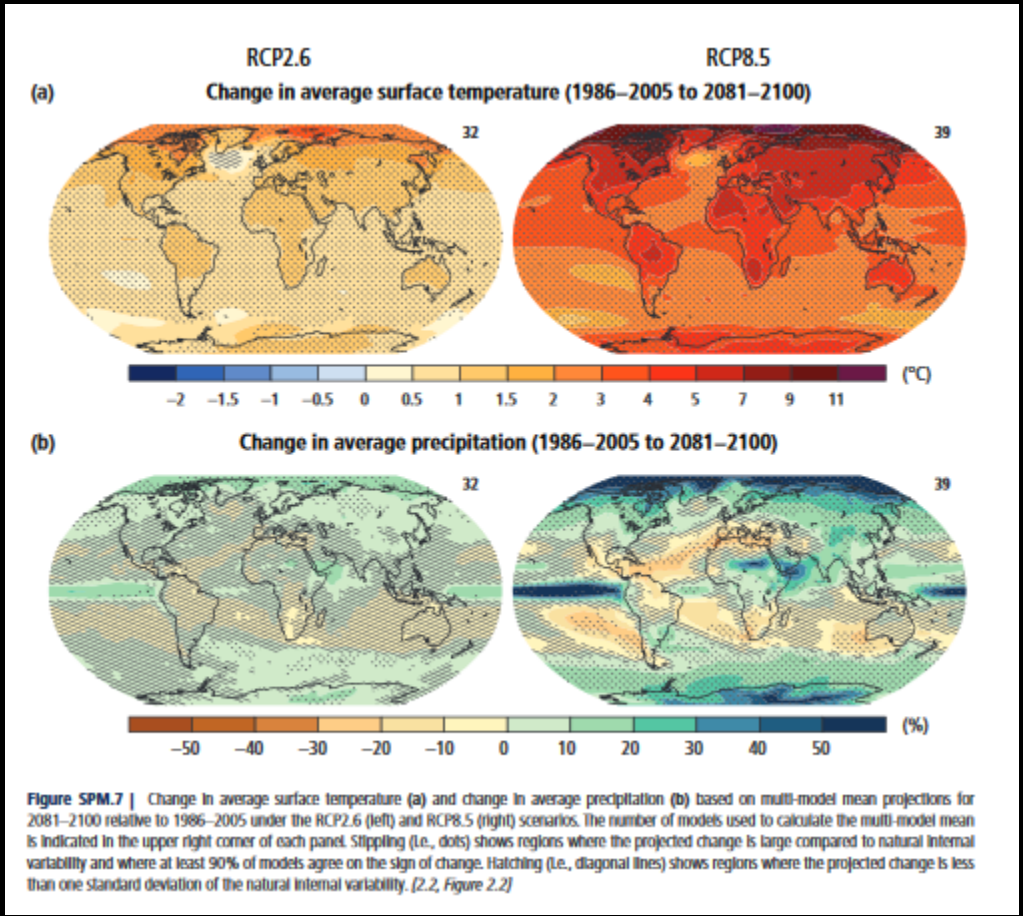
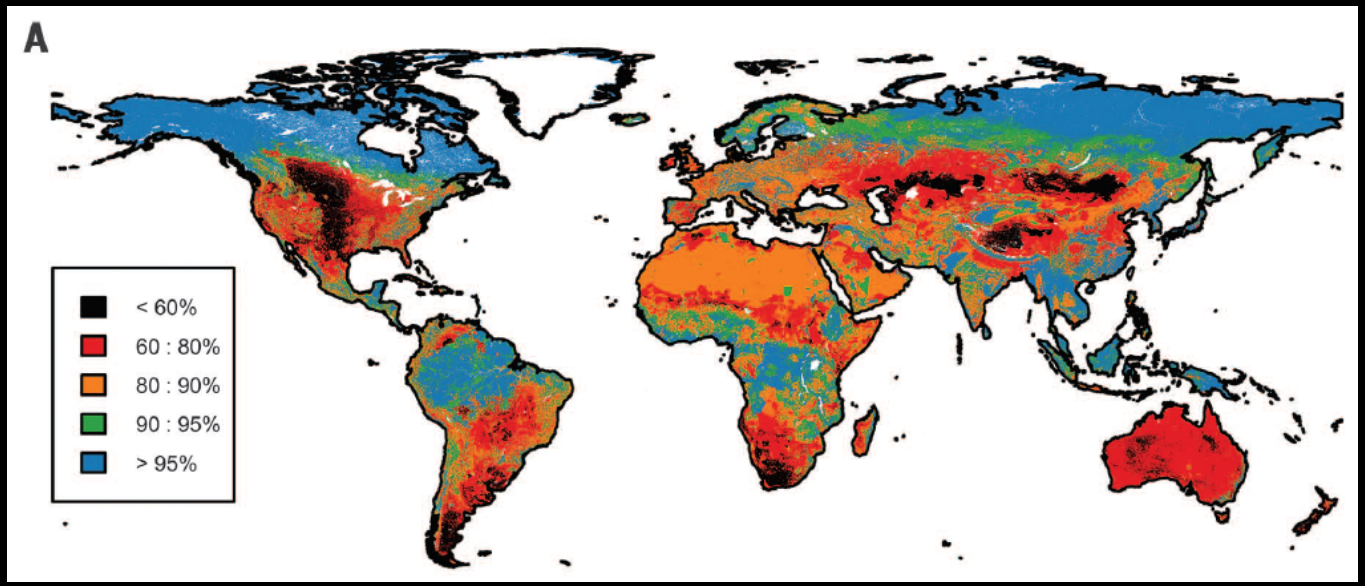


Figure SPM.7 | Change in average surface temperature **(a)** and change in average precipitation **(b)** based on multi-model mean projections for 2081–2100 relative to 1986–2005 under the RCP2.6 (left) and RCP8.5 (right) scenarios. The number of models used to calculate the multi-model mean is indicated in the upper right corner of each panel. Stippling (i.e., dots) shows regions where the projected change is large compared to natural internal variability and where at least 90% of models agree on the sign of change. Hatching (i.e., diagonal lines) shows regions where the projected change is less than one standard deviation of the natural internal variability. *[2.2, Figure 2.2]*

Intergovernmental panel on climate change 5th Report (2014)

Evolution in a changing world



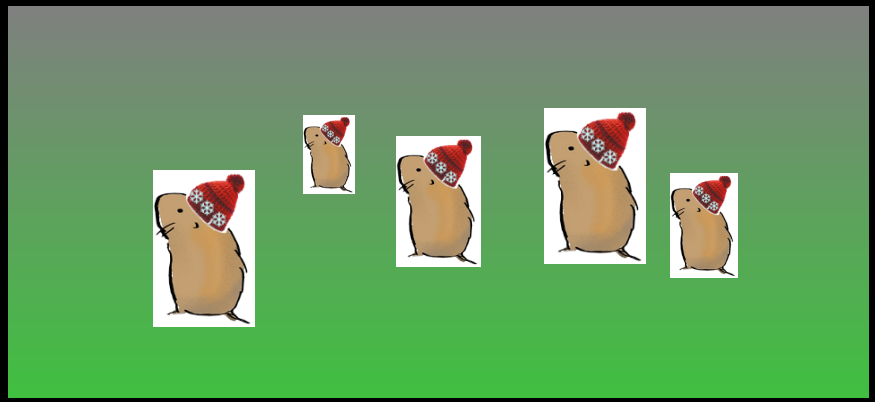
Newbold & al. (2016). Has land use pushed terrestrial biodiversity beyond the planetary boundary? A global assessment. Science, 353

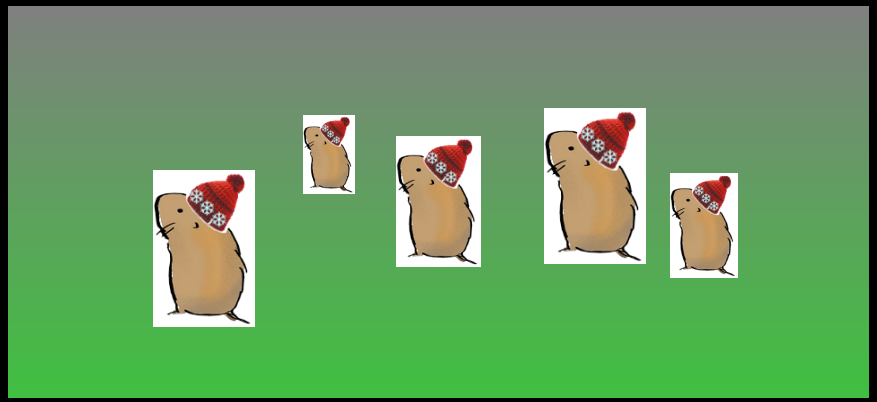
Evolution in a changing world

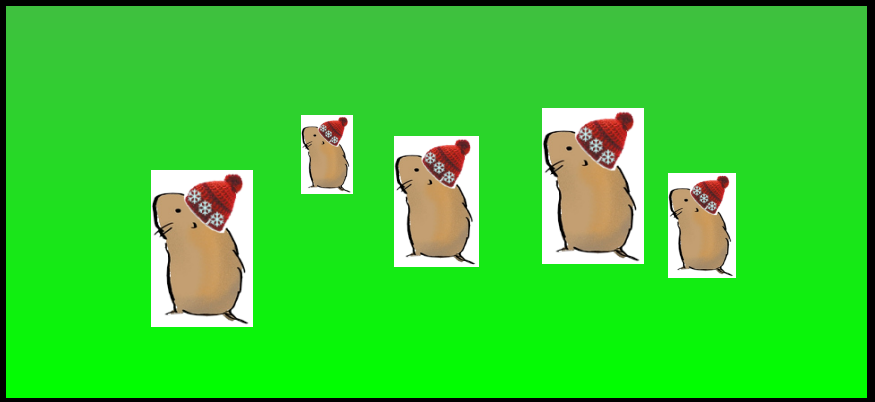
Ecological and Evolutionary Responses to Recent Climate Change

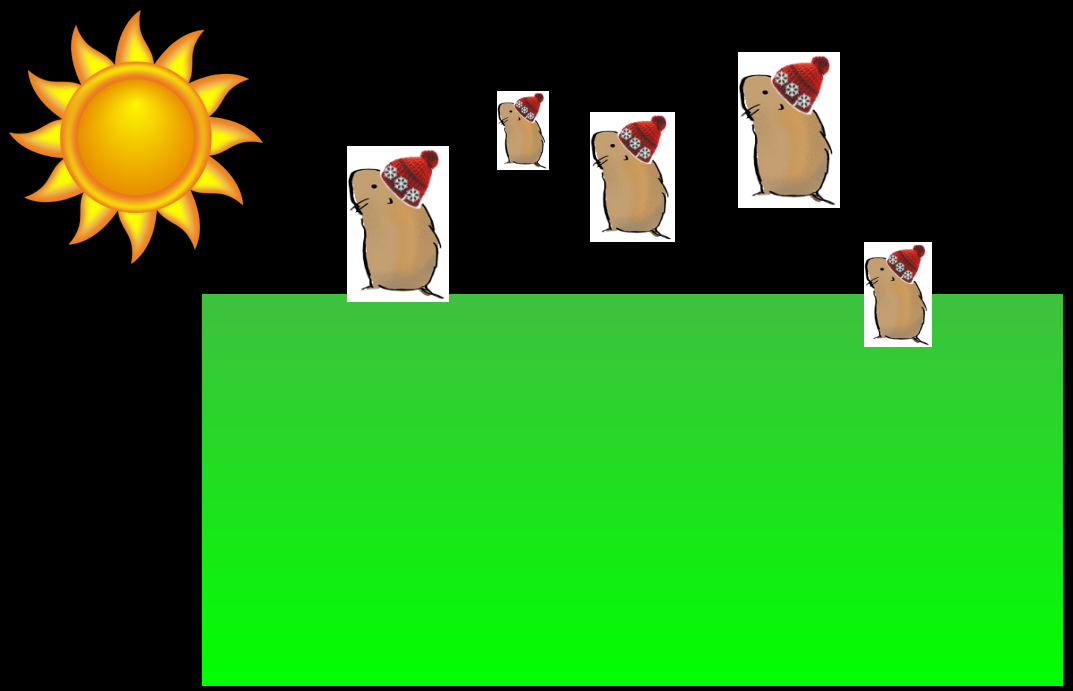
Annual Review of Ecology, Evolution, and Systematics
Vol. 37: 637-669 (Volume publication date December 2006)
First published online as a Review in Advance on August 24, 2006
DOI: 10.1146/annurev.ecolsys.37.091305.110100

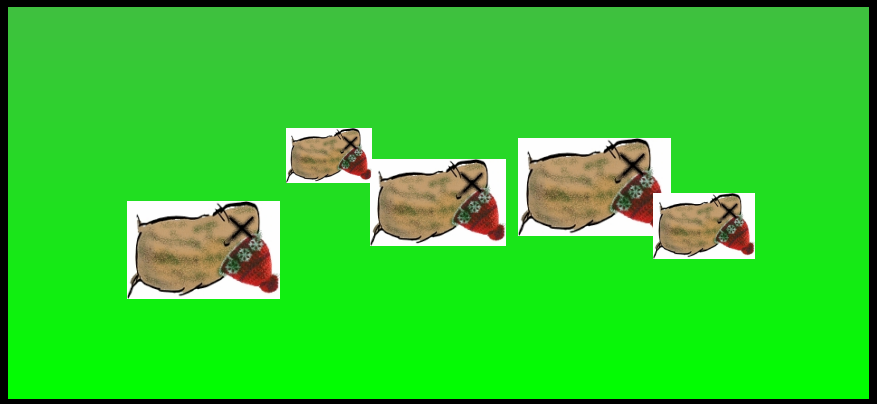
Camille Parmesan
Section of Integrative Biology, University of Texas, Austin, Texas 78712; email: parmesan@mail.utexas.edu

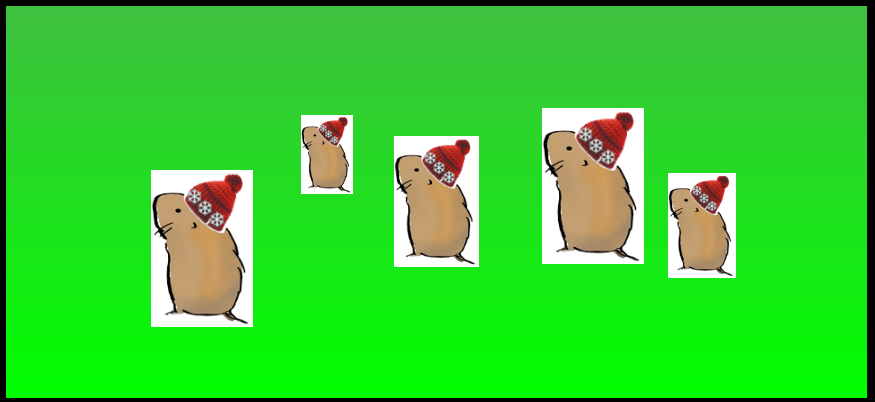


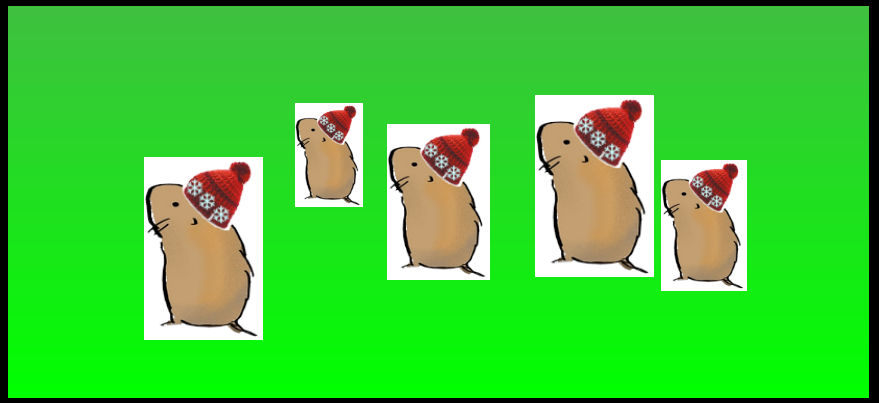


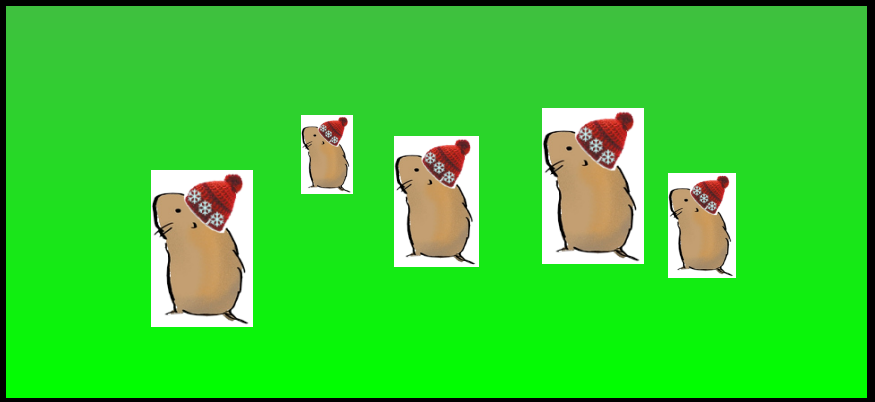


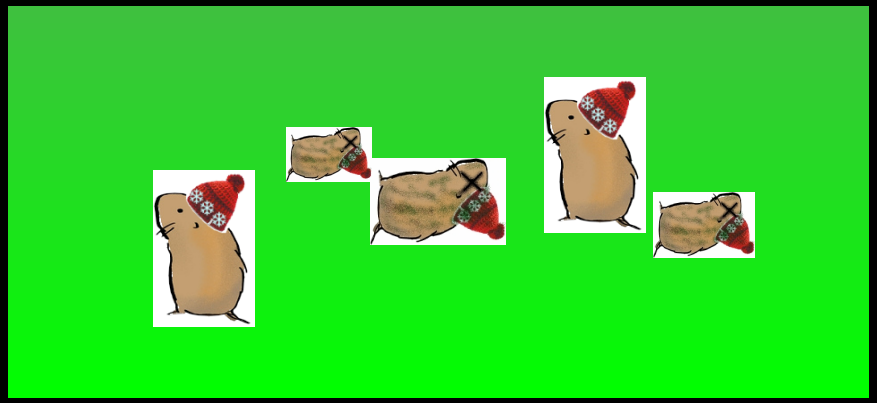


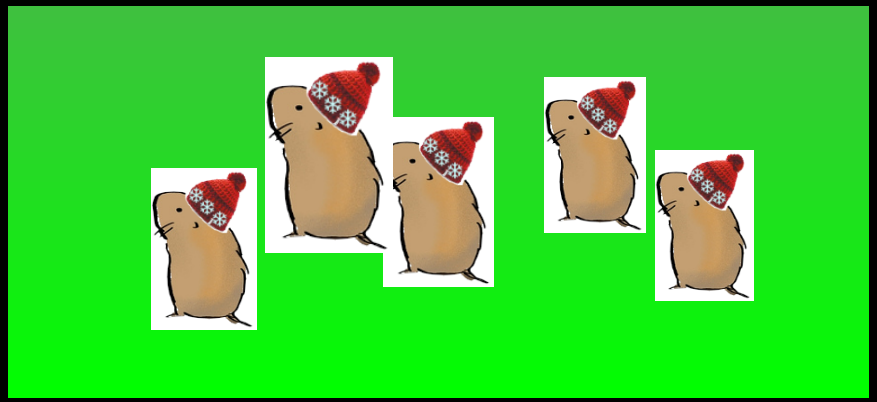












Evolution or plasticity? What drives phenotypic change?

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4. **Animal model** - Henderson (1950) Estimation of genetic parameters. Annals of Mathematical Statistics, 21

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REVIEW

Disentangling evolutionary, plastic and demographic processes underlying trait dynamics: a review of four frameworks

Koen J. van Benthem[1]*†, Marjolein Bruijning[2]†, Timothée Bonnet[1]†, Eelke Jongejans[2]‡, Erik Postma[1]‡ and Arpat Ozgul[1]‡

[1]*Department of Evolutionary Biology and Environmental Studies, University of Zurich, Winterthurerstrasse 190, 8057 Zurich, Switzerland; and* [2]*Department of Animal Ecology and Physiology, Radboud University, 6500 GL Nijmegen, The Netherlands*

Question	Animal model	Geber's method	Age-structured Price's equation	Integral projection models
Evolution?	++	+	−−	−−
Selection?	+	+	++	++
Heritability?	++	±	−	−
Changing age structure?	+	±	++	++

The animal model

Pedigree $\rightarrow$ similarity between relatives $\rightarrow$ **additive genetic variance**

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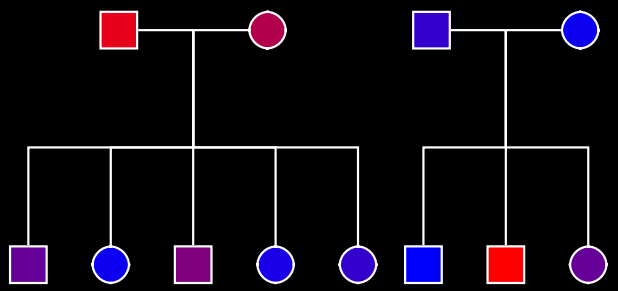

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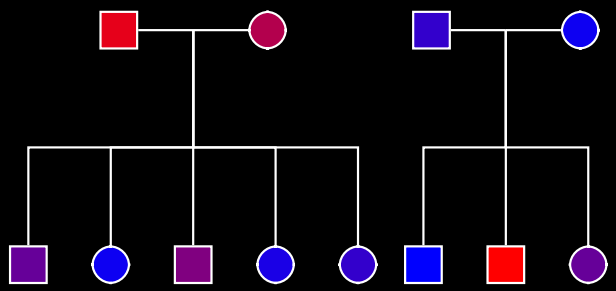
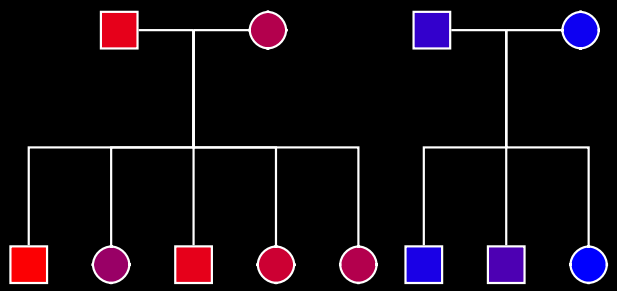


heritability$\approx$1



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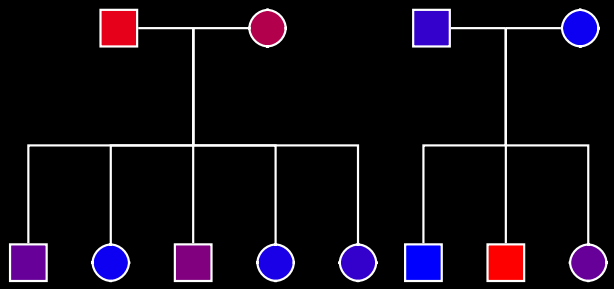

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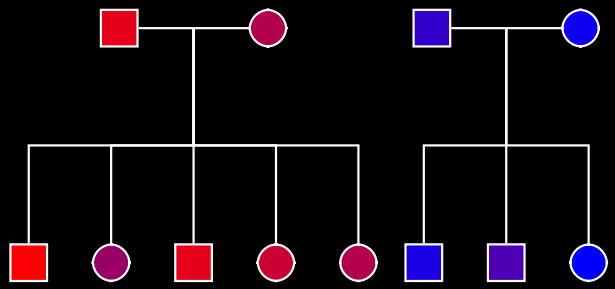
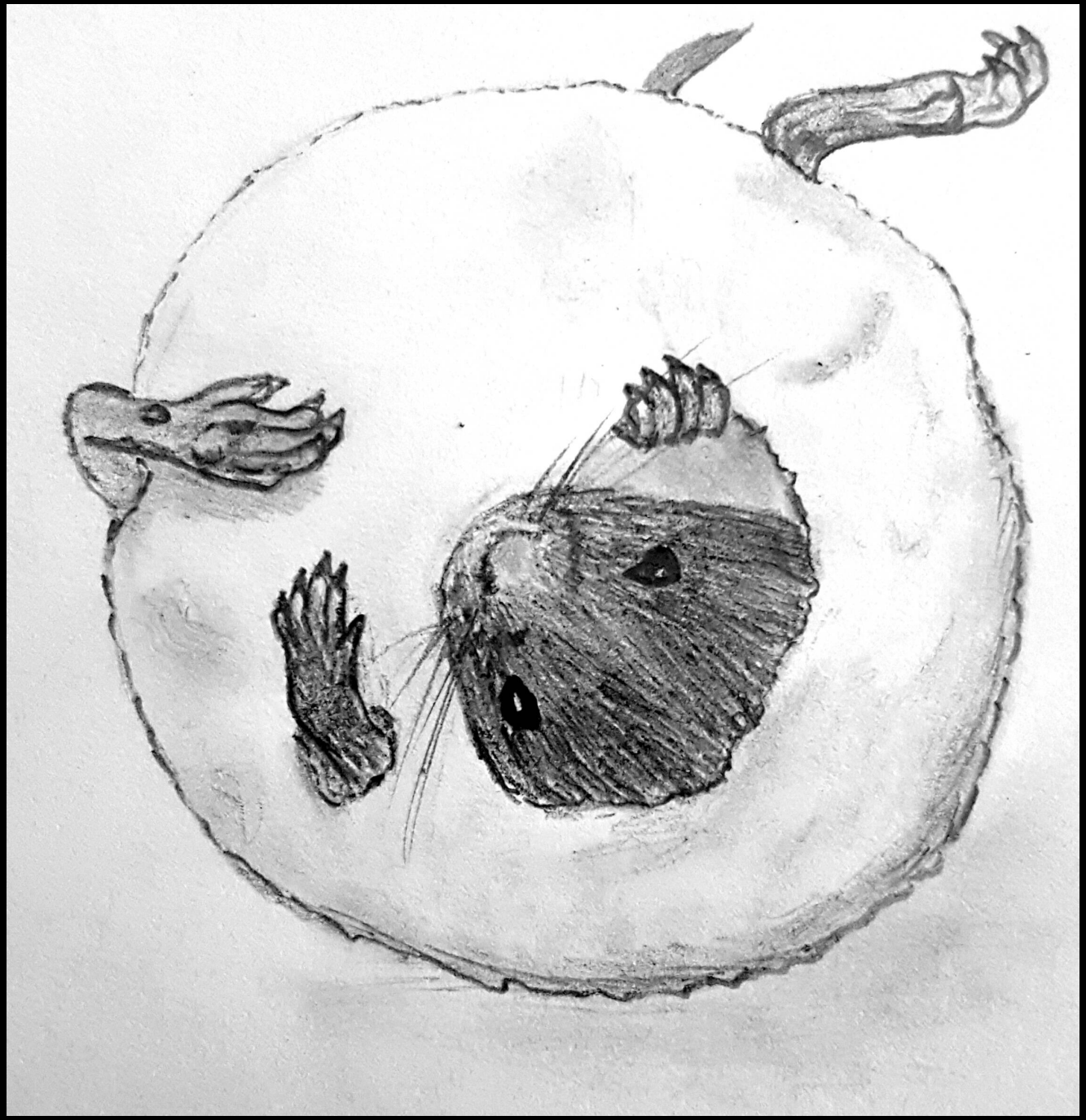


Breeding value

= Individual additive genetic value

Change with time = evolution



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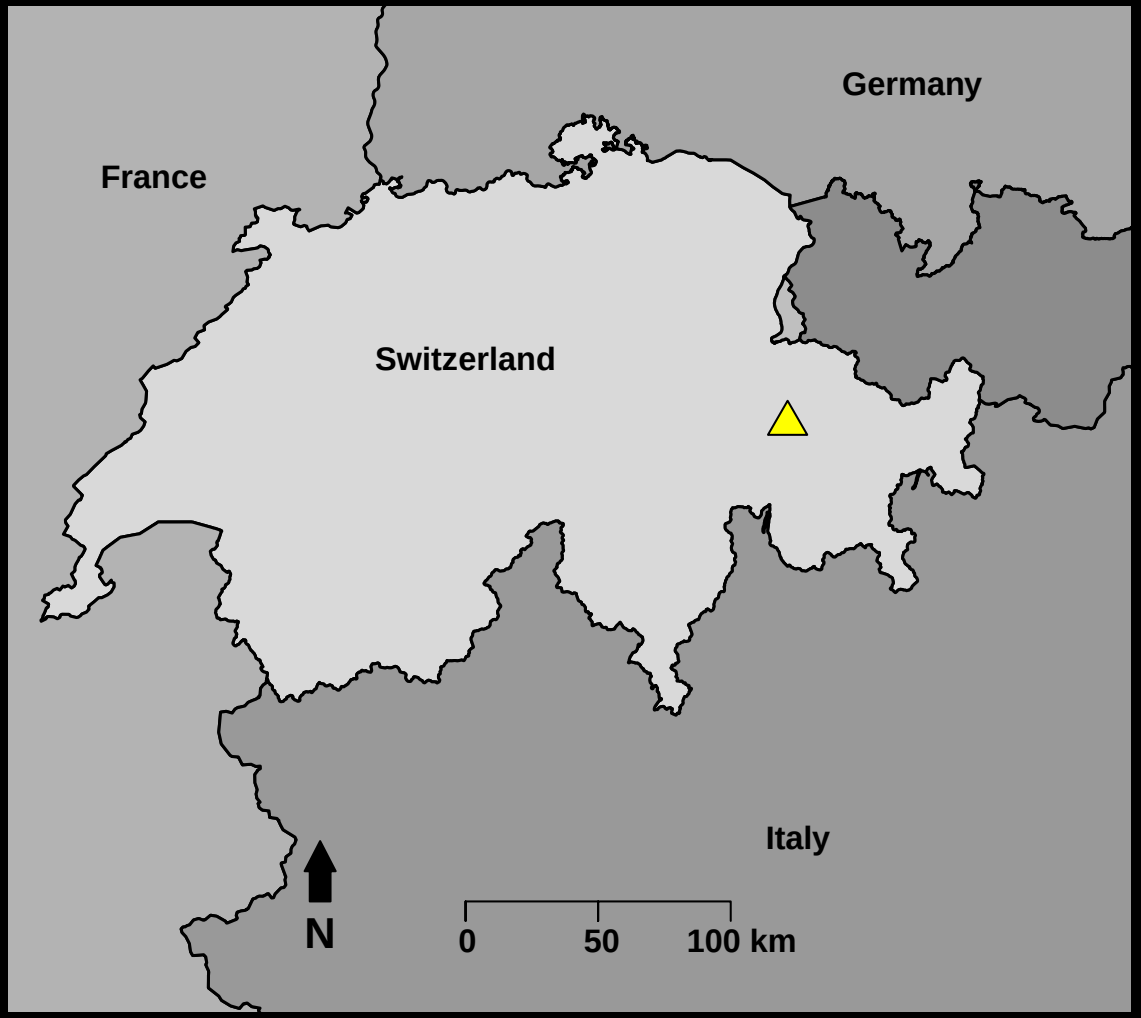
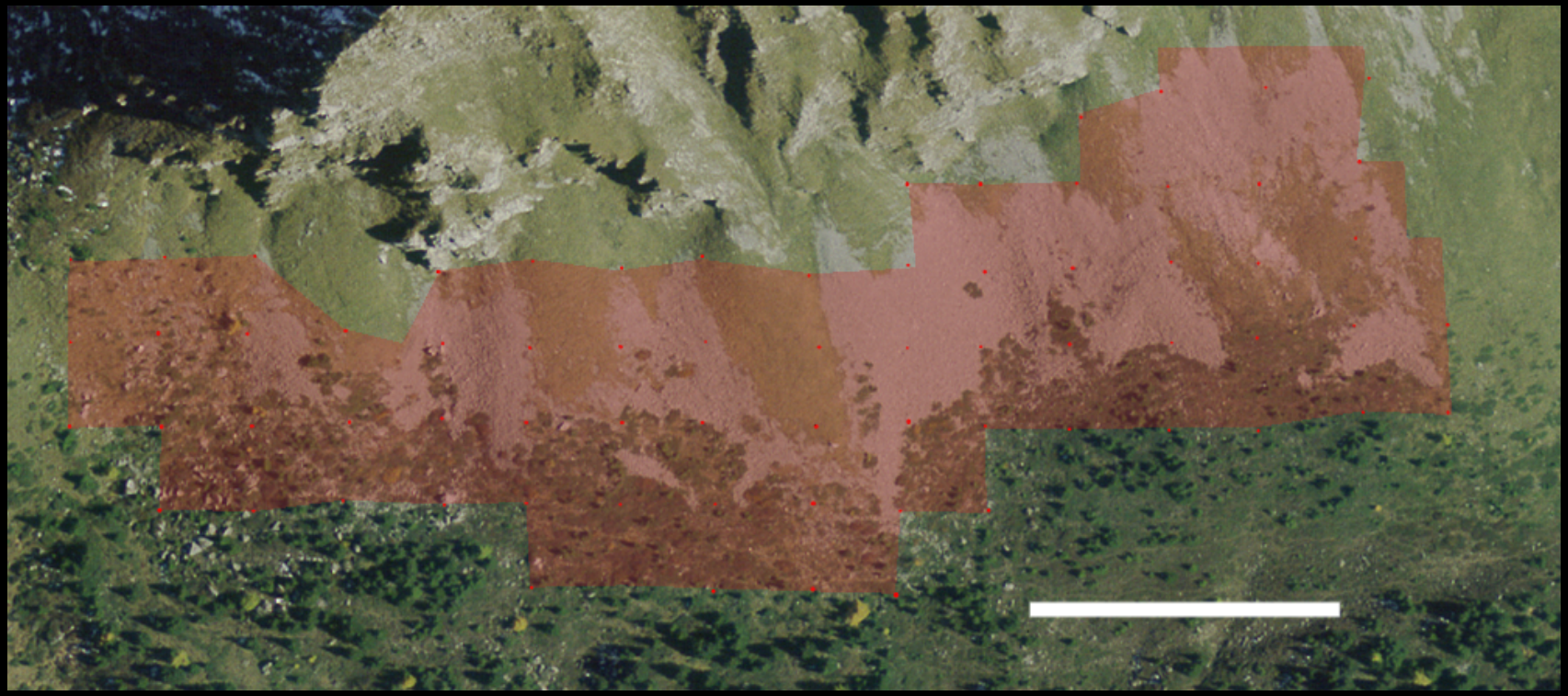
- 30-45g
- 10-14cm long + 5-8cm tail

Snow vole (*Chionomys nivalis*, Martins 1842)

- NOT white
- Rock-dweller
- 30-45g
- 10-14cm long + 5-8cm tail
- Slow life pace


Germany
France
Switzerland
Italy
N
0
50
100 km



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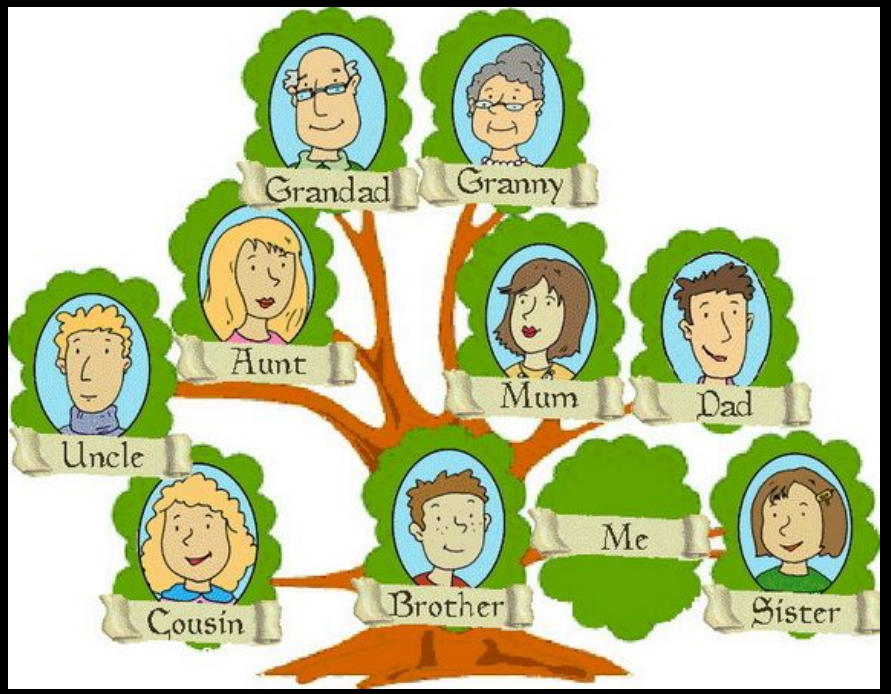

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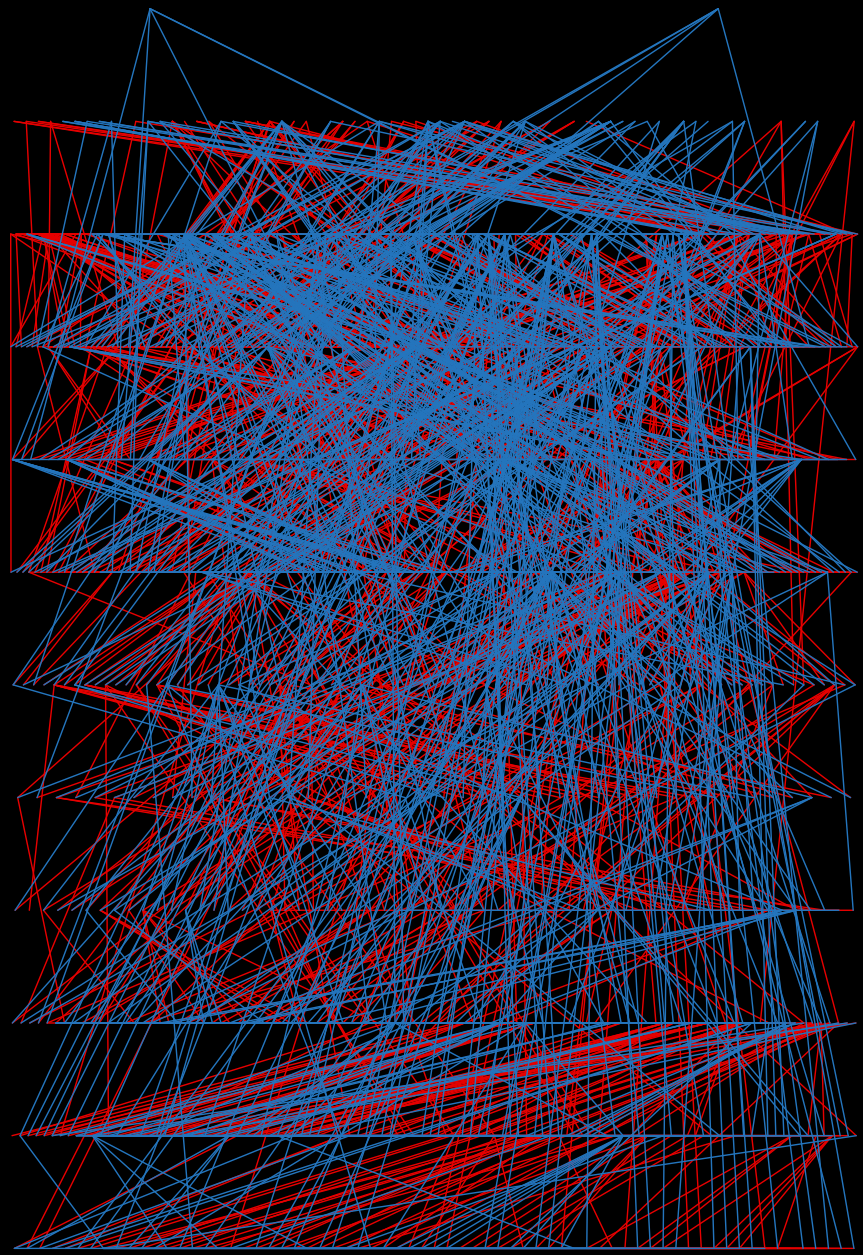

Are snow vole evolving? Why?

Do selection and evolution fluctuate?

What is left?