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Rapid evolution of local adaptation to different host fruits in wild *D. suzukii* populations

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Rapid evolution of local adaptation to different host fruits in wild *D. suzukii* populations

Nicolas Rode, Montpellier

People involved



Laure Olazcuaga
PhD student



Arnaud Estoup & Mathieu Gautier
co-supervisors

Drosophila suzukii

Invasive species



Drosophila suzukii

Invasive species

- Generalist species



Drosophila suzukii

Invasive species

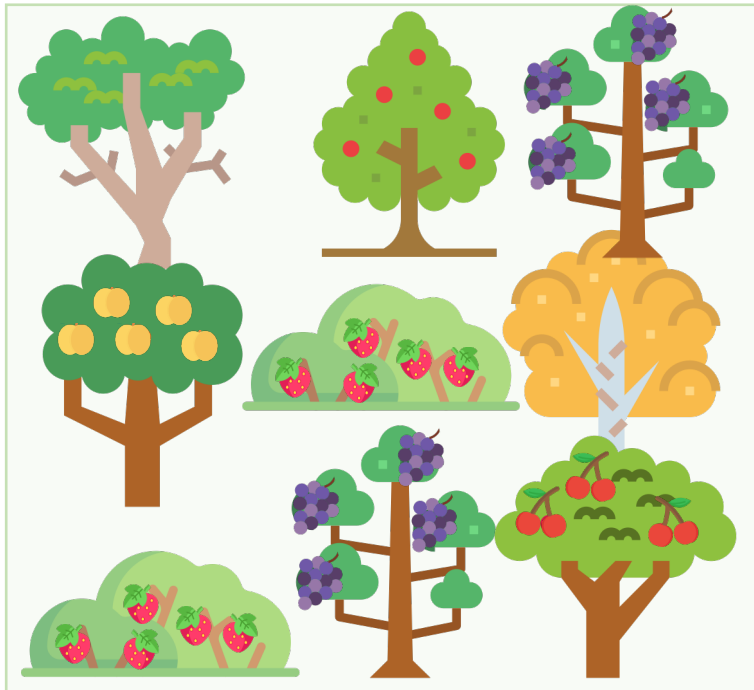
- Generalist species



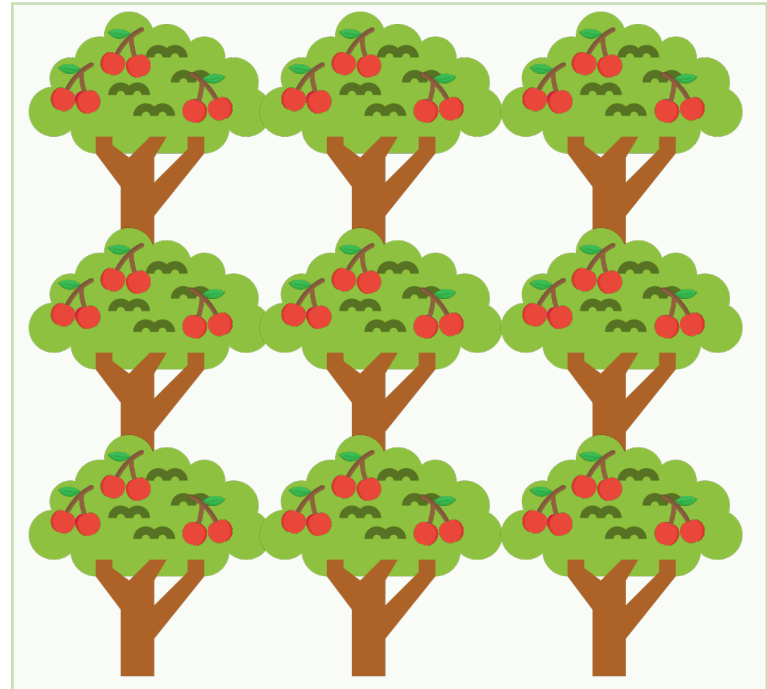
Long term goal: improve cropping systems



Polyculture



Monoculture



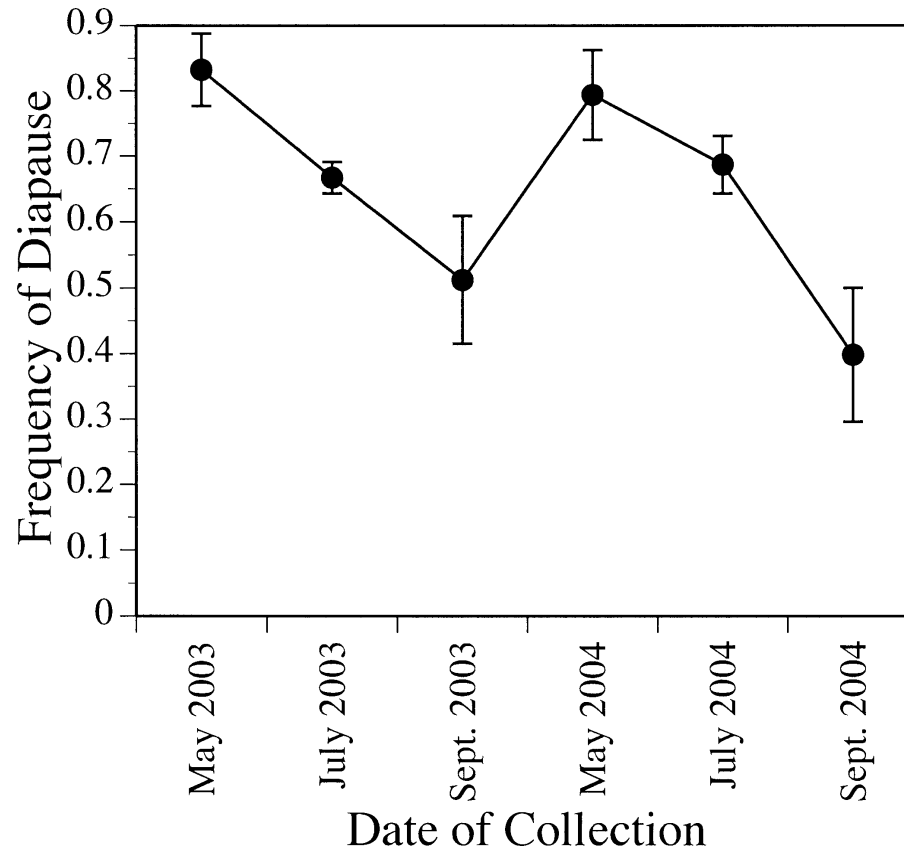
Questions

Adaptation to different host fruits?

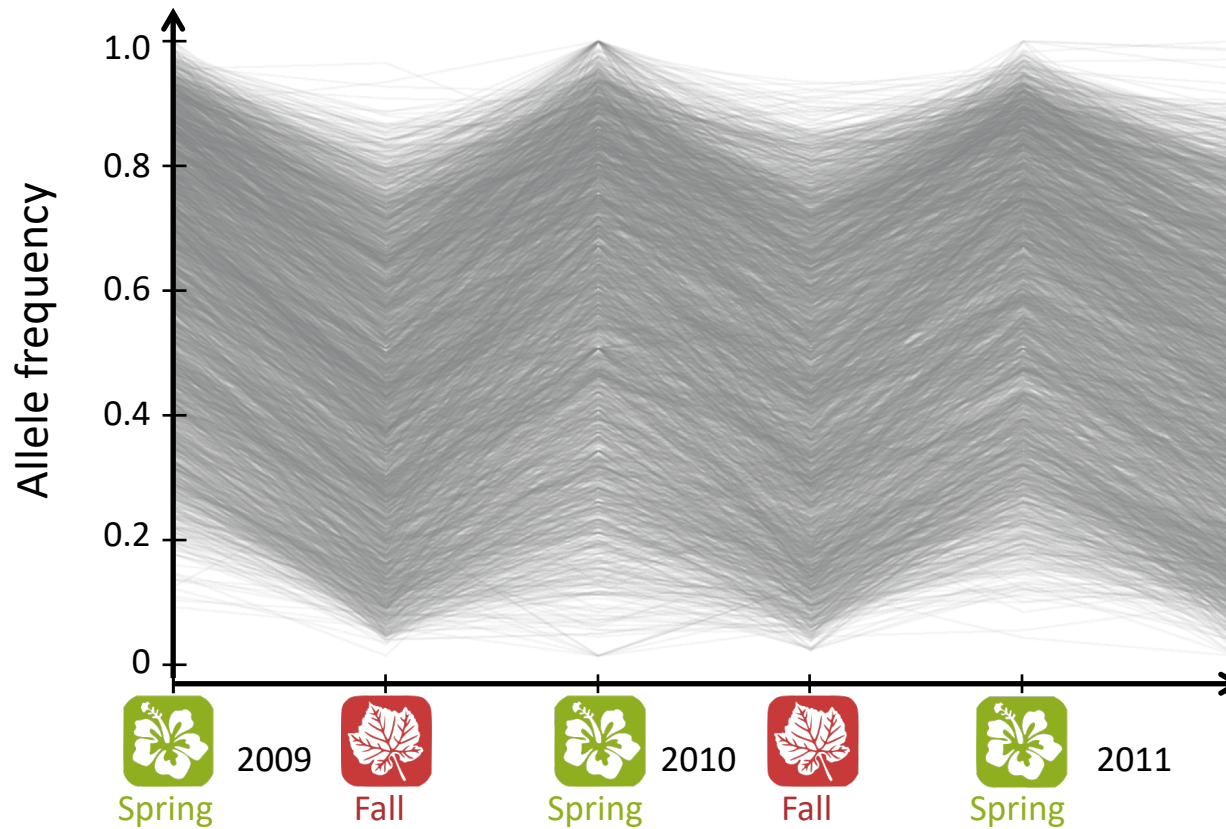
Speed of adaptation?

Role of adaptive phenotypic plasticity?

Adaptive seasonal oscillations in *D. melanogaster*



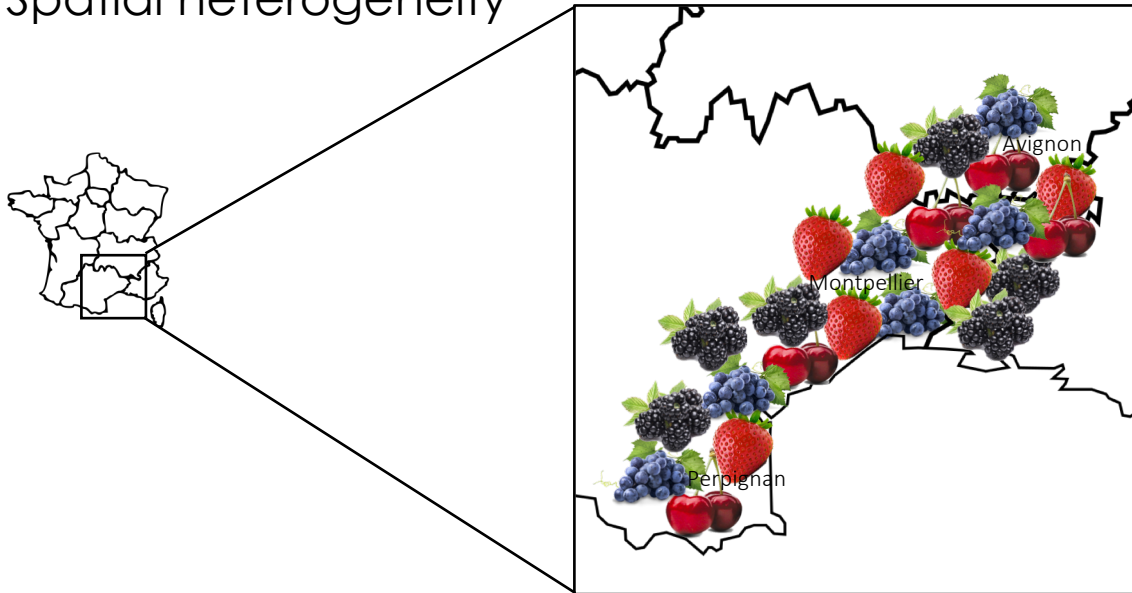
Shift in allele frequencies



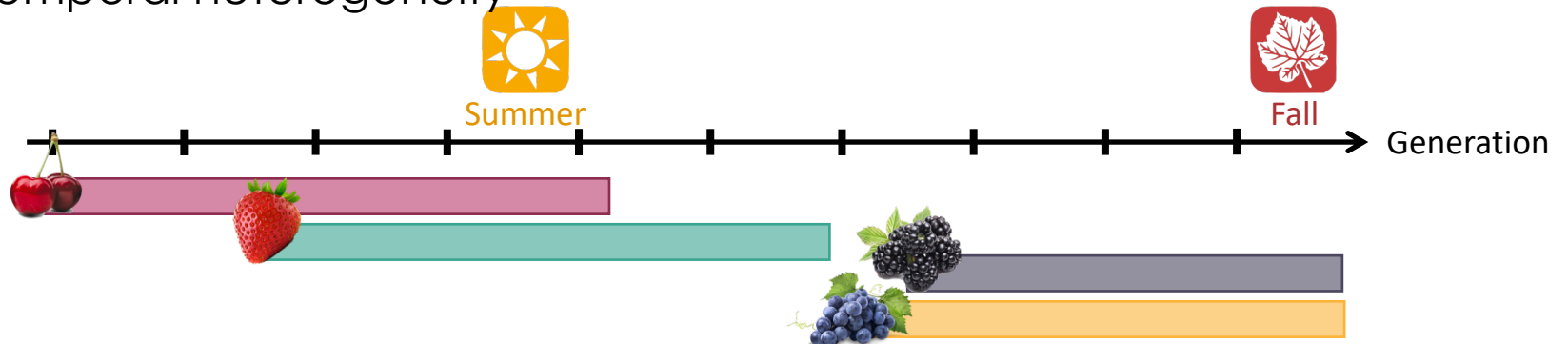
[Bergland et al., 2014]

D. sukuzii: environmental heterogeneity

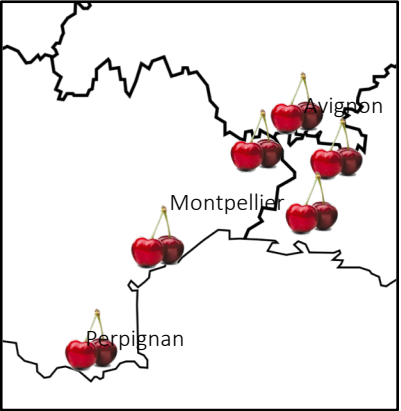
Spatial heterogeneity



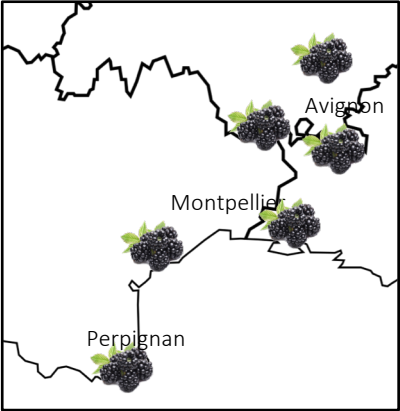
Temporal heterogeneity



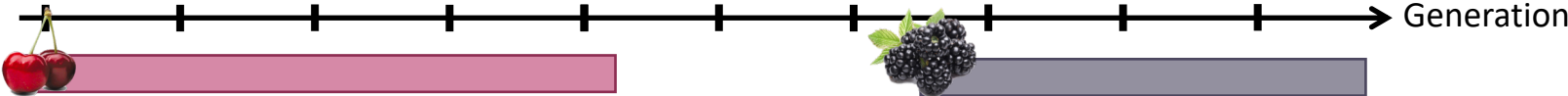
Change in genotype frequencies?



Summer

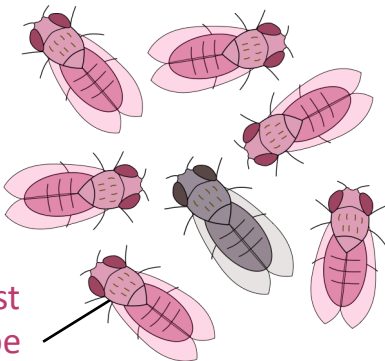


Fall

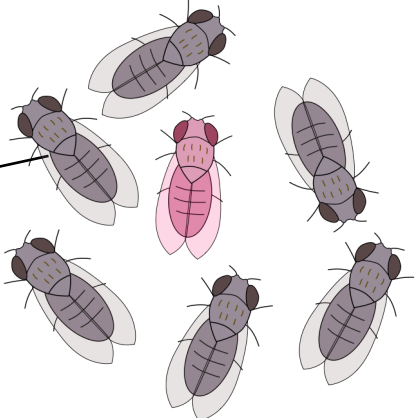


Population

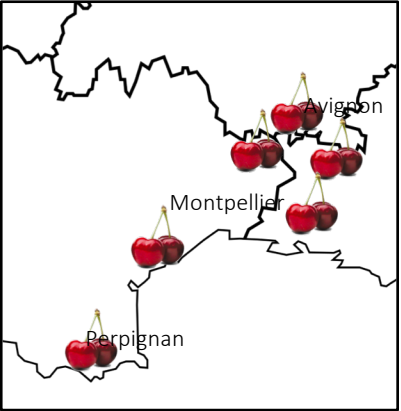
Specialist genotype



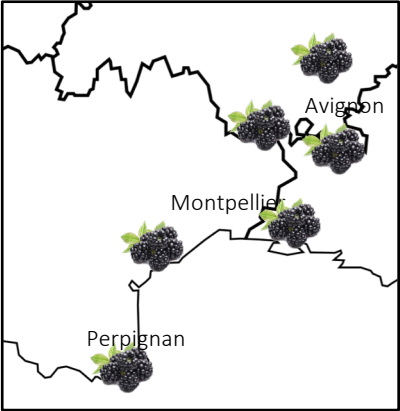
Specialist genotype



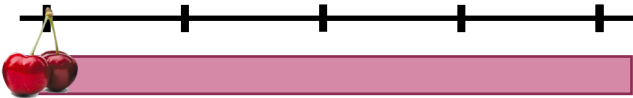
Change in genotype frequencies?



Summer



Fall



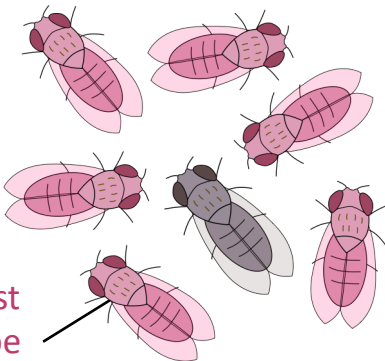
~4/5 generations



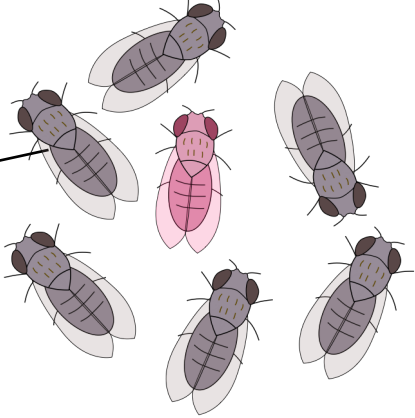
~4/5 generations

Population

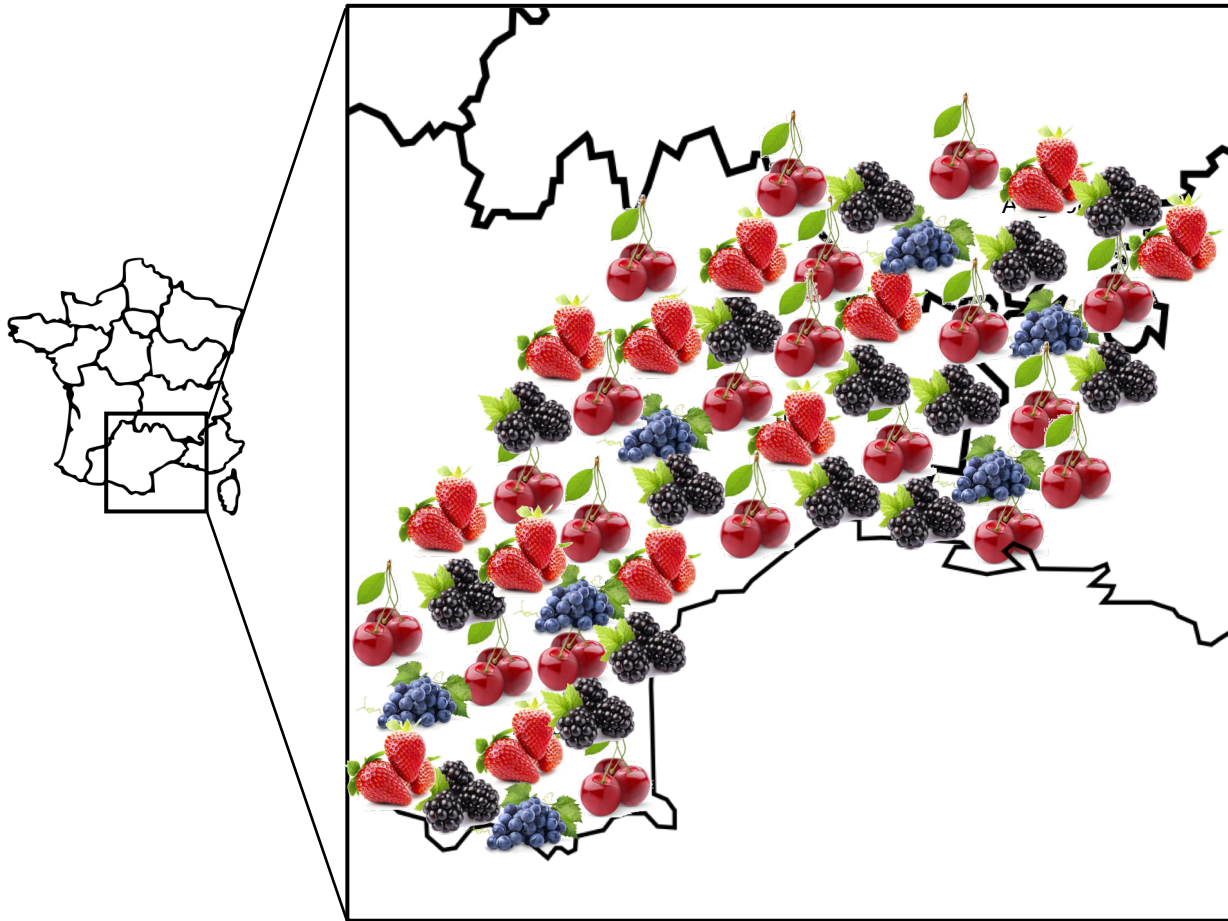
Specialist genotype



Specialist genotype



Sampling fly populations



12 locations for 

20 locations for 

15 locations for 

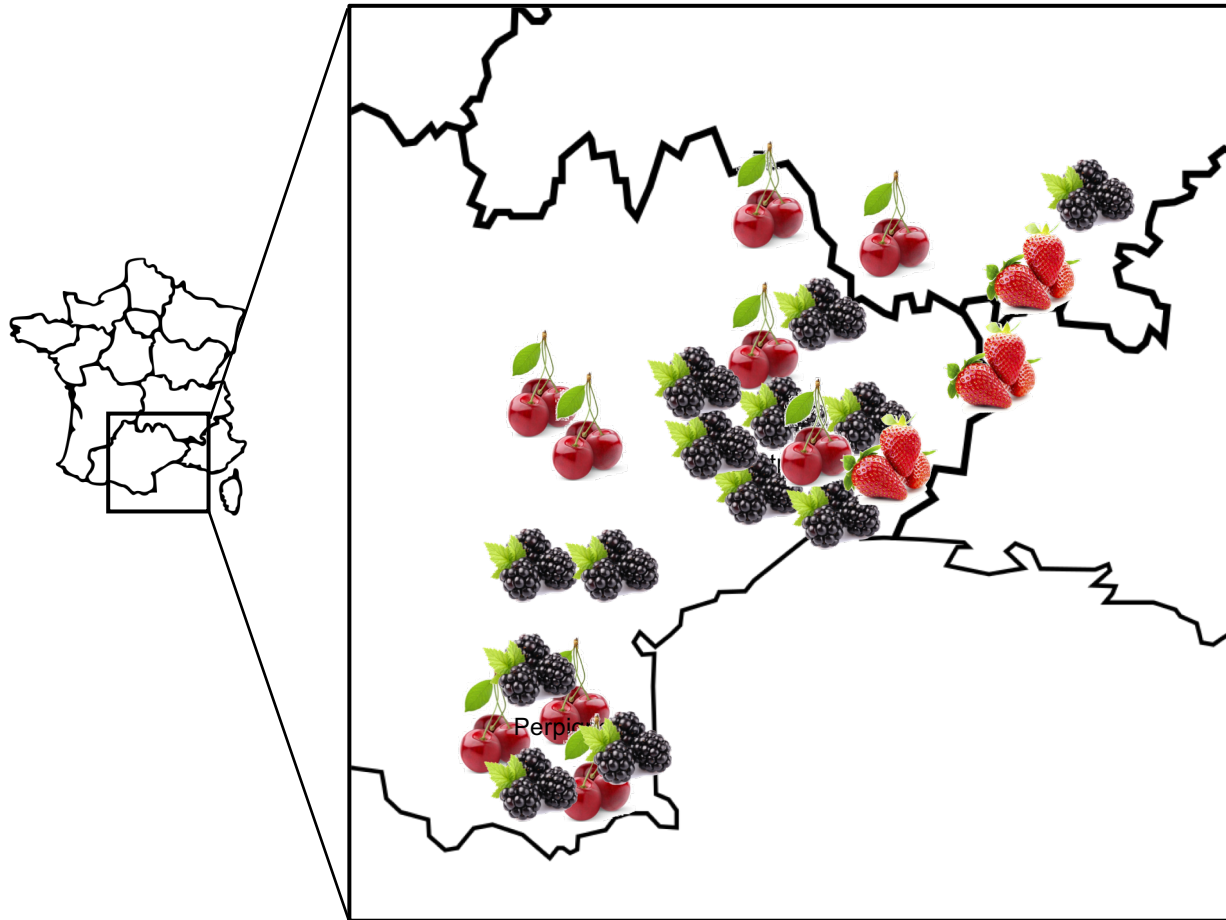
7 locations for 





More than 200 containers
~ 8 months

Distribution of fly populations



3 locations for



9 locations for



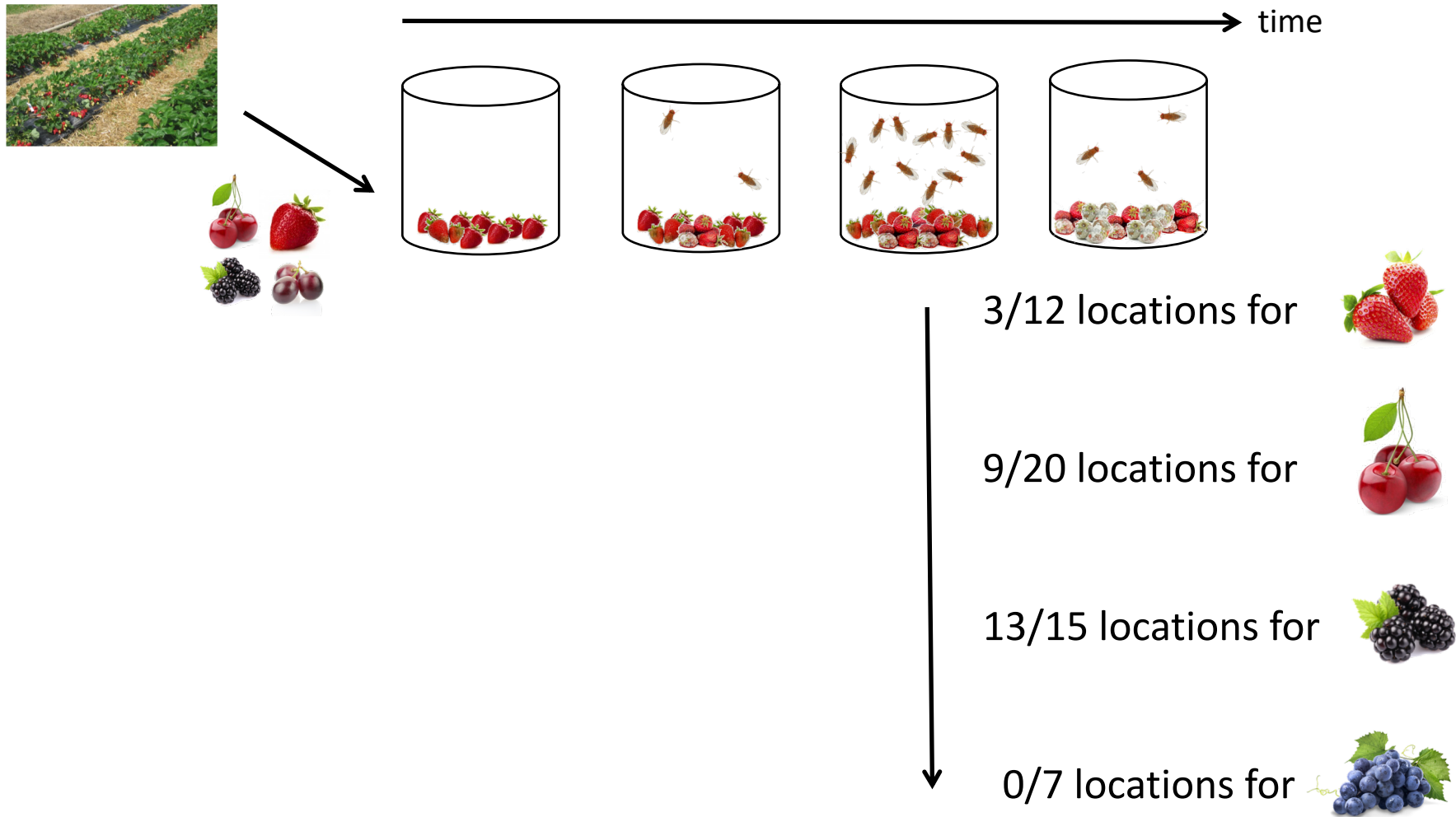
13 locations for



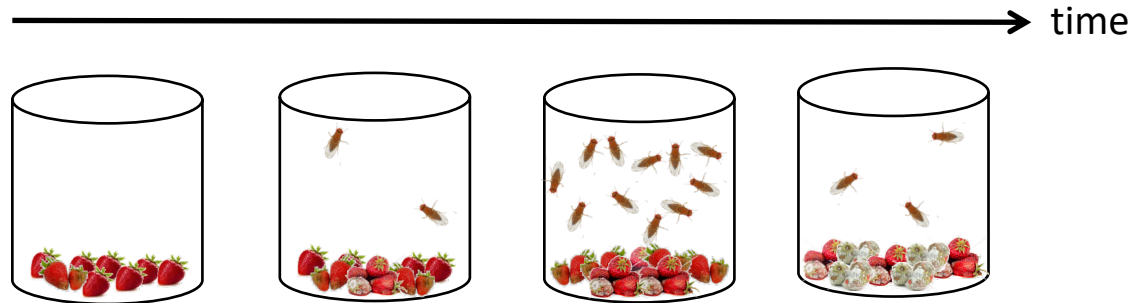
0 locations for



Sampling fly populations



Sampling fly populations



3/12 locations for



9/20 locations for



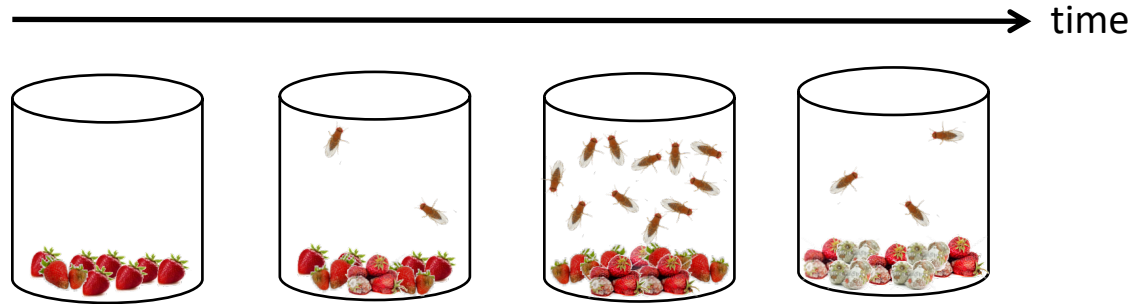
13/15 locations for



0/7 locations for



Sampling fly populations



Reciprocal transplant experiments

3/12 locations for



9/20 locations for



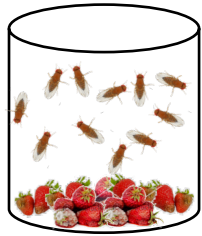
13/15 locations for



0/7 locations for



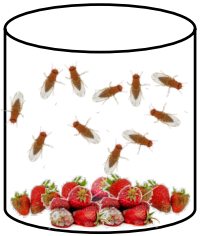
Reciprocal transplant experiments



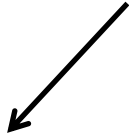
Groups of
20 flies



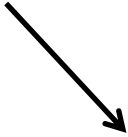
Reciprocal transplant experiments



Groups of
20 flies



Emergence rate



Oviposition preference



Fruits purees:

- Cherry
- Strawberry
- Blackberry



Number of eggs
Number of adults

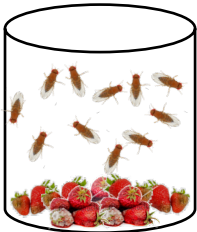
- Apricot
- Blackberry
- Blackcurrant
- Cherry
- Cranberry
- Fig



Number of eggs

- Grape
- Kiwi
- Raspberry
- Rose Hips
- Strawberry
- Tomato

Reciprocal transplant experiments



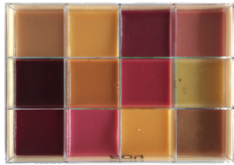
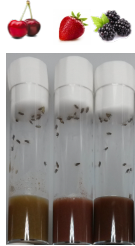
Groups of
20 flies

G1



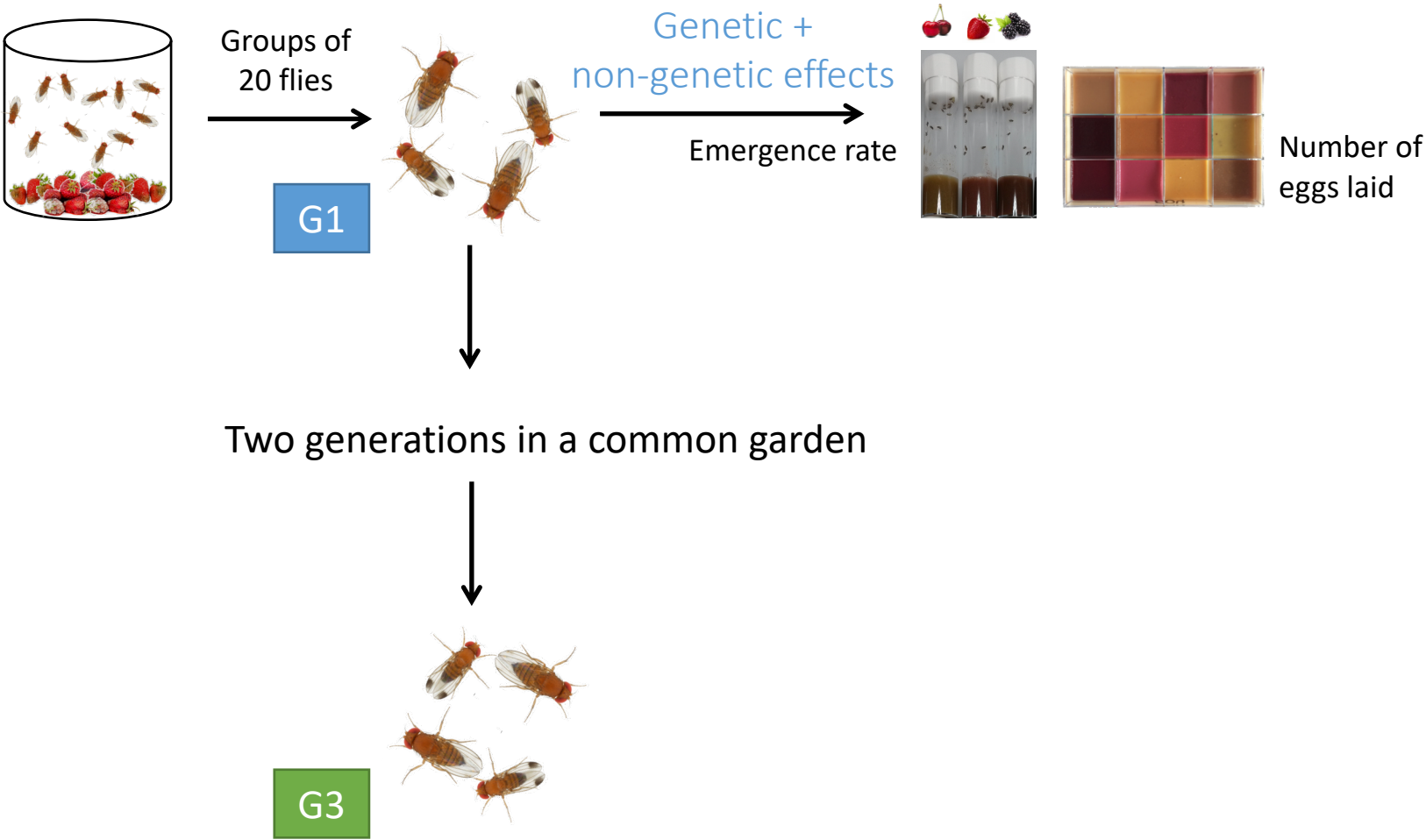
Genetic +
non-genetic effects

Emergence rate

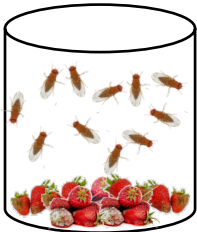


Number of
eggs laid

Reciprocal transplant experiments



Reciprocal transplant experiments



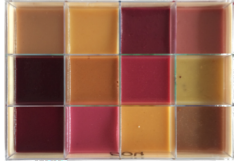
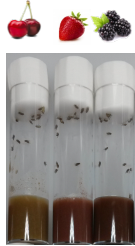
Groups of
20 flies

G1



Genetic +
non-genetic effects

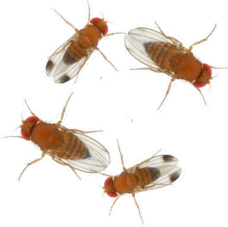
Emergence rate



Number of
eggs laid

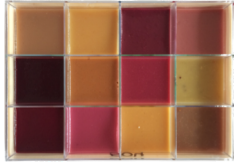
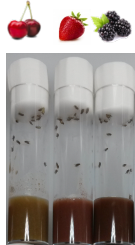
Two generations in a common garden

G3



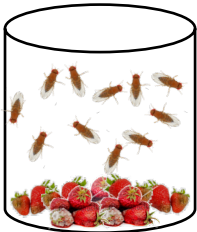
Genetic effects

Emergence rate



Number of
eggs laid

Reciprocal transplant experiments



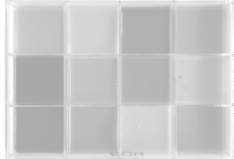
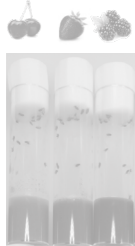
Groups of
20 flies

G1



Genetic +
non-genetic effects

Emergence rate



Number of
eggs laid

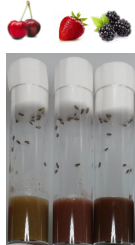
Two generations in a common garden

G3



Genetic effects

Emergence rate

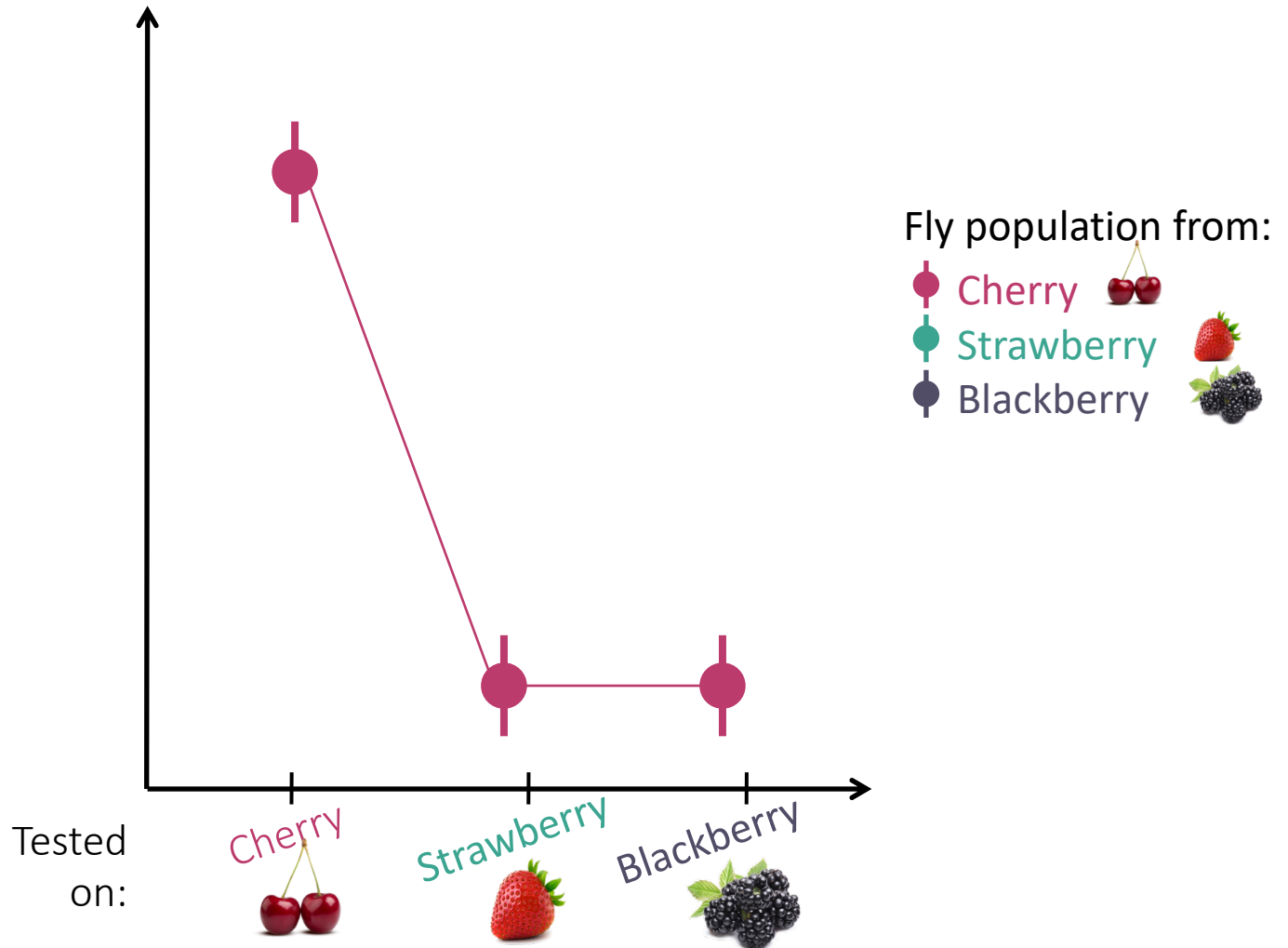


Number of
eggs laid

Expectations: Local adaptation



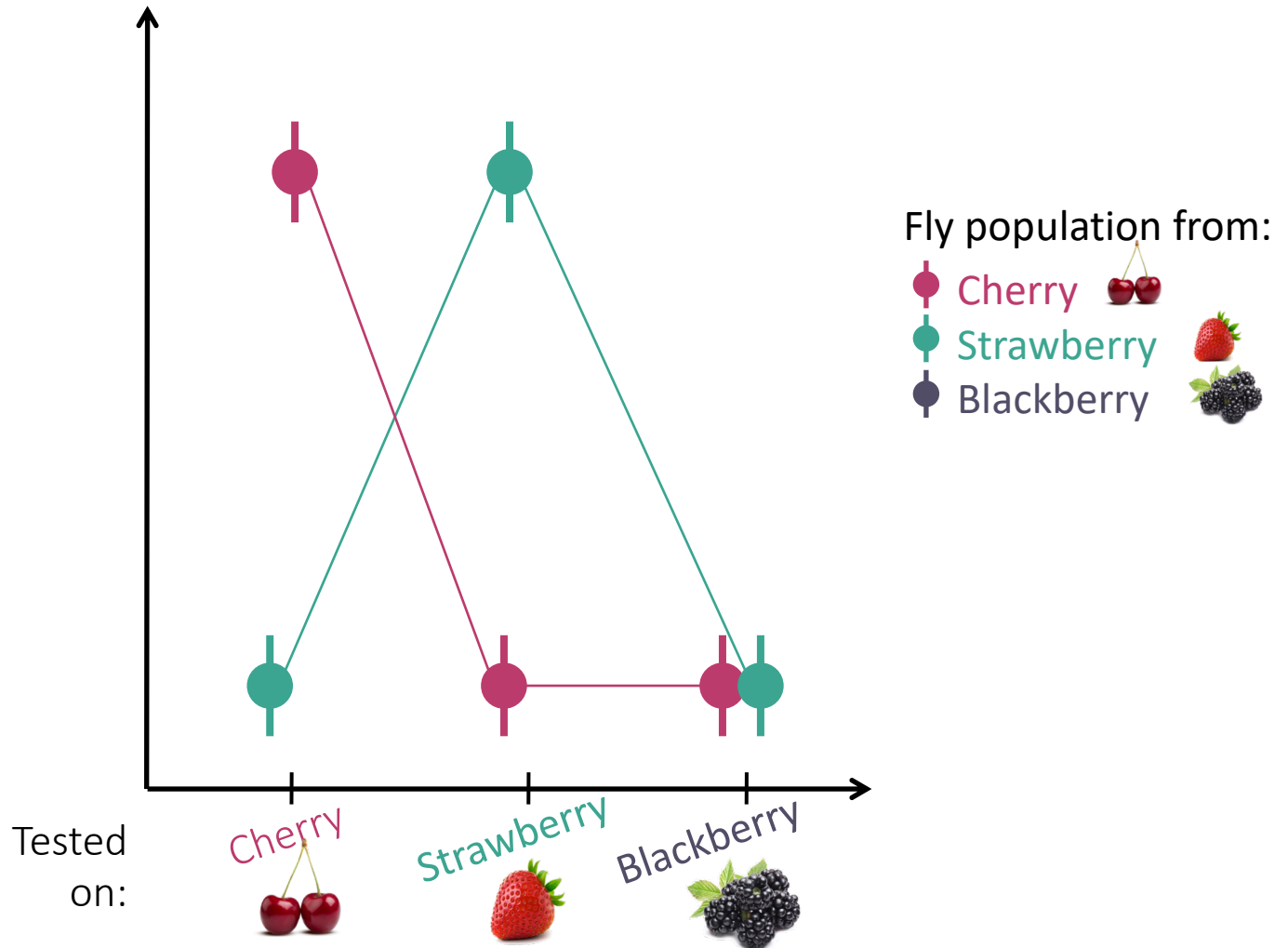
Expected mean fitness



Expectations: Local adaptation



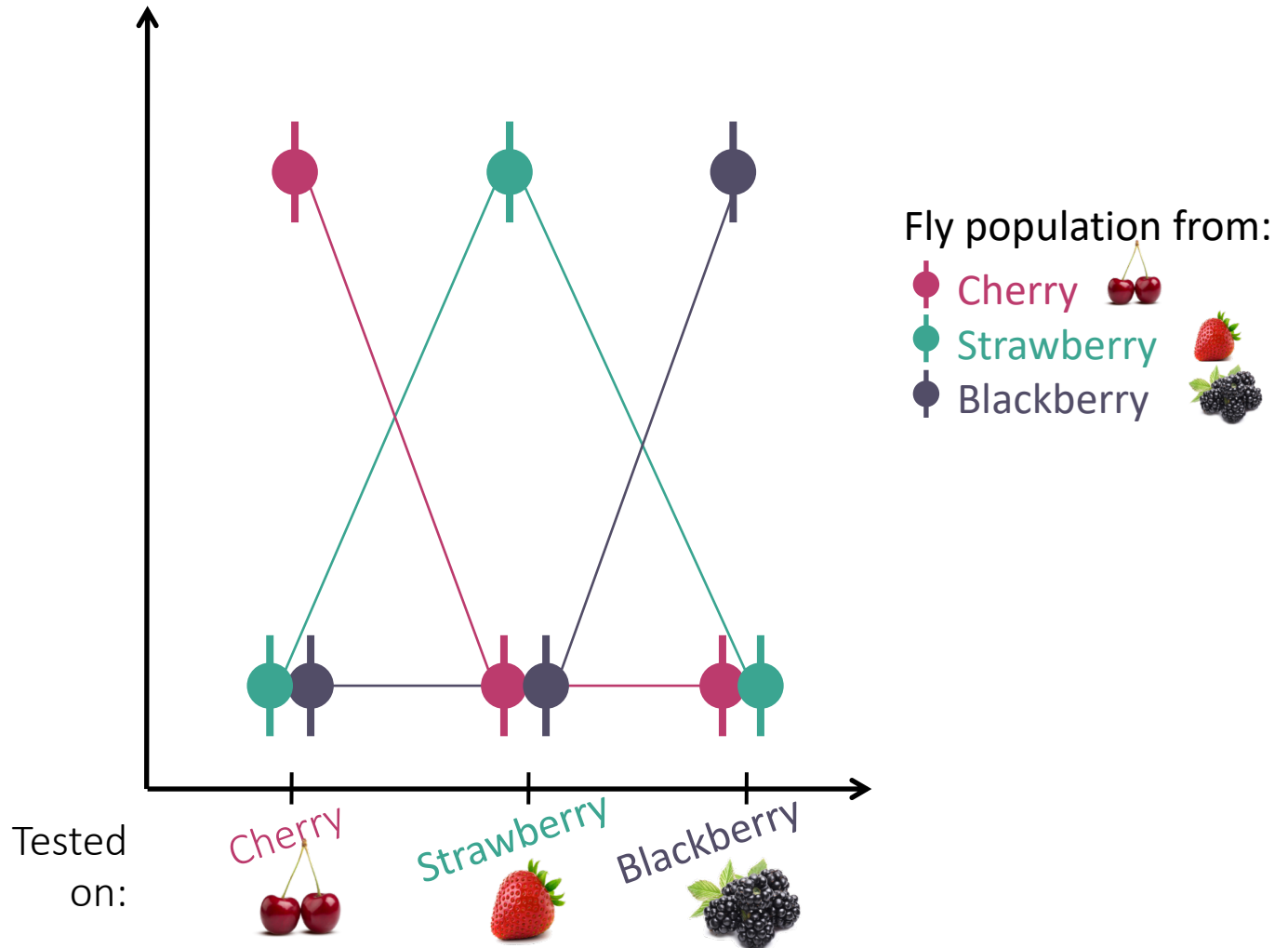
Expected mean fitness



Expectations: Local adaptation



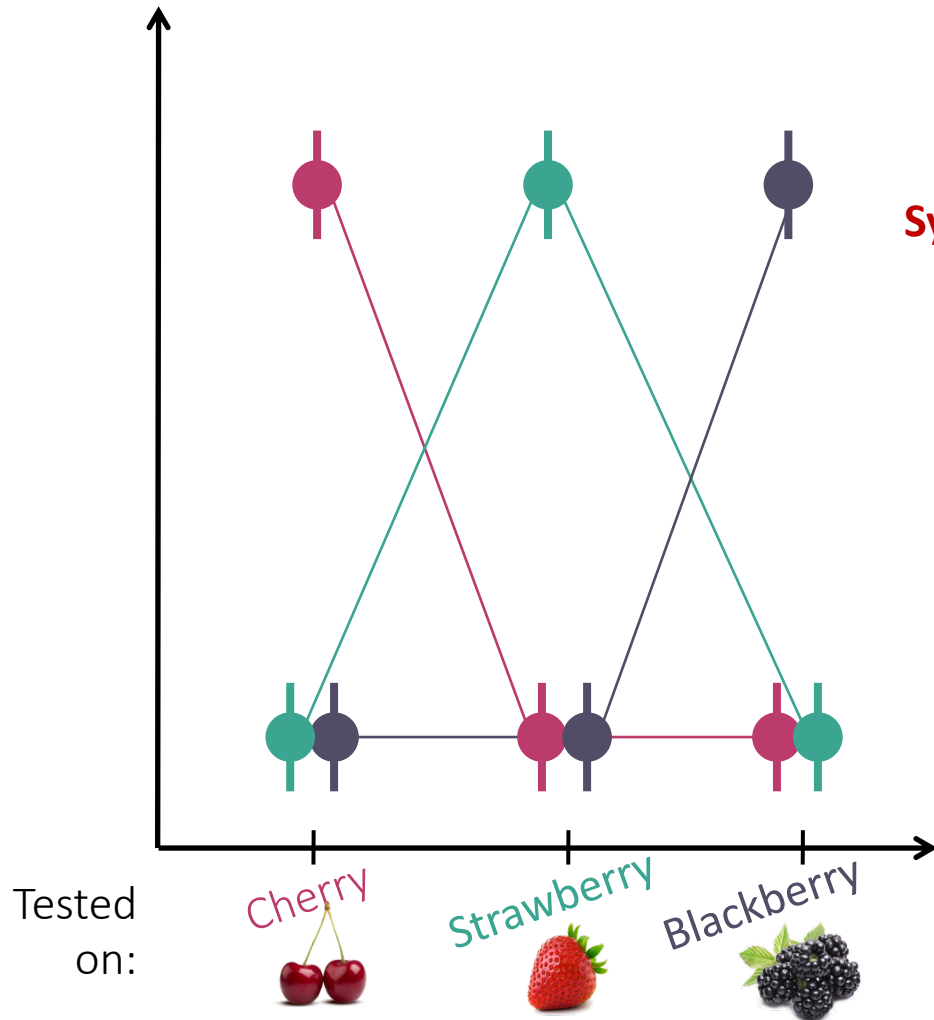
Expected mean fitness



Expectations: Local adaptation



Expected mean fitness



Statistical test:

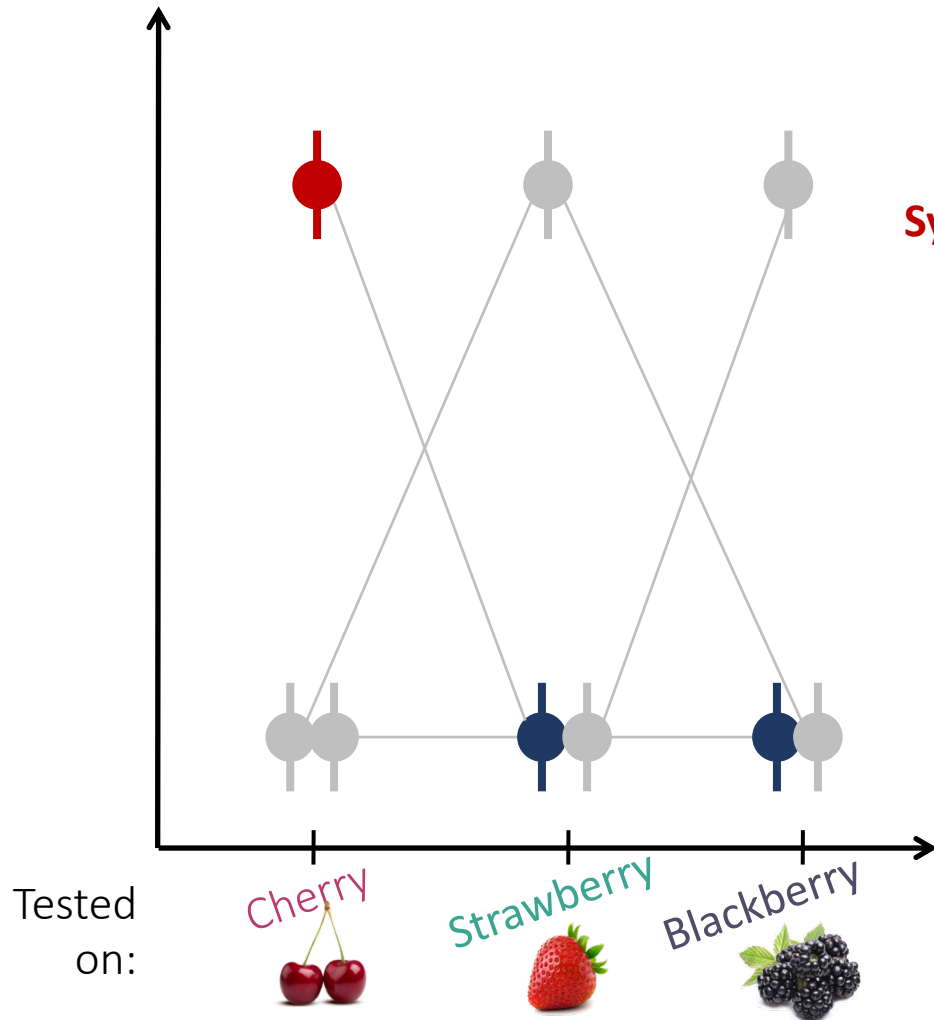
Sympatric vs. Allopatric

[Blanquart et al., 2013]

Expectations: Local adaptation



Expected mean fitness



Statistical test:

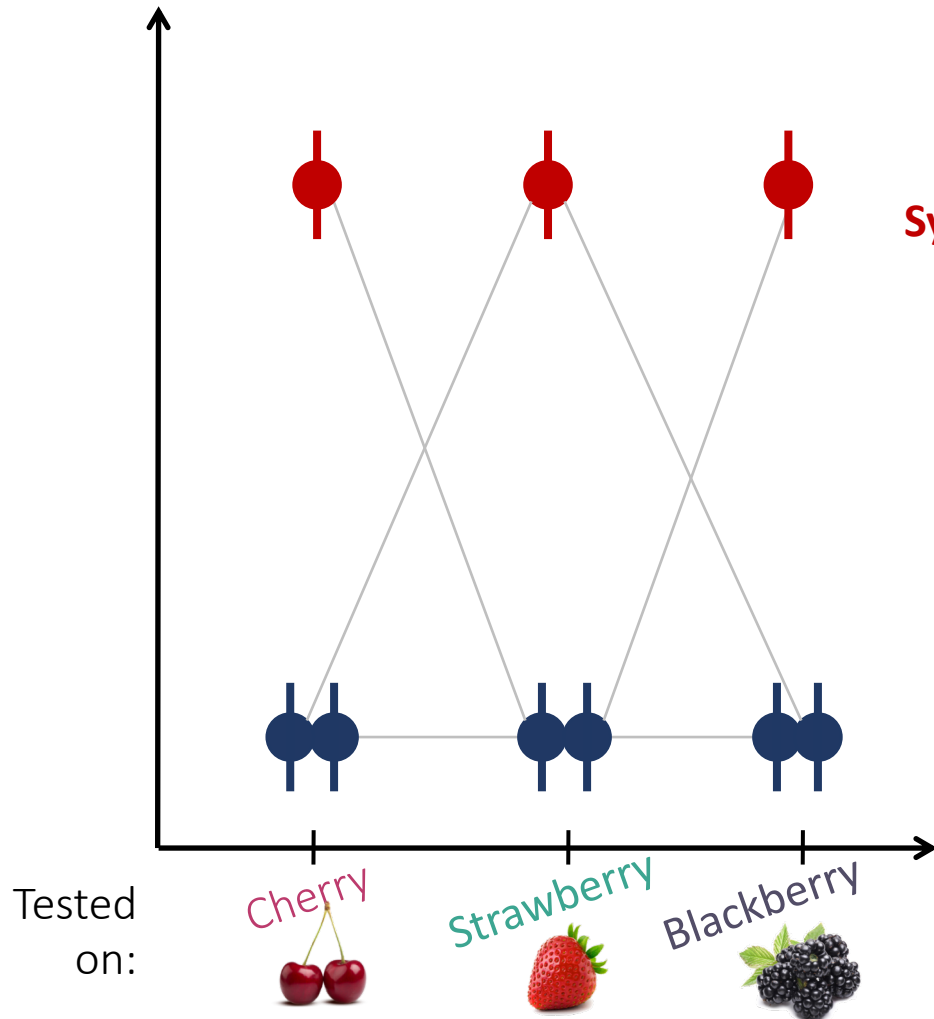
Sympatric vs. Allopatric

[Blanquart et al., 2013]

Expectations: Local adaptation



Expected mean fitness



Statistical test:

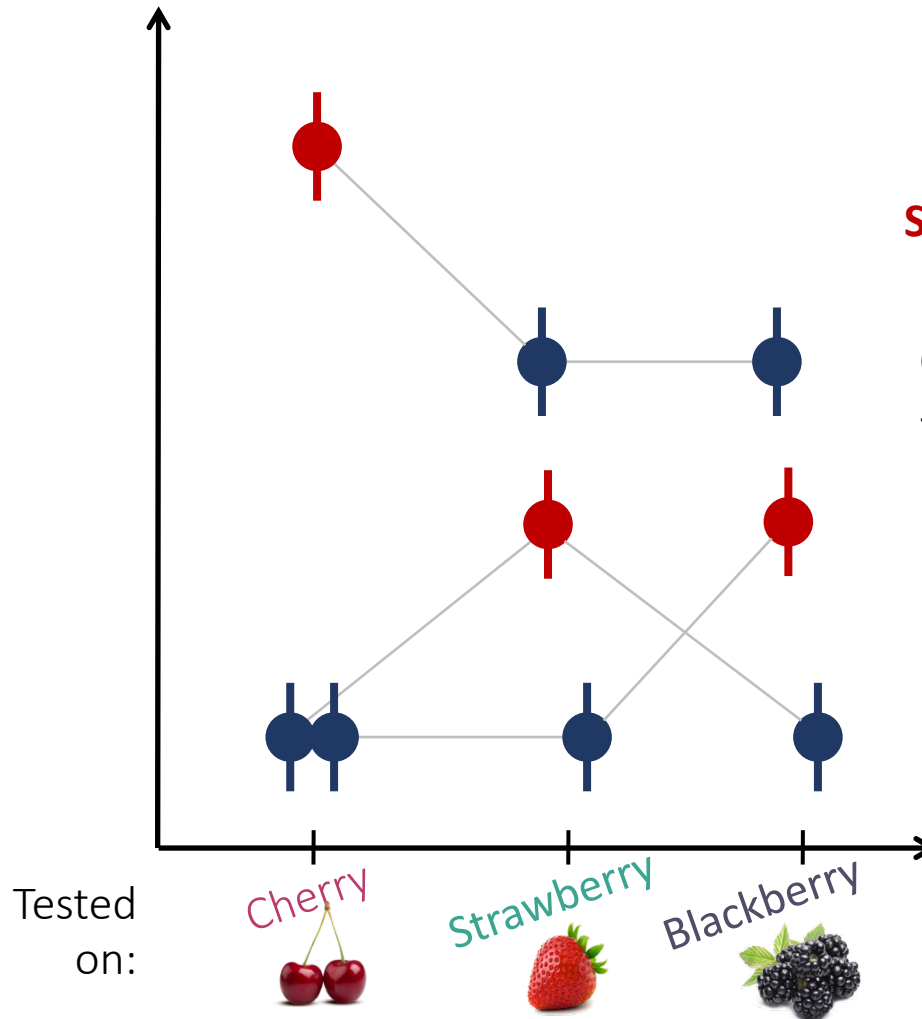
Sympatric vs. Allopatric

[Blanquart et al., 2013]

Expectations: Local adaptation



Expected mean fitness



Statistical test:

Sympatric vs. Allopatric

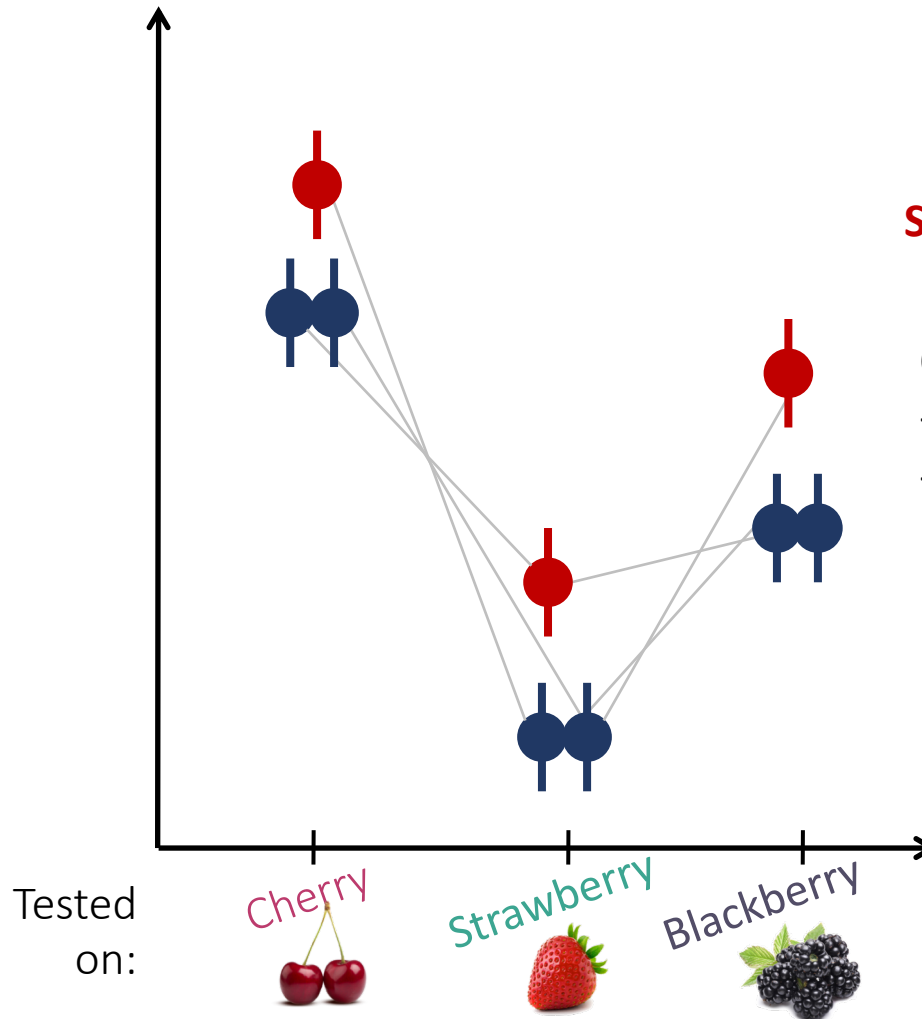
Control for the effect of:
- Genetic quality

[Blanquart et al., 2013]

Expectations: Local adaptation



Expected mean fitness



Statistical test:

Sympatric vs. Allopatric

Control for the effect of:

- Genetic quality
- Environment quality

[Blanquart et al., 2013]

Expectations: Local adaptation



$$\text{Trait}_{ijk} = SA_{ij} + \text{origin_fruit:test_fruit}_{ij} + \text{error}_{ijk}$$

Statistical test:

Sympatric vs. Allopatric

Control for the effect of:

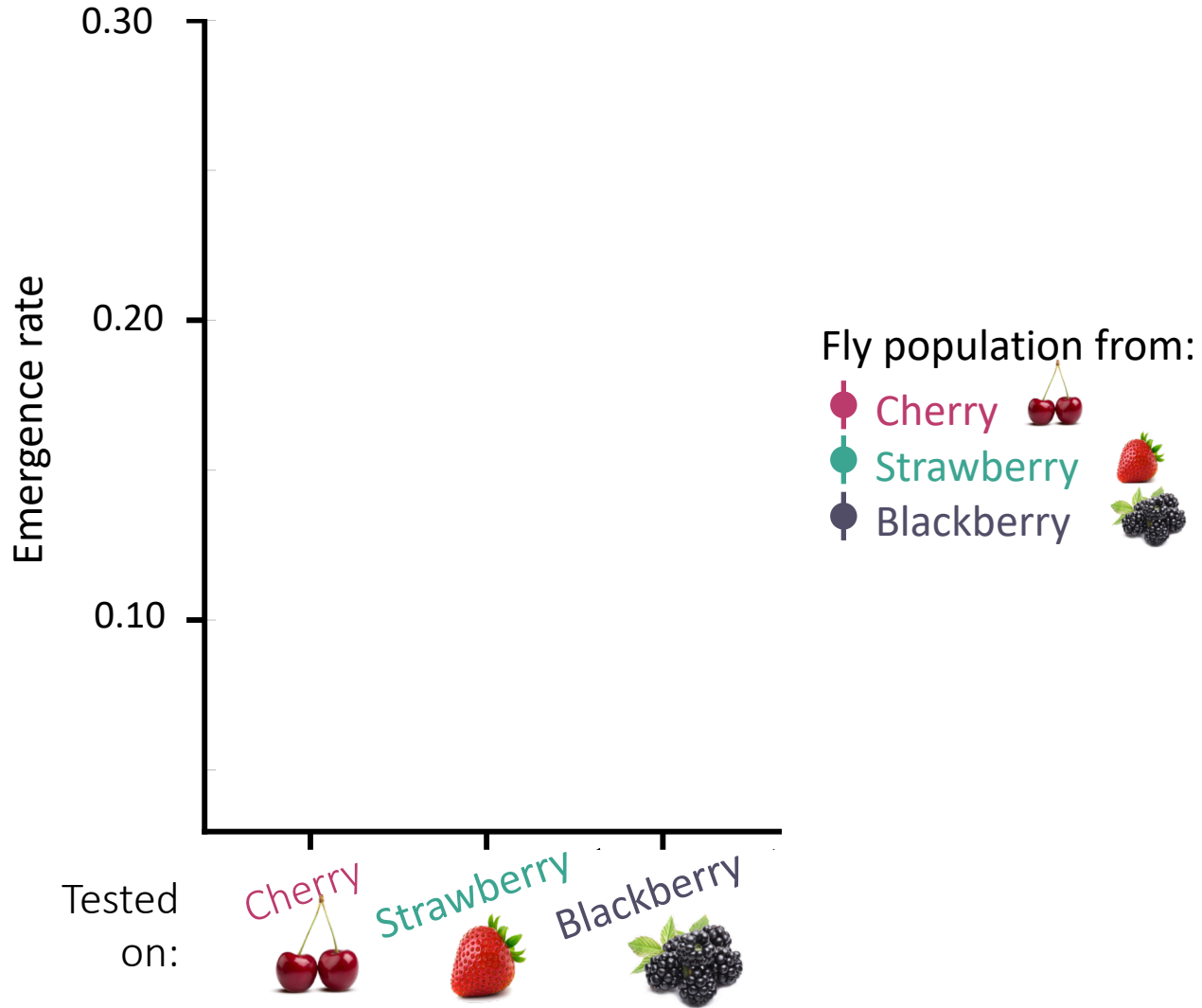
- Genetic quality
- Environment quality

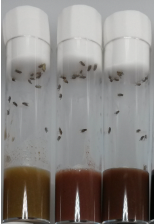
[Blanquart et al., 2013]

Emergence rate (G3)

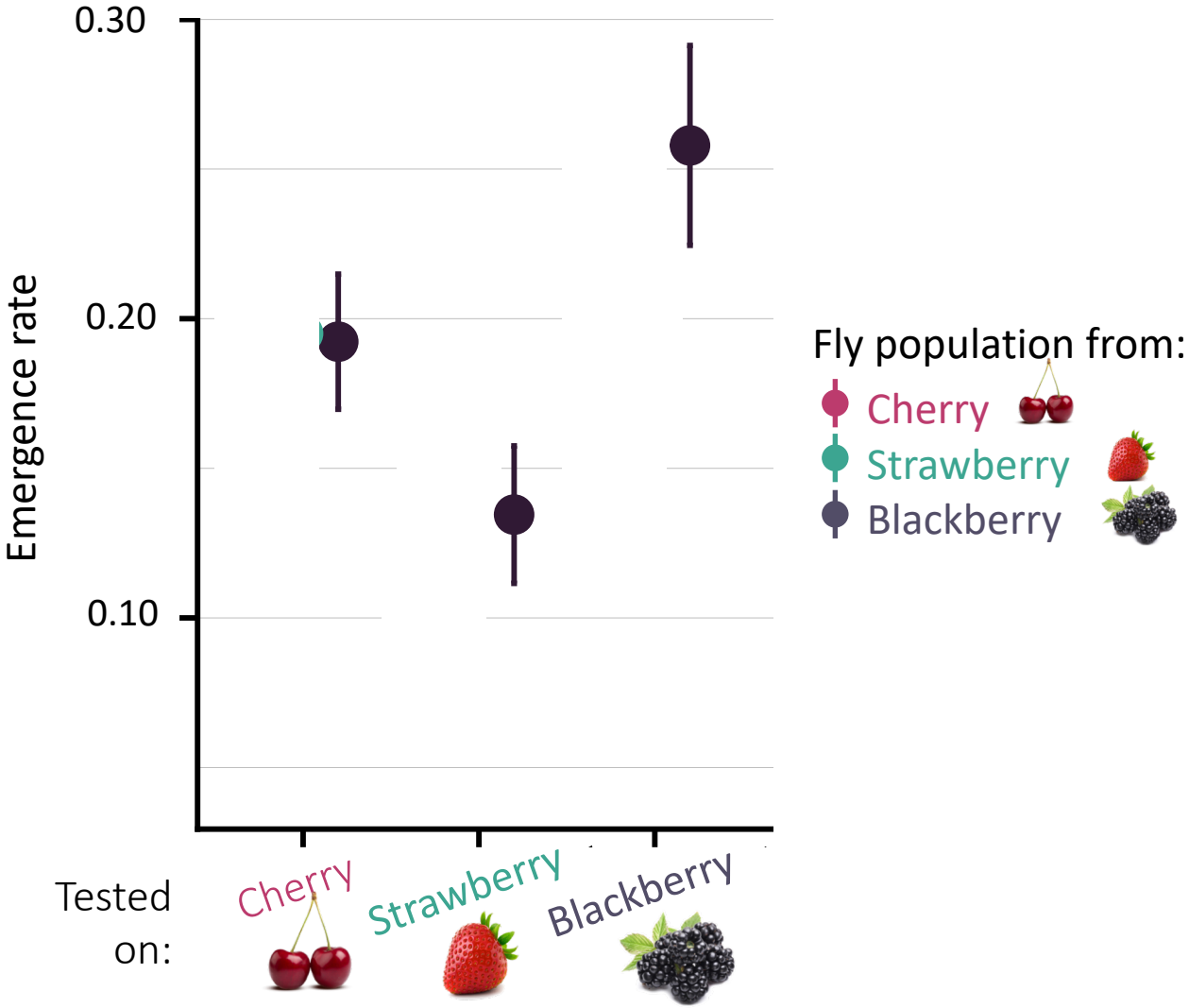


Emergence rate (G3)

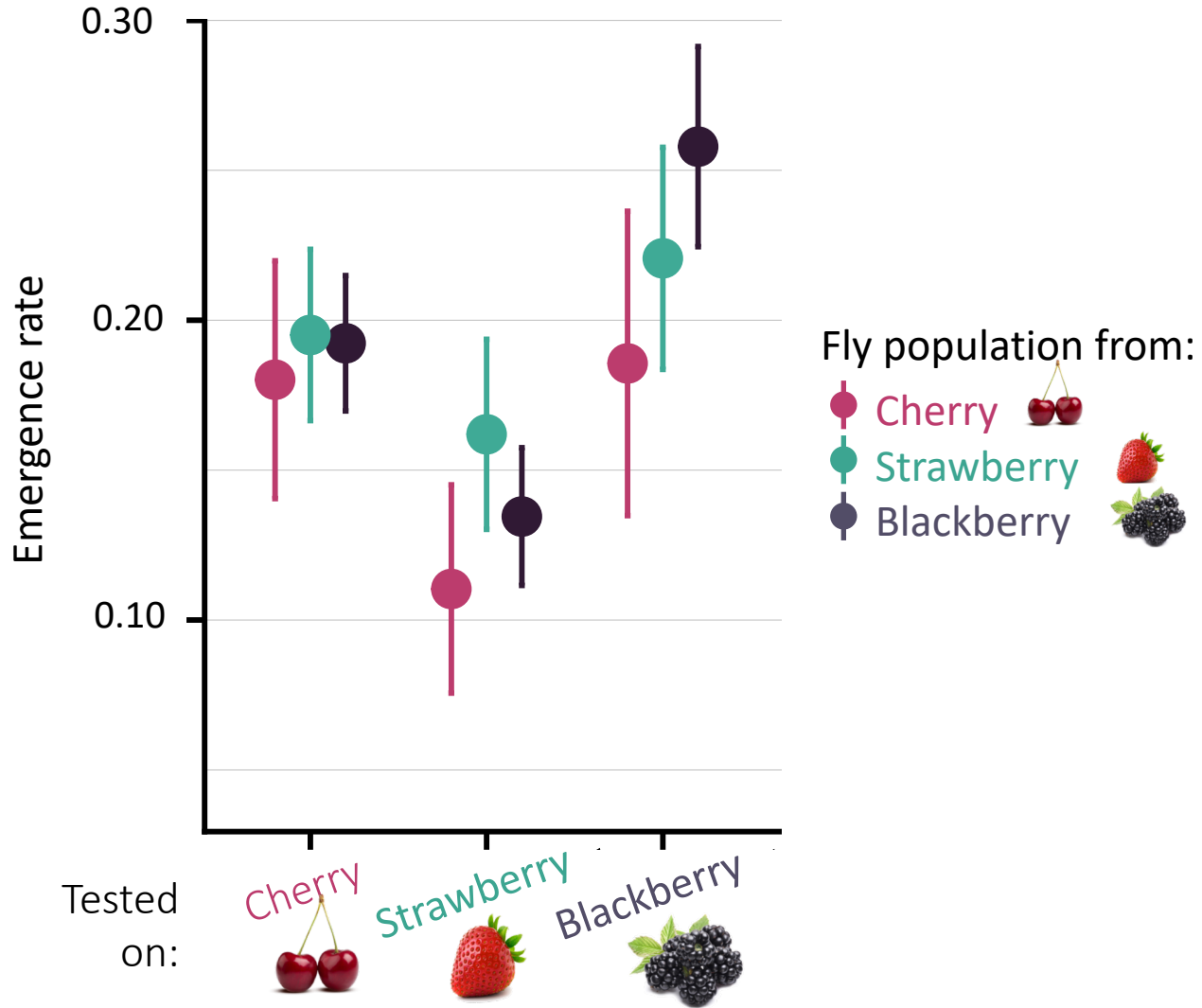
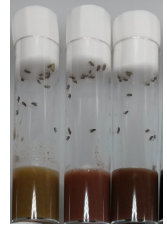


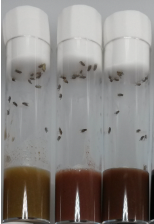


Emergence rate (G3)

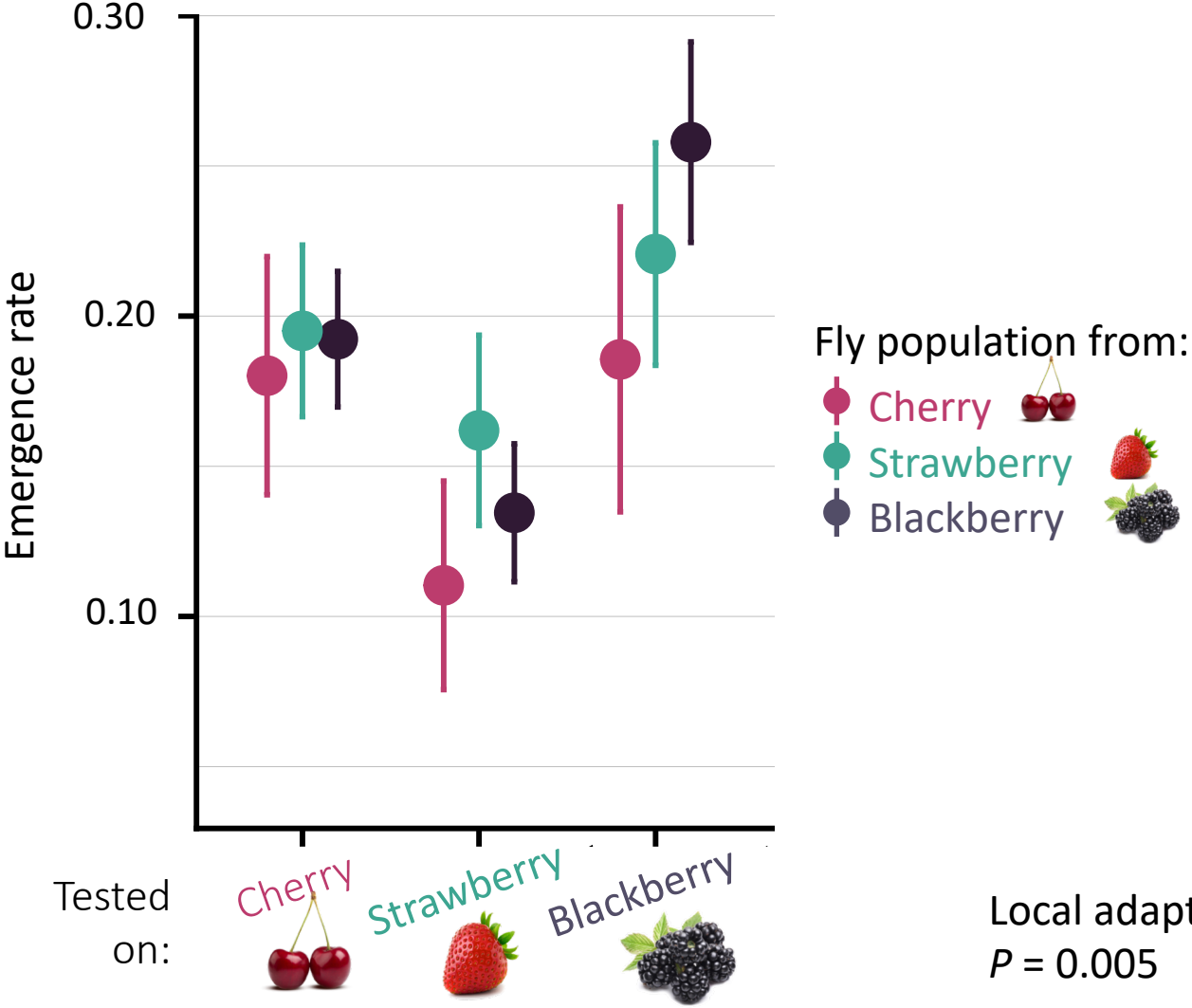


Emergence rate (G3)





Emergence rate (G3)

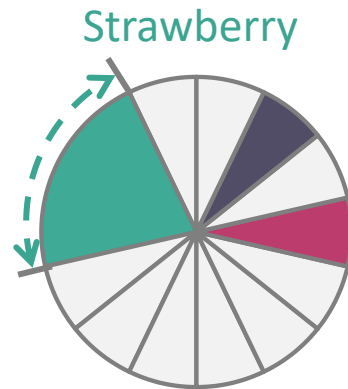


Local adaptation pattern
 $P = 0.005$

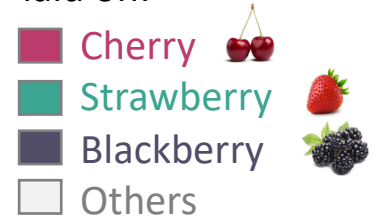
Expectations: Local oviposition preference



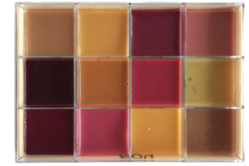
Fly populations from:



Expected
proportion of eggs
laid on:



Oviposition preference (G3)



Fly populations from:

Cherry

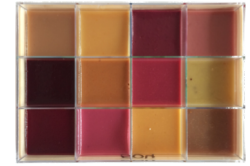
Strawberry

Blackberry

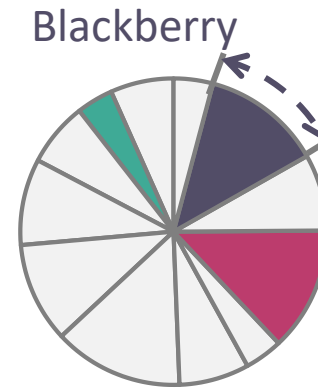
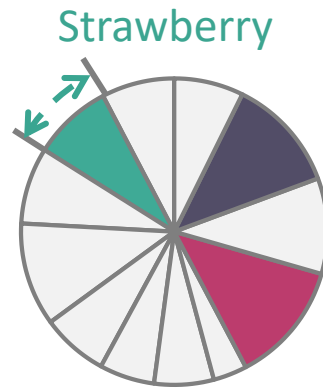
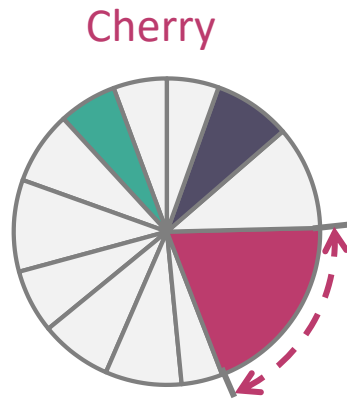
Proportion of eggs laid on:



Oviposition preference (G3)



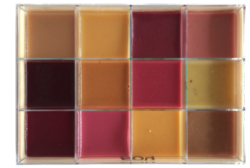
Fly populations from:



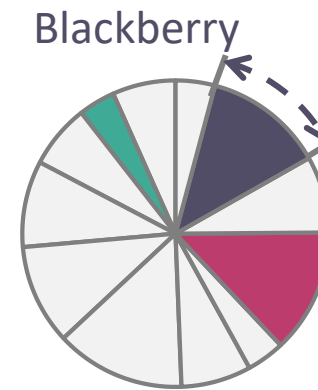
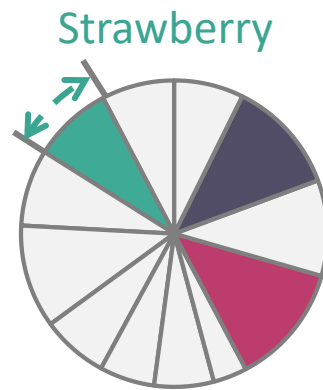
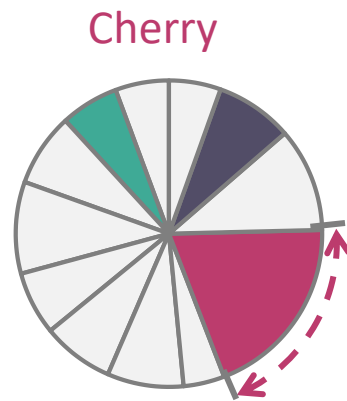
Proportion of eggs laid on:



Oviposition preference (G3)



Fly populations from:



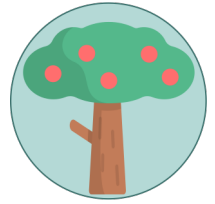
Proportion of eggs laid on:



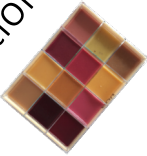








Local adaptation pattern

$P = 0.020$

Results (G3)



Wild populations	Number of eggs 	Emergence rate 	Oviposition preference 
  	 $P > 0.05$	 $P = 0.005$	 $P = 0.020$

Ongoing work: adaptive phenotypic plasticity?

Genetic + non-genetic effects

Generation 3: $\text{Trait}_{ijk} = \text{origin_fruit:test_fruit}_{ij} + \text{error}_{ijk}$

Ongoing work: adaptive phenotypic plasticity?

Genetic + non-genetic effects

Generation 3: $\text{Trait}_{ijk} = \text{origin_fruit:test_fruit}_{ij} + \text{error}_{ijk}$

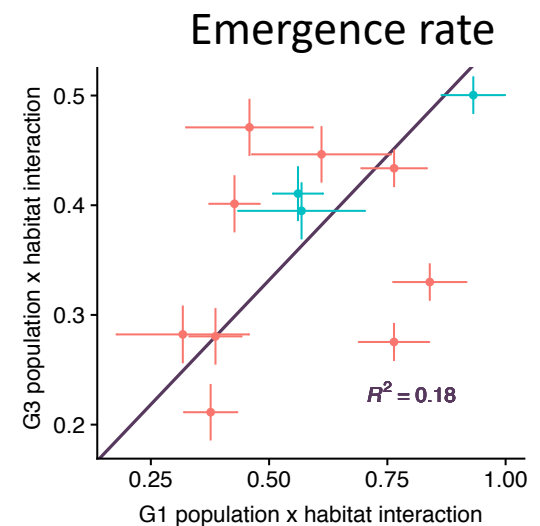
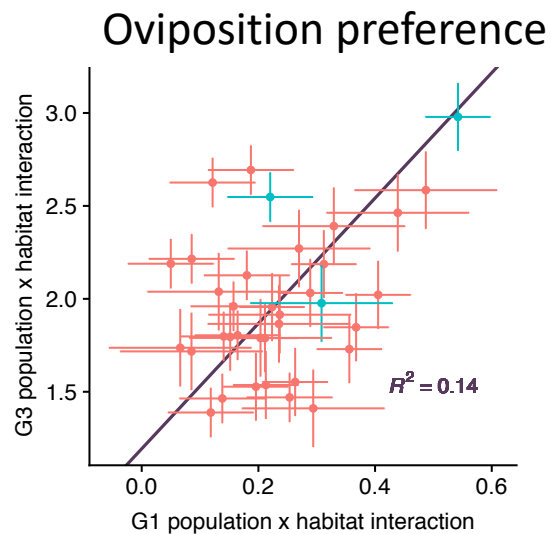
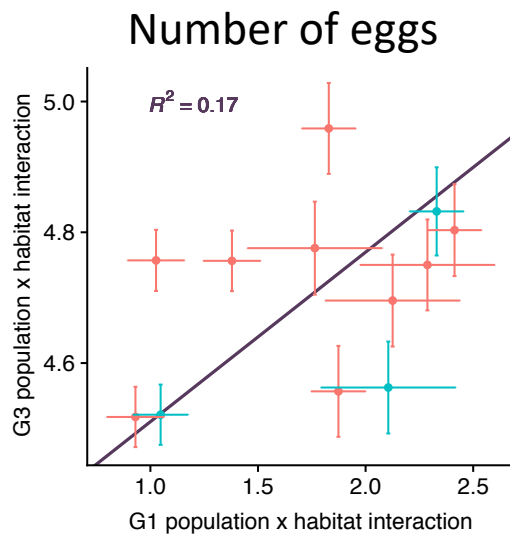
Generation 1: $\text{Trait}_{ijk} = \text{origin_fruit:test_fruit}_{ij} + \text{origin_fruit:test_fruit}_{ij} + \text{error}_{ijk}$

Ongoing work: adaptive phenotypic plasticity?

Genetic + non-genetic effects

Generation 3: $\text{Trait}_{ijk} = \text{origin_fruit}:\text{test_fruit}_{ij} + \text{error}_{ijk}$

Generation 1: $\text{Trait}_{ijk} = \text{origin_fruit}:\text{test_fruit}_{ij} + \text{origin_fruit}:\text{test_fruit}_{ij} + \text{error}_{ijk}$

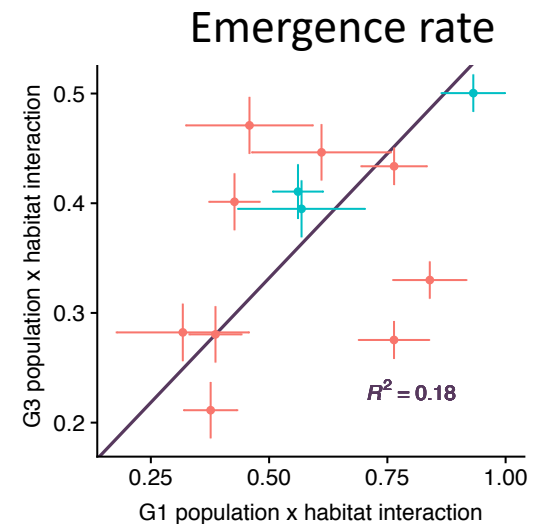
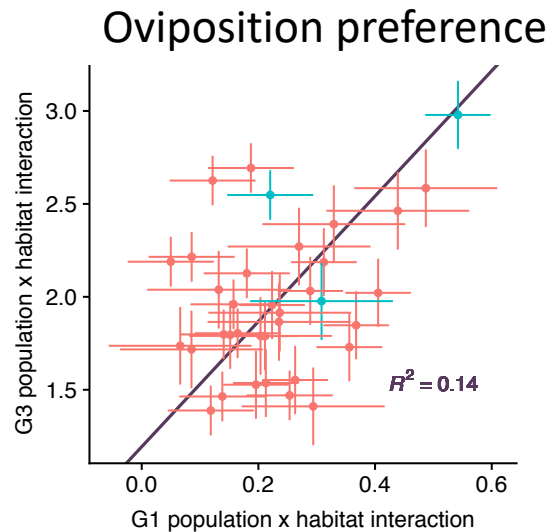
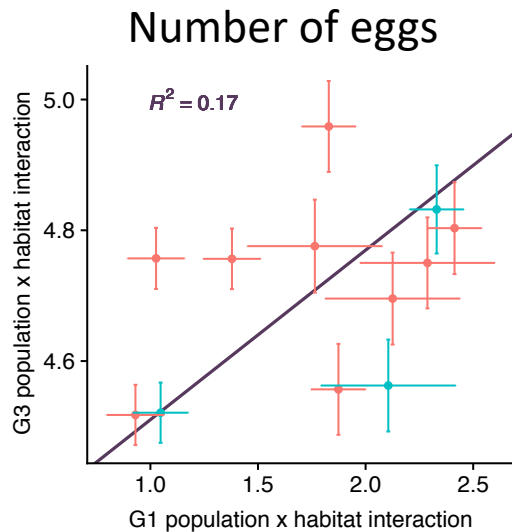


Ongoing work: adaptive phenotypic plasticity?

Genetic + non-genetic effects

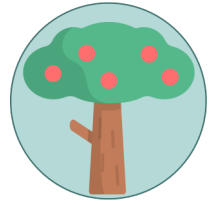
Generation 3: $\text{Trait}_{ijk} = \text{origin_fruit:test_fruit}_{ij} + \text{error}_{ijk}$

Generation 1: $\text{Trait}_{ijk} = \text{origin_fruit:test_fruit}_{ij} + \text{origin_fruit:test_fruit}_{ij} + \text{error}_{ijk}$

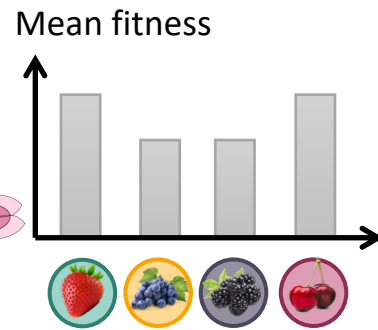
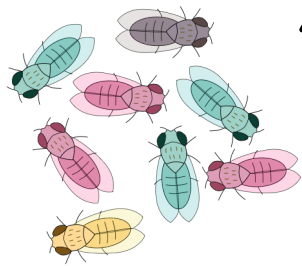


➔ no evidence of adaptive plasticity

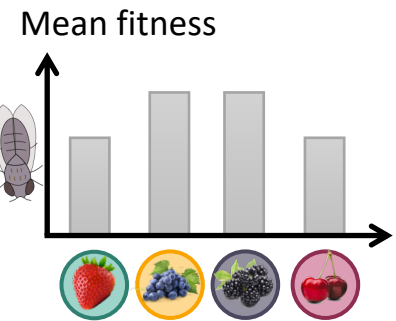
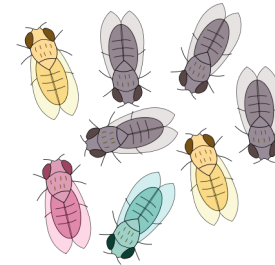
Conclusions



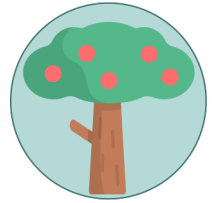
Summer



Fall



Perspectives

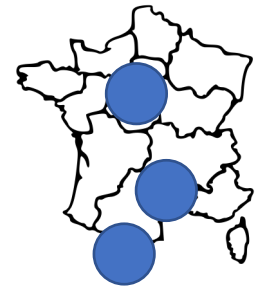


Basis of the adaptive traits:

Genetic architecture

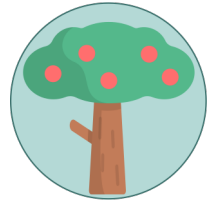
Role of microbiota

Transgenerational epigenetic mechanisms



USA: WI, CO

Perspectives

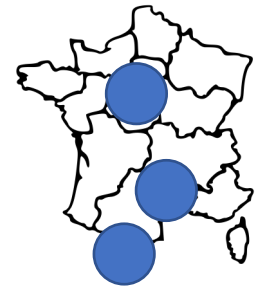


Basis of the adaptive traits:

Genetic architecture

Role of microbiota

Transgenerational epigenetic mechanisms



USA: WI, CO

Selective pressure:

chemical compounds



Acknowledgements



Laure Olazcuaga



Arnaud Estoup



Mathieu Gautier



Julien Foucaud



Anne Loiseau



Merci !



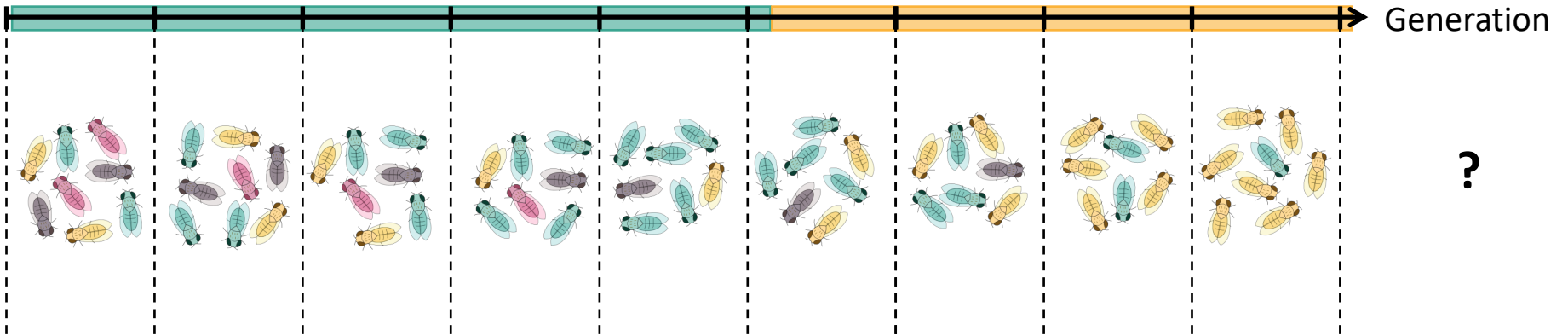
Transitional adaptation phase?



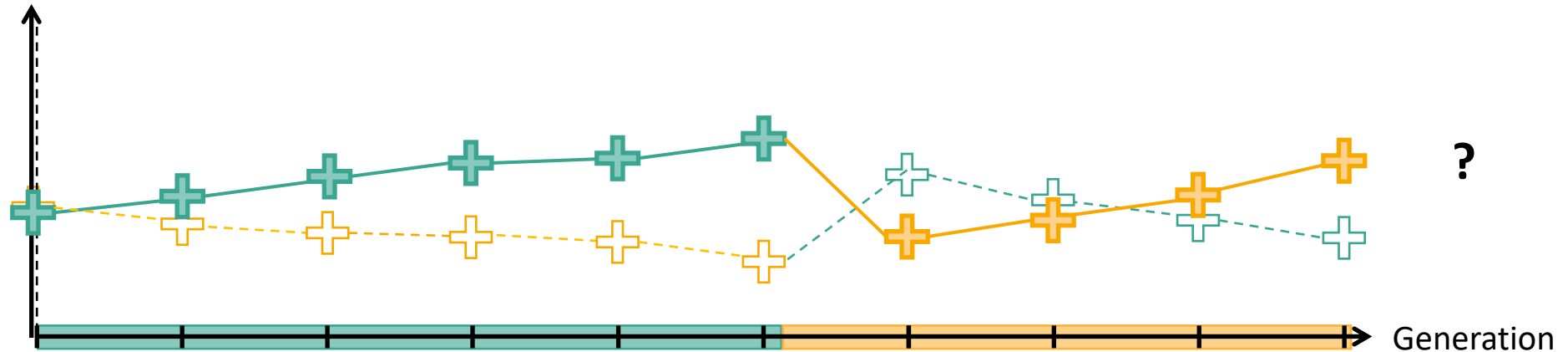
Summer



Fall



Mean fitness



Consequences of homogeneous environment?



Watsonville strawberry fields, USA, 2012

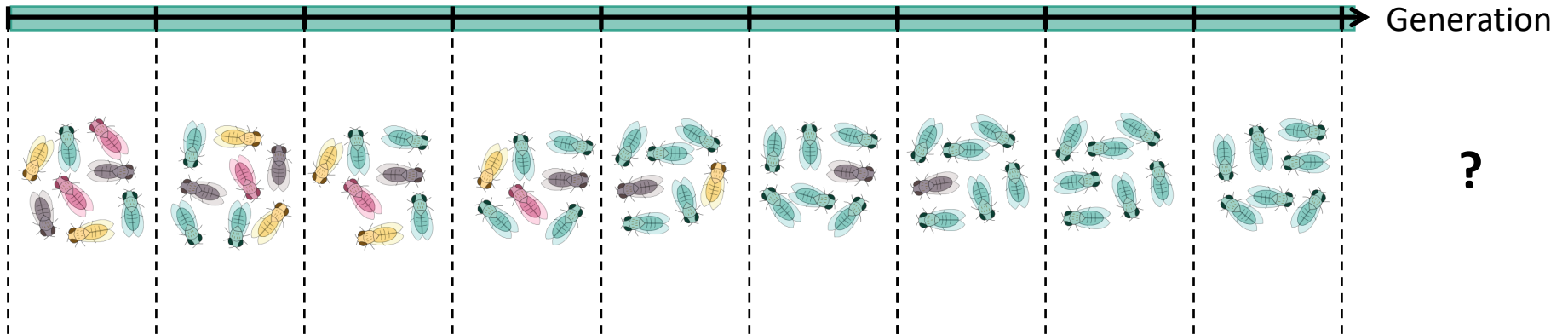
Consequences of homogeneous environment?



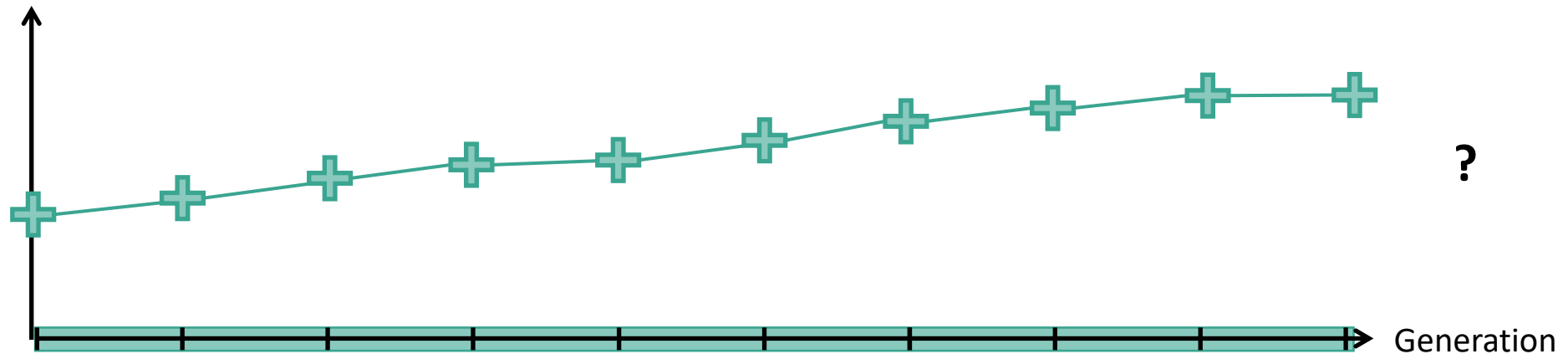
Summer



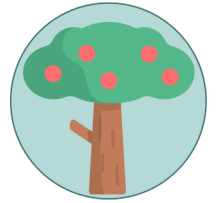
Fall



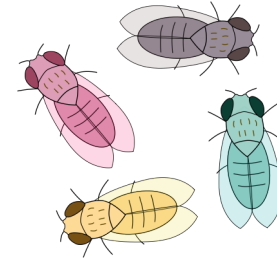
Mean fitness



Conclusion: generalist with polymorphism



- Phenotypic variability in fruit exploitation

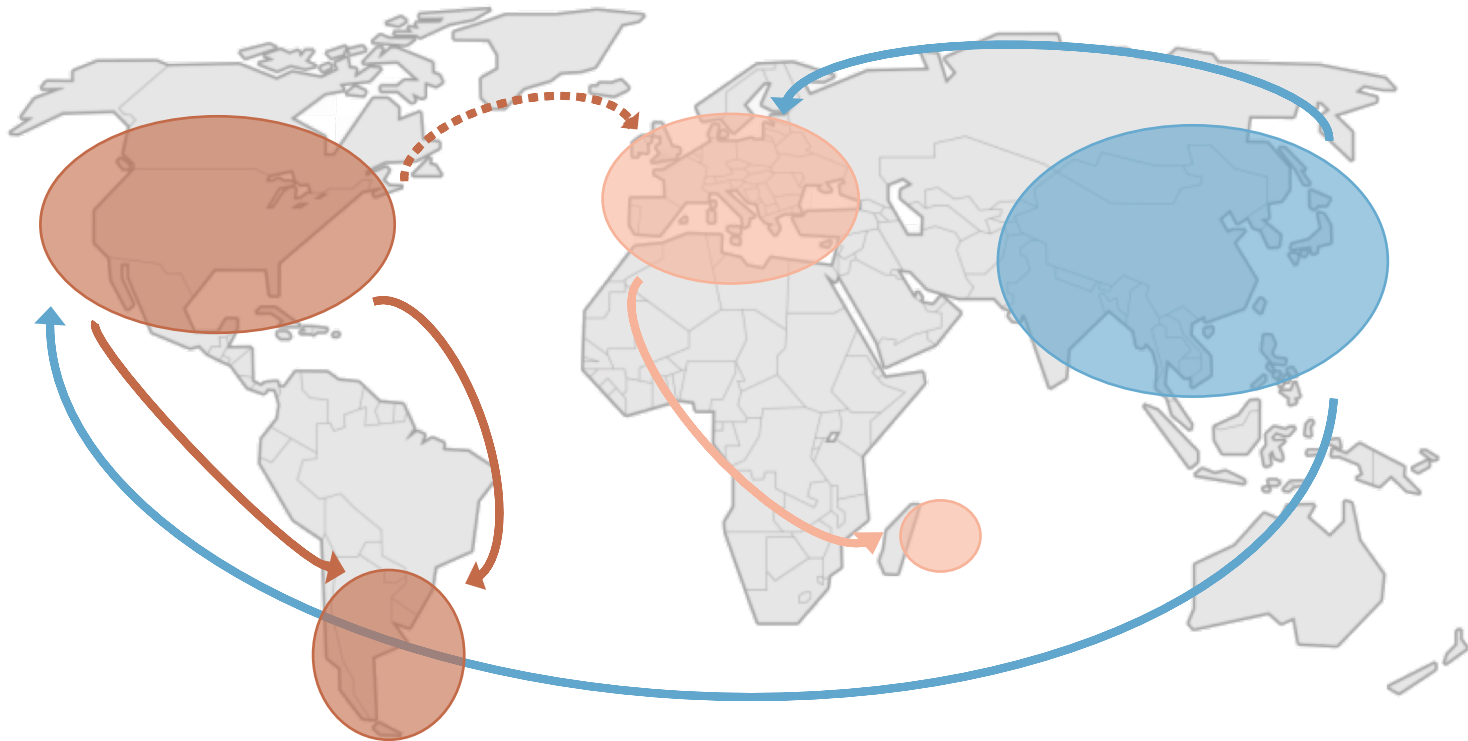


- Maintenance of genetic diversity throughout the year

- Does specialization evolve in homogeneous environments?

Drosophila suzukii

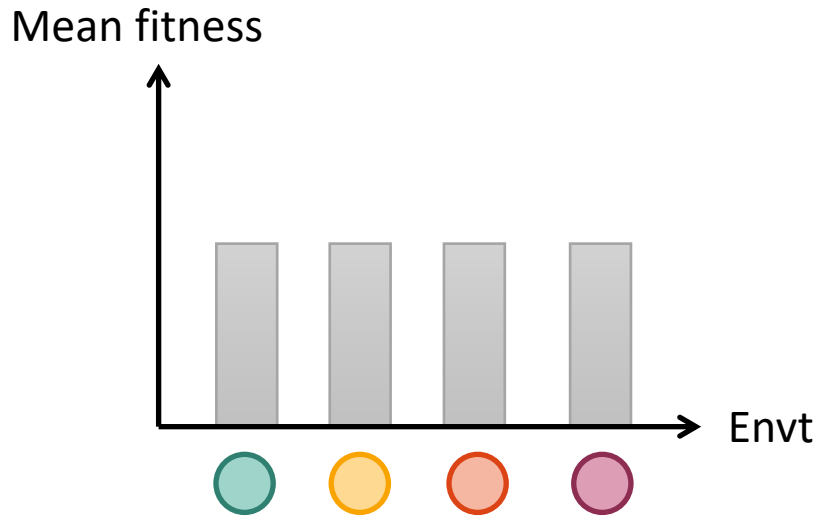
Invasive species



[Frainout et al., 2017; Andreatza et al., 2017]

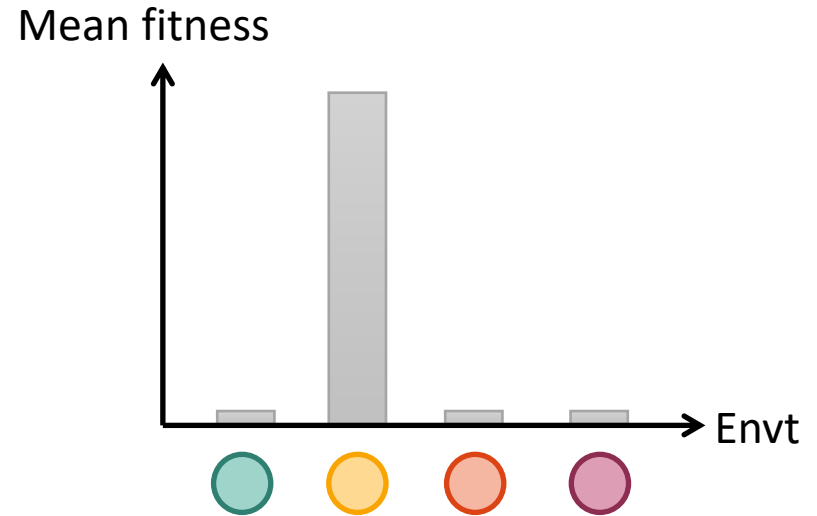
Population comparisons

Drosophila yakuba
(Mainland Africa)



Rotten fruits

Drosophila yakuba
(Mayotte)

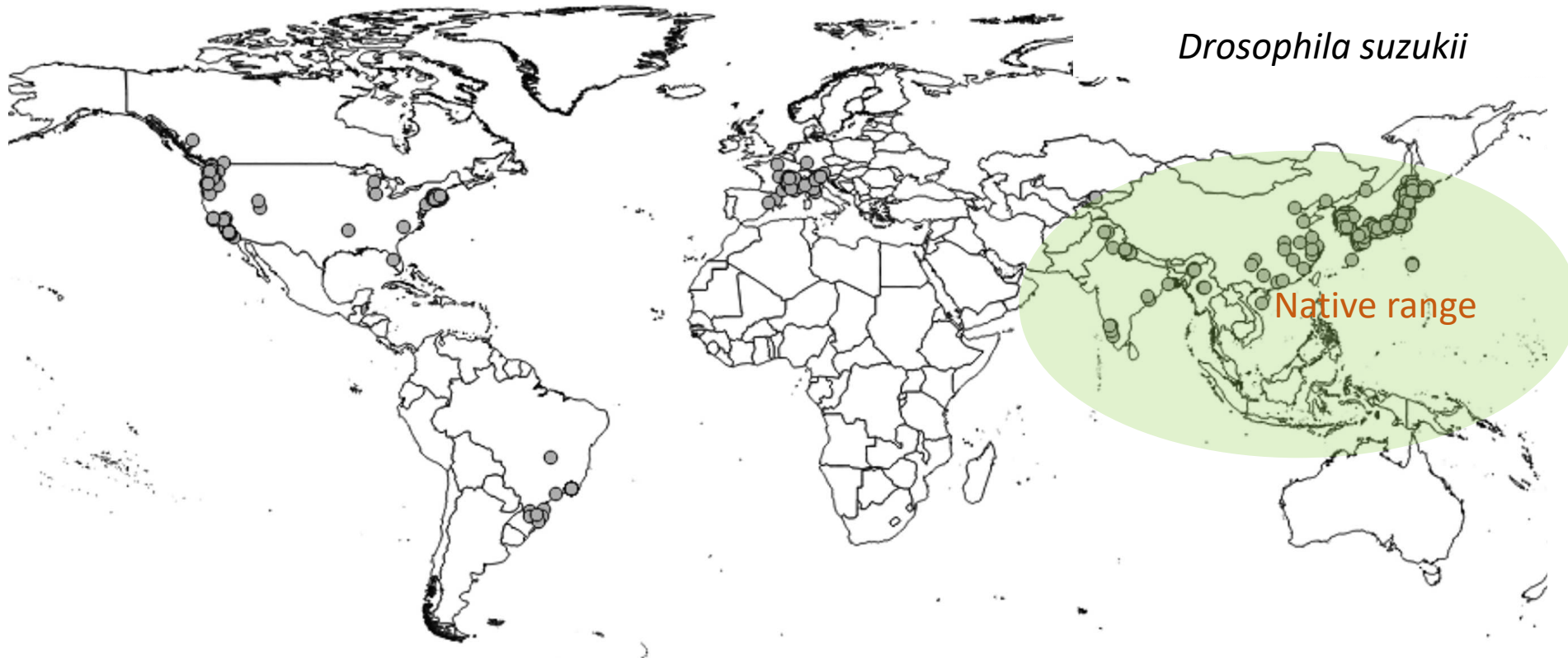


Nono fruit

Distribution de *D. suzukii*



Drosophila suzukii

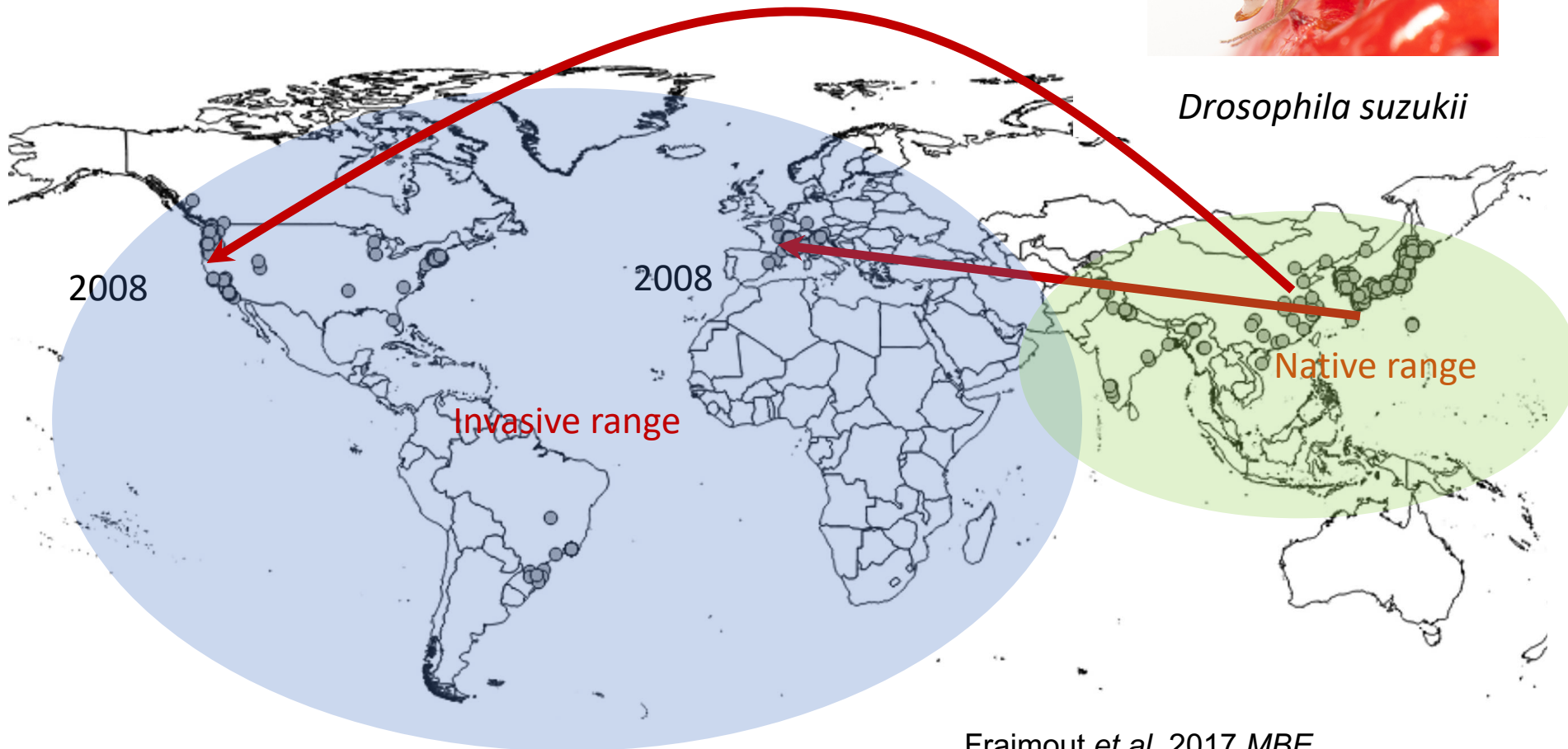


Frainout *et al.* 2017 *MBE*
Andreazza *et al.* 2017 *Neotrop. Entomol.*

Distribution de *D. suzukii*



Drosophila suzukii



2008

2008

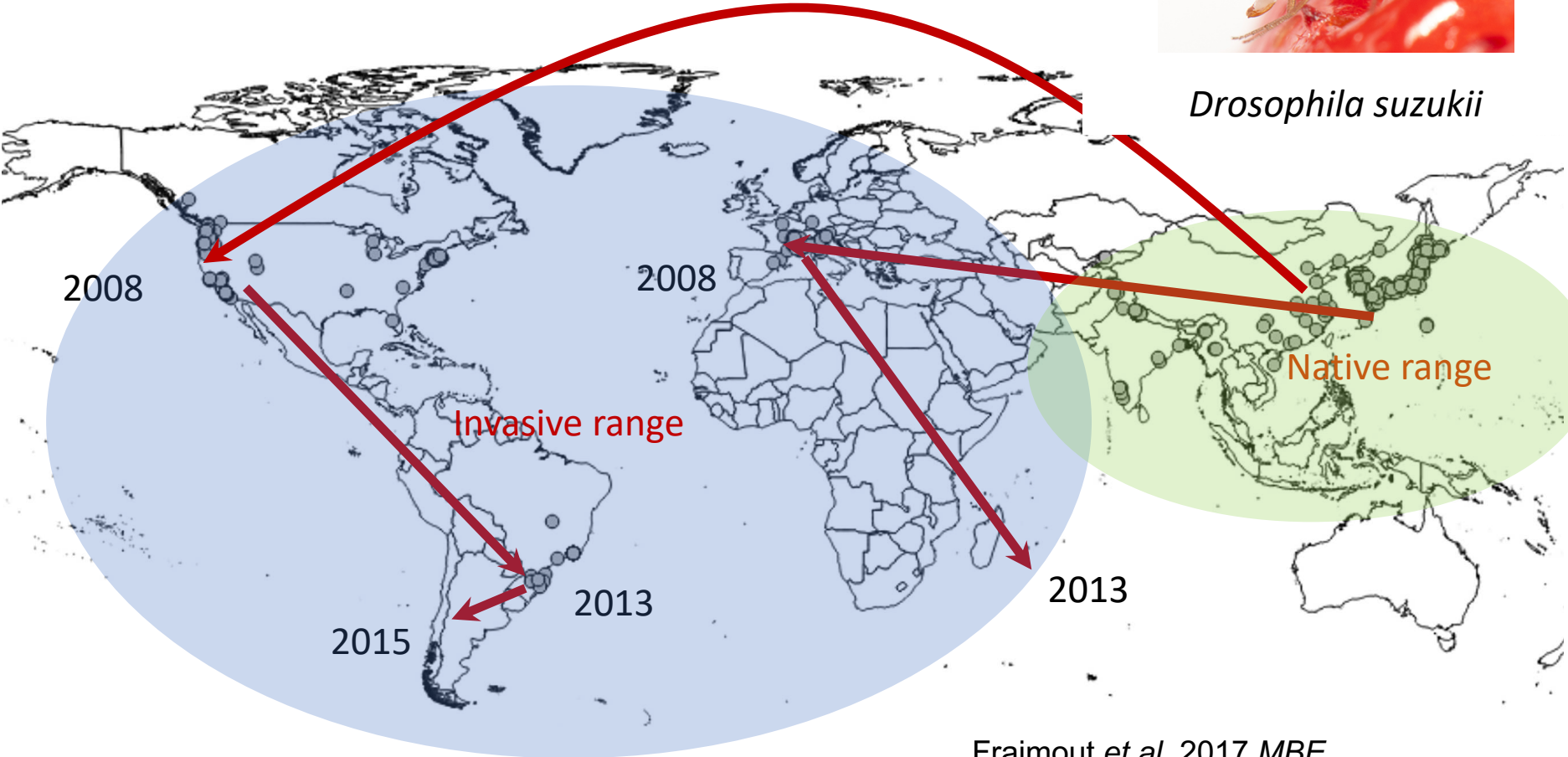
Invasive range

Native range

Distribution de *D. suzukii*



Drosophila suzukii



Frainout *et al.* 2017 *MBE*
Andreazza *et al.* 2017 *Neotrop. Entomol.*

Generalist populations



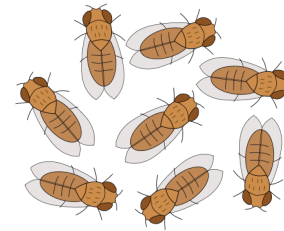
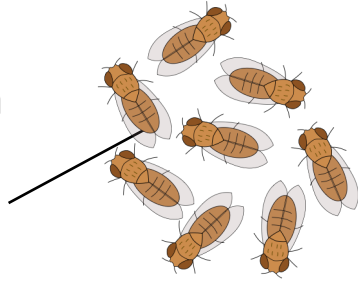
Summer



Fall

Without
polymorphism

Generalist
genotype



Generalist genotypes

OR

With
polymorphism

Generalist populations

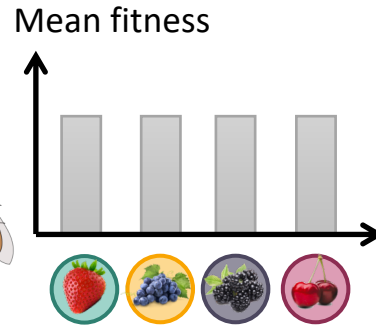
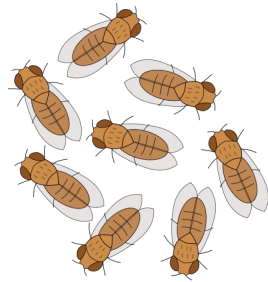


Summer

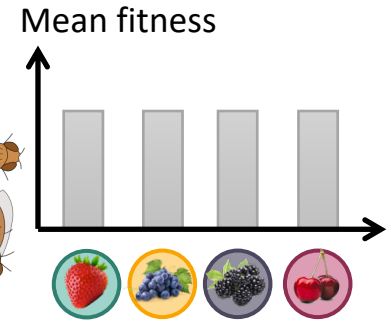
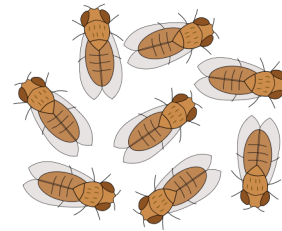


Fall

Without
polymorphism



Generalist genotypes



OR

With
polymorphism

Generalist populations

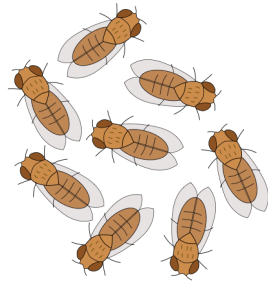


Summer

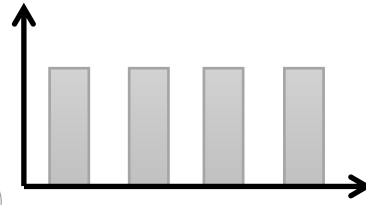


Fall

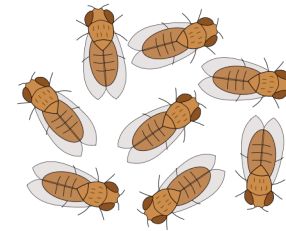
Without
polymorphism



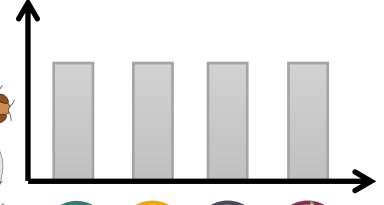
Mean fitness



Generalist genotypes

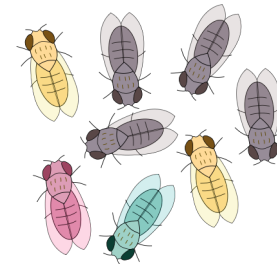
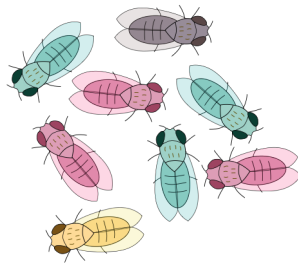


Mean fitness



OR

With
polymorphism



Pool of specialist genotypes

Generalist populations

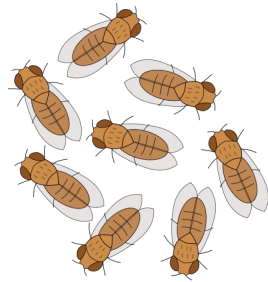


Summer

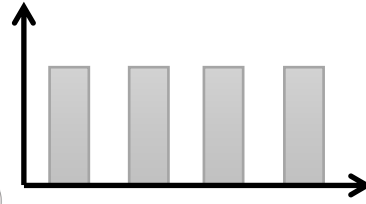


Fall

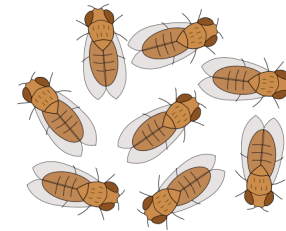
Without
polymorphism



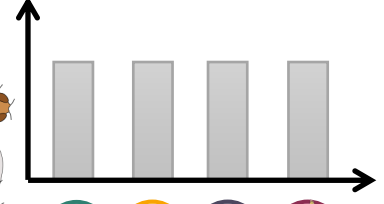
Mean fitness



Generalist genotypes

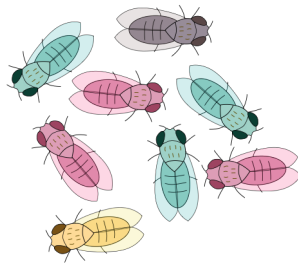


Mean fitness

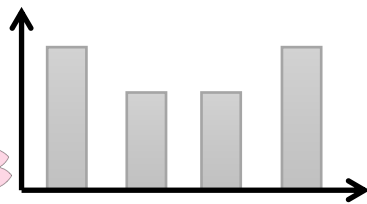


OR

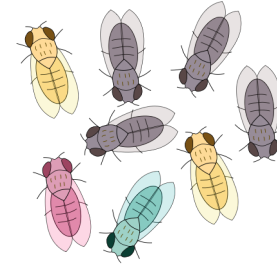
With
polymorphism



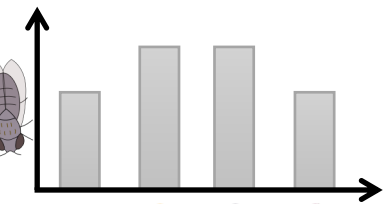
Mean fitness



Pool of specialist genotypes



Mean fitness



Heterogenous selection in natural populations?

Origin and maintenance of biodiversity

Microevolution → macroevolution

Epidemiology, biological invasions