TOPIC 3. **Plant breeding systems and pollen dispersal**

Reproductive Barriers

Sílvia Castro, Mariana Castro, João Loureiro

Reproductive barriers

… the origin of the species

Speciation, the process by which new species form, has two requirements:

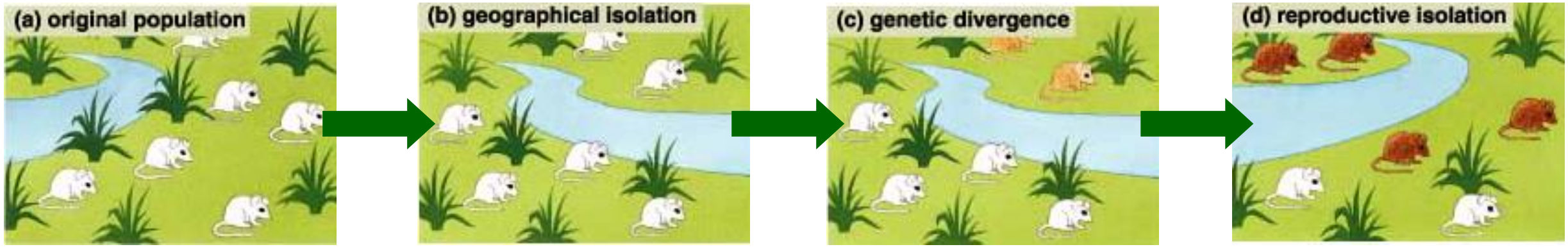
- Reproductive isolation of populations (gene flow sufficiently reduced)
- Genetic divergence (divergent evolution)

Two main modes:

- Allopatric
- Sympatric

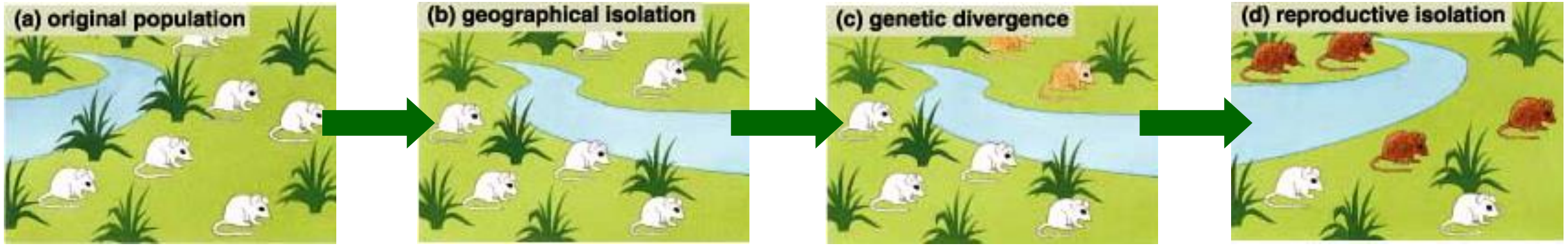
Reproductive barriers

Allopatric speciation Divergence occurs in geographic isolation

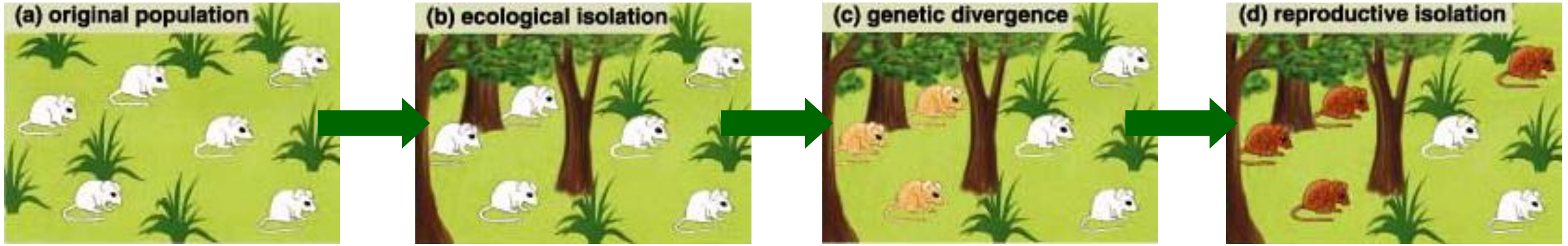


Reproductive barriers

Allopatric speciation Divergence occurs in geographic isolation



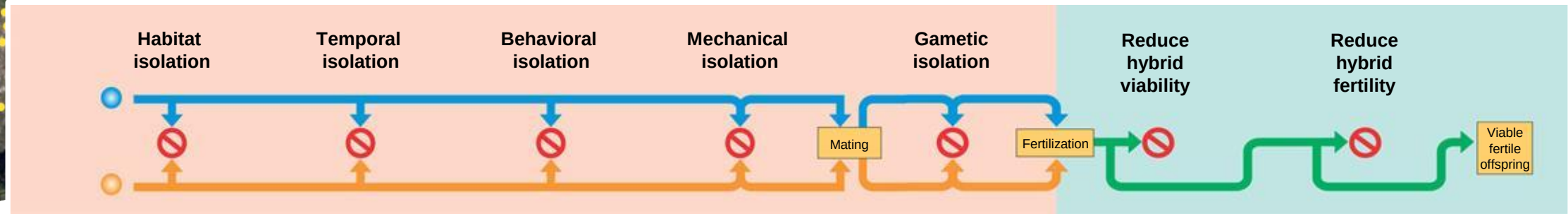
Sympatric speciation Divergence occurs despite lack of geographic isolation



Reproductive barriers
… when growing in sympatry

Two main barriers:

- Pre-zygotic barriers (pre-pollination and post-pollination)
- Post-zygotic barriers



Reproductive barriers

… when growing in sympatry

Anthoxanthum alpinum (2*x*, 4*x*)

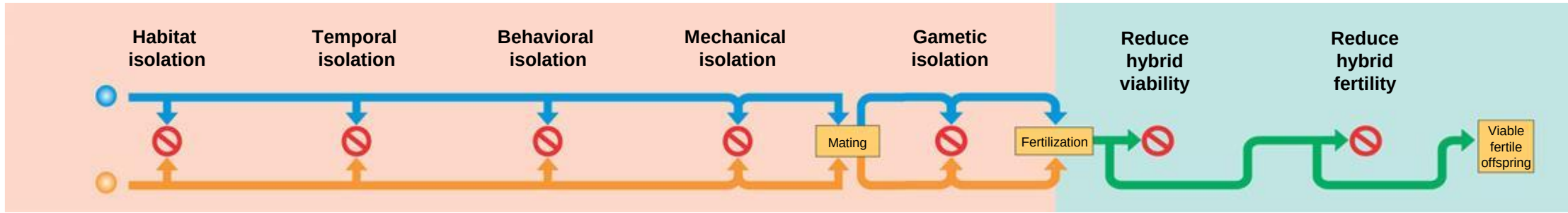
Gymnadenia conopsea (4*x*, 8*x*)

Heuchera grossulariifolia (2*x*, 4*x*)

Pedicularis species

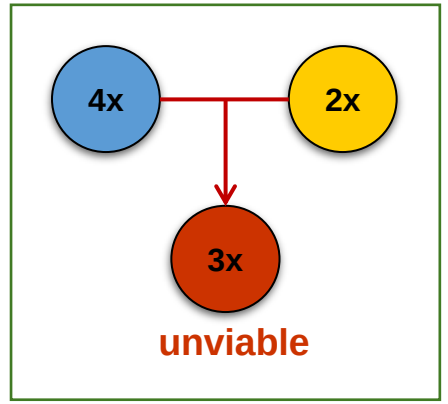
Chamerion angustifolium (2*x*, 4*x*)

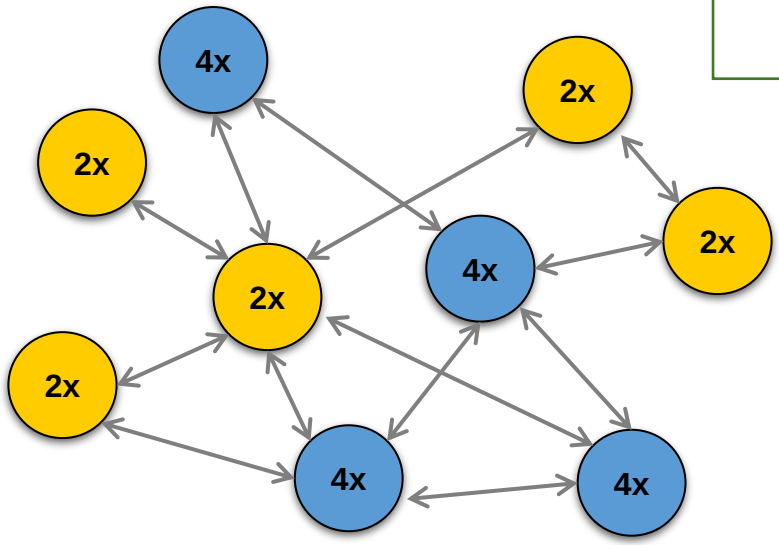
Mercurialis annua (2*x*, 6*x*)

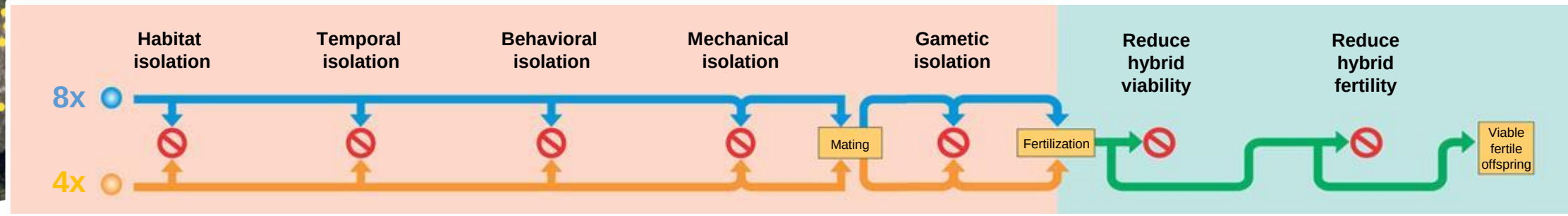


Reproductive barriers

… when growing in sympatry

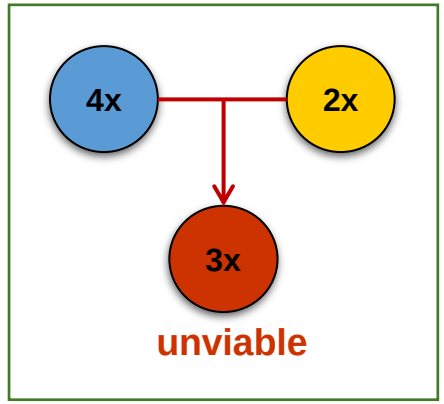


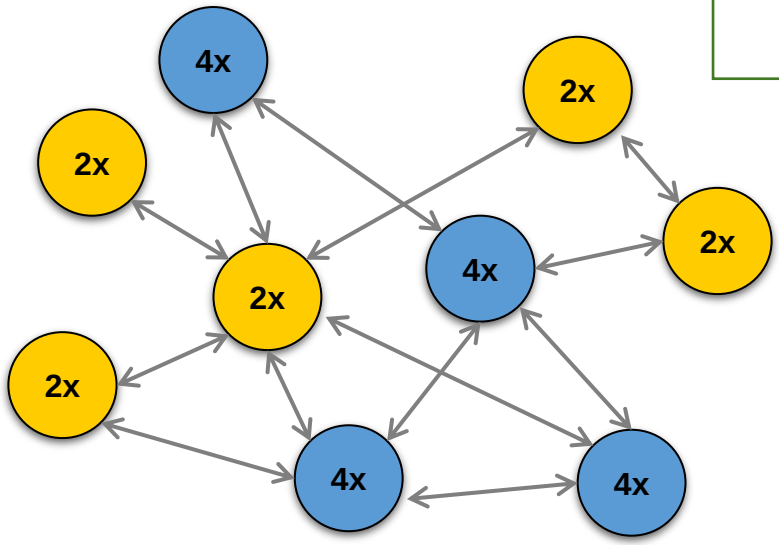


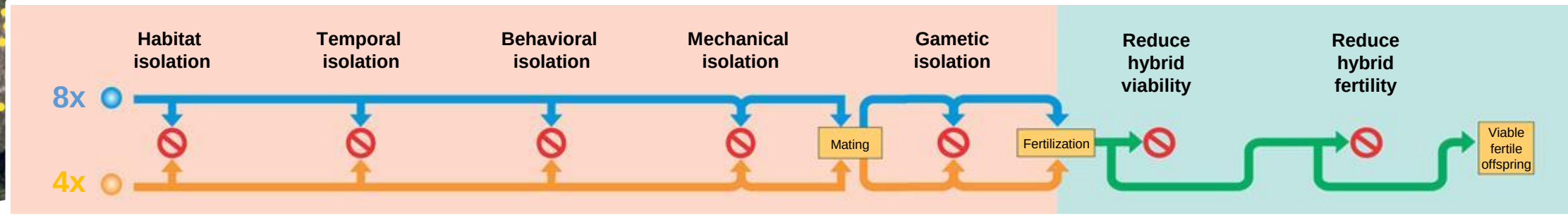


Reproductive barriers
… when growing in sympatry

- **frequency dependent selection** will eliminate the minority cytotype (Levin 1983)

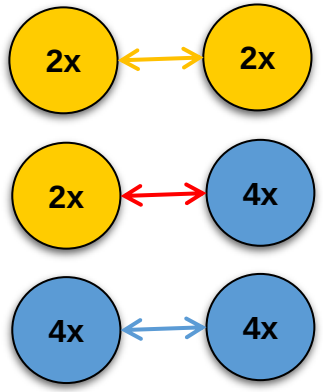


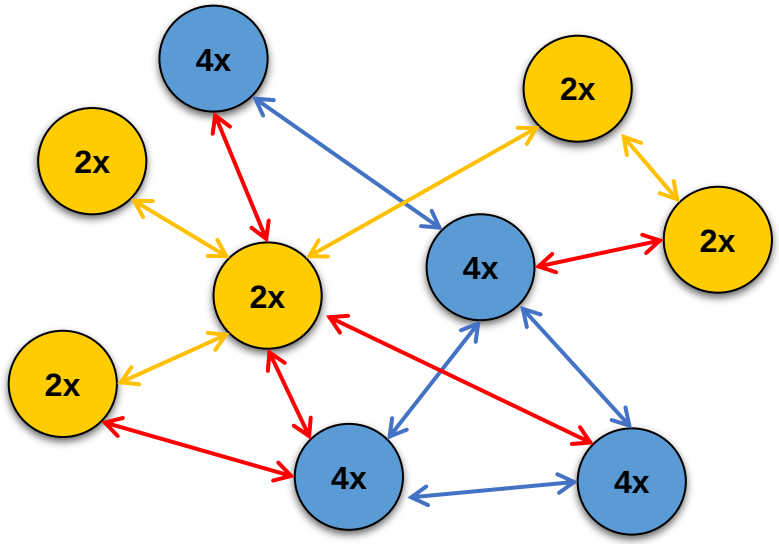


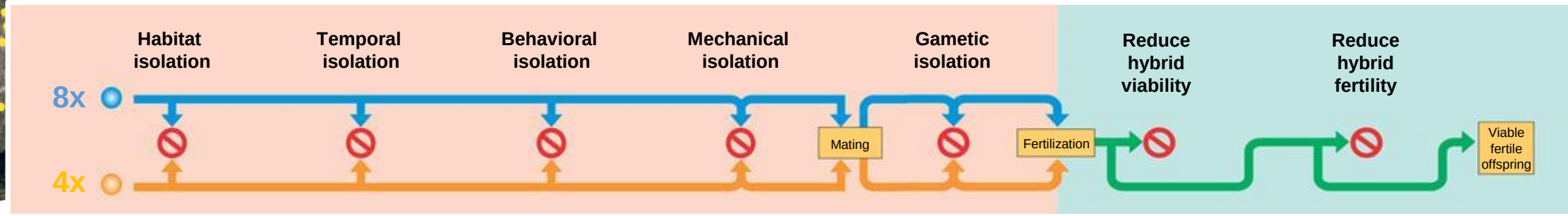


Reproductive barriers

… when growing in sympatry







Gladiolus communis L. (Iridaceae)

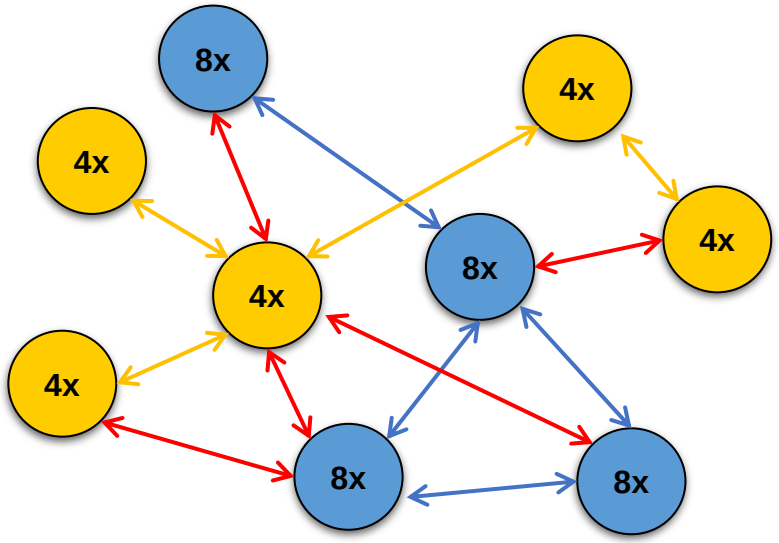
FLOWERLAB

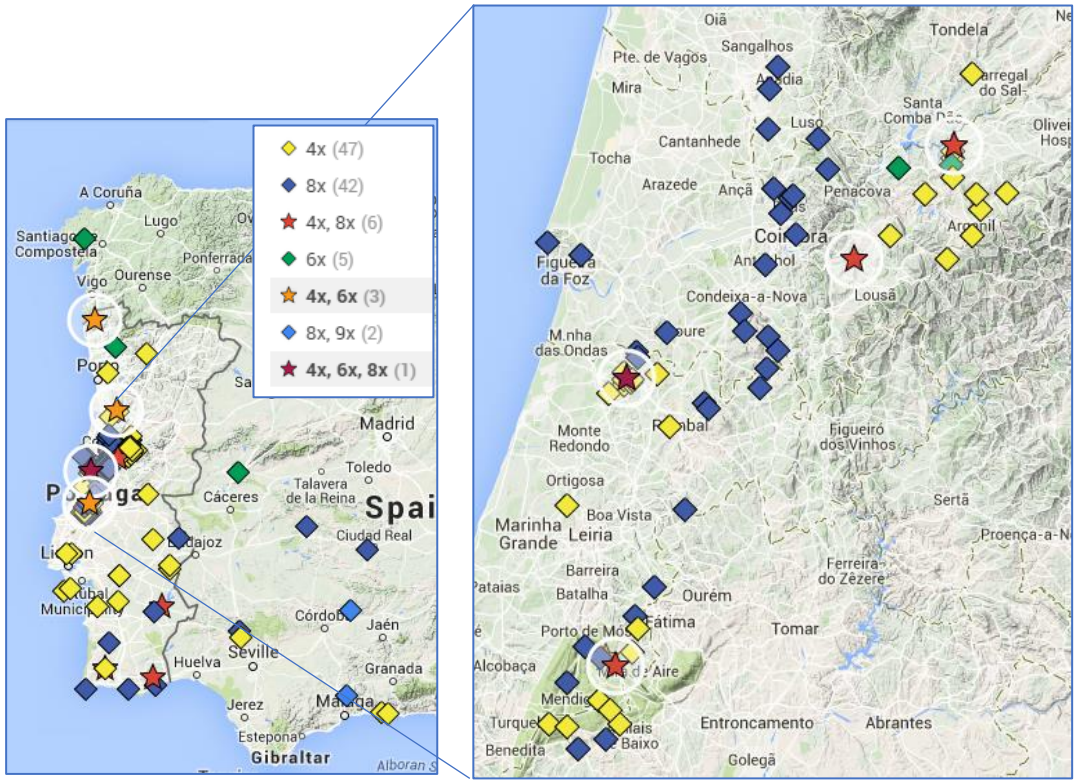
Mariana Castro[1], Brian Husband[2], João Loureiro[1], **Sílvia Castro**[1]

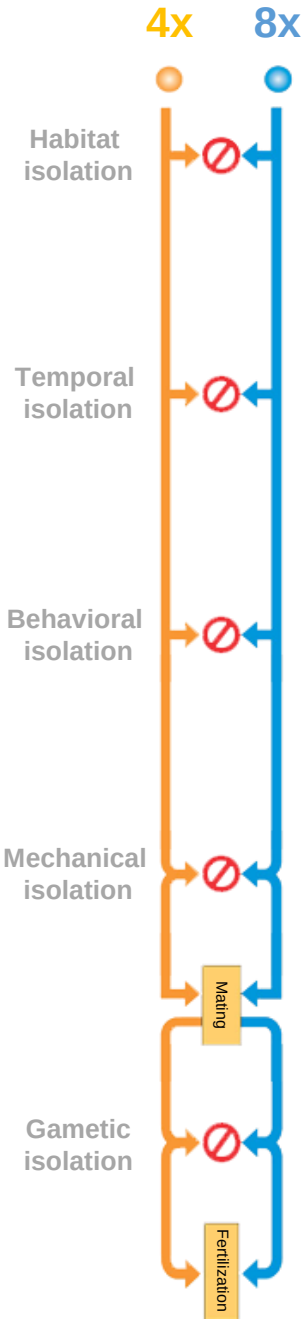
[1]CFE - Centre for Functional Ecology and Department of Life Sciences, University of Coimbra, Coimbra, Portugal
[2]Department of Integrative Biology, University of Guelph, Guelph, Ontario, Canada

@cfe_FLOWerLab

Objective Quantify the **strength of isolation** across **multiple reproductive stages** in a **tetraploid–octoploid contact zone** to understand cytotype coexistence.

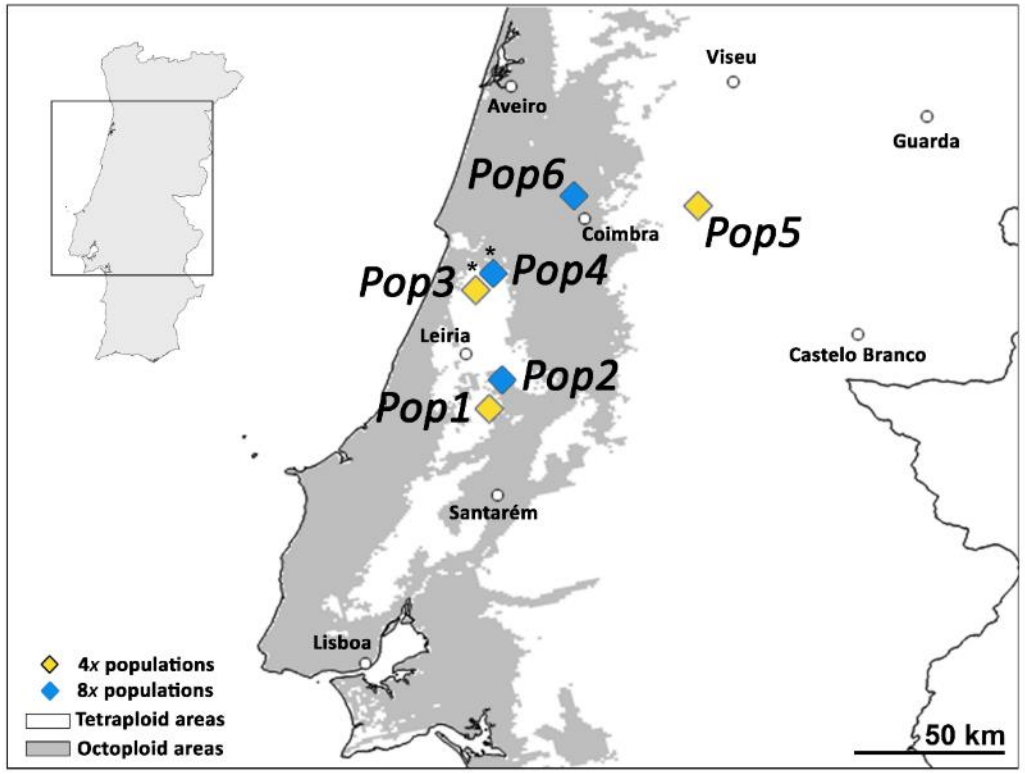


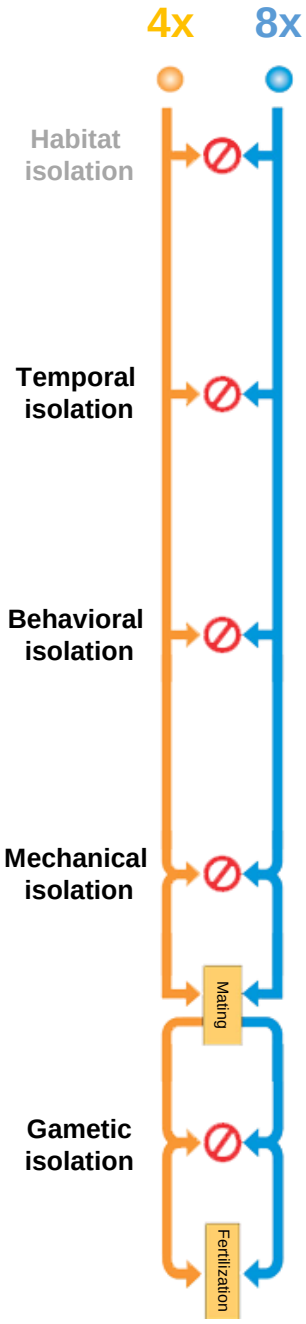




Quantifying assortative mating

- **flowering asynchrony**
- **pollinator behavior**
- **morphological overlap**
- **self-fertilization**
- **gametic competition**

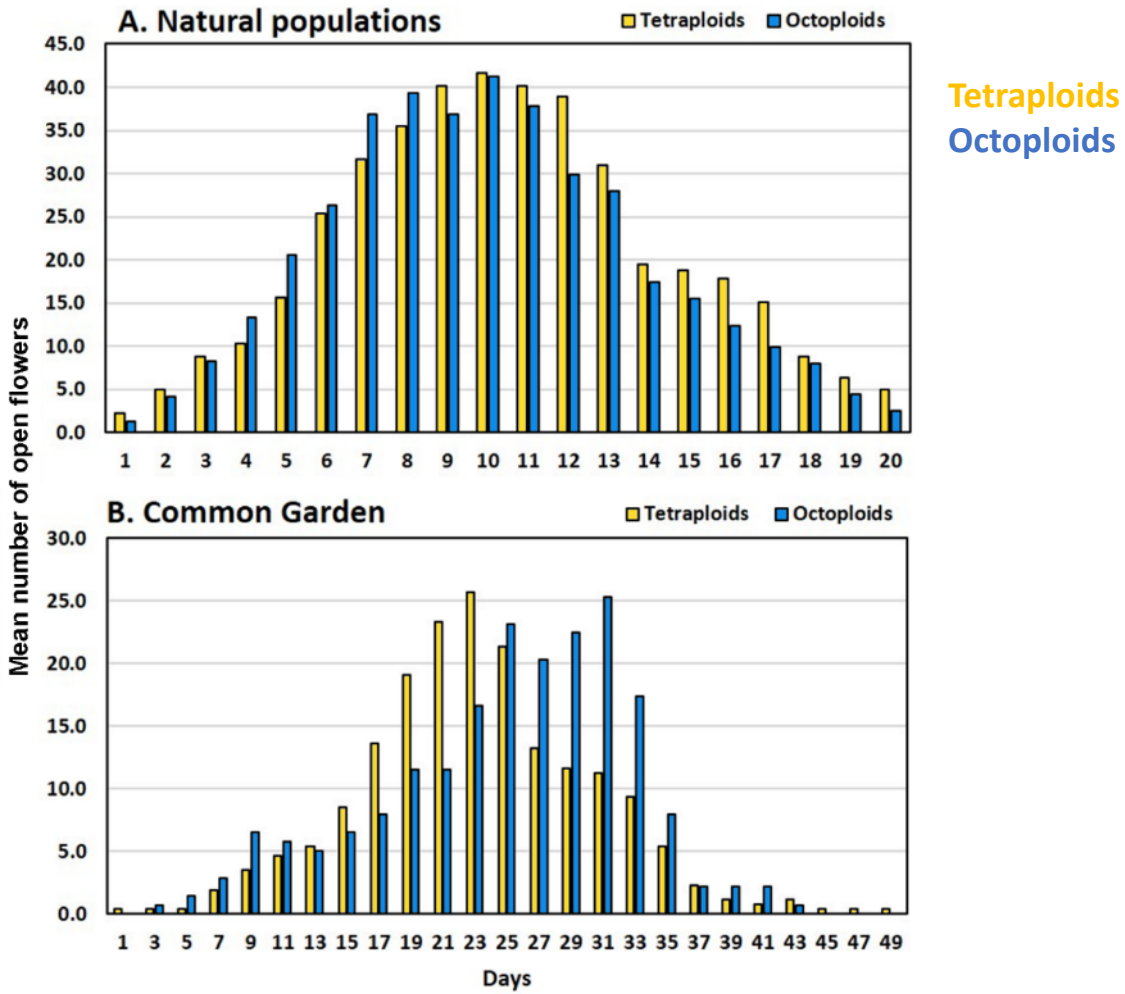




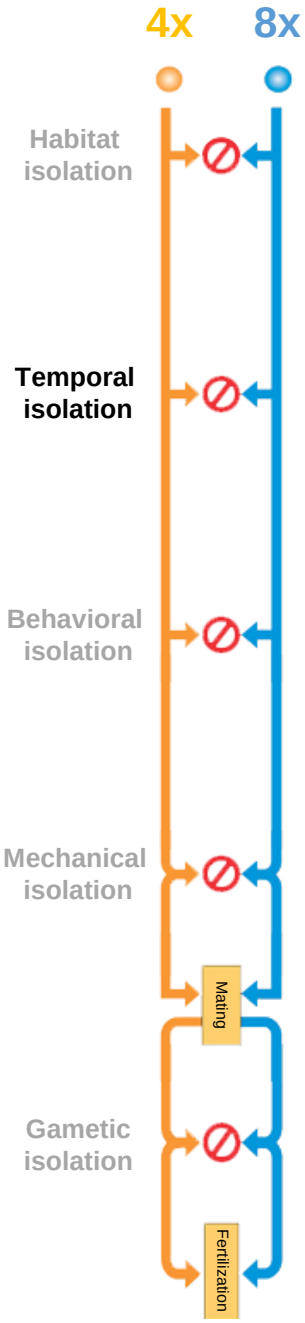
- Selected 3 pairs of **tetraploid** and **octoploid** populations

Flowering asynchrony

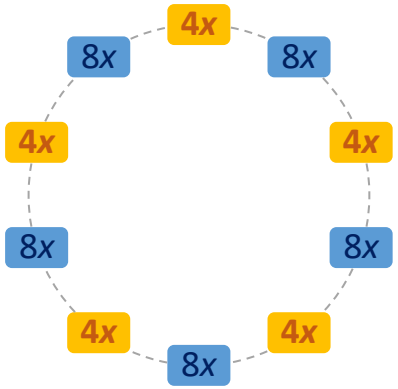
- **high degree of overlap in flowering time** (both in natural populations and in common garden)



Tetraploids
Octoploids

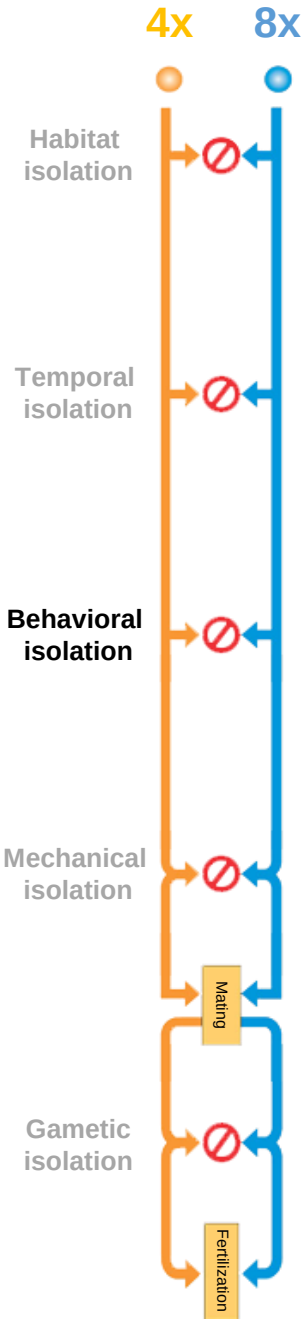


Pollinator behaviour

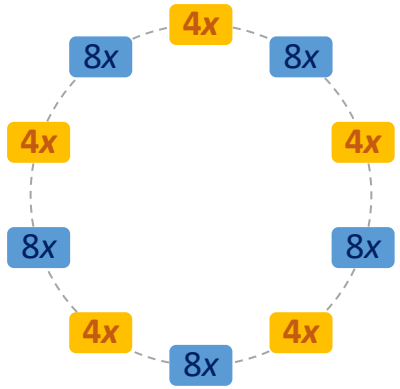


Floral preference index

Floral constancy index



Pollinator behaviour



Floral preference index

Floral constancy index

Main pollinators:

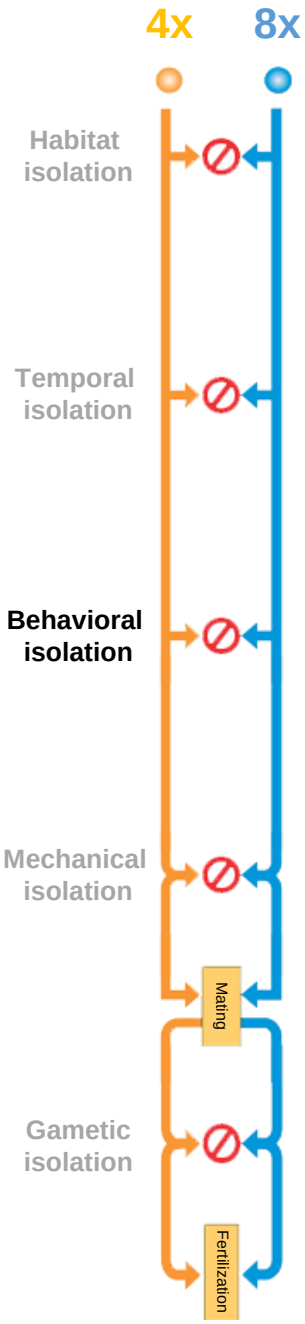
Anthidium florentinum

Anthophora sp.

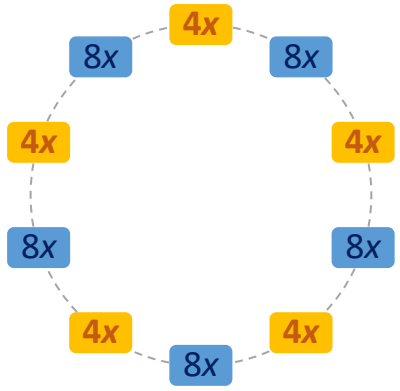
Bombus pascuorum

Bombus terrestris

Colletes sp.



Pollinator behaviour



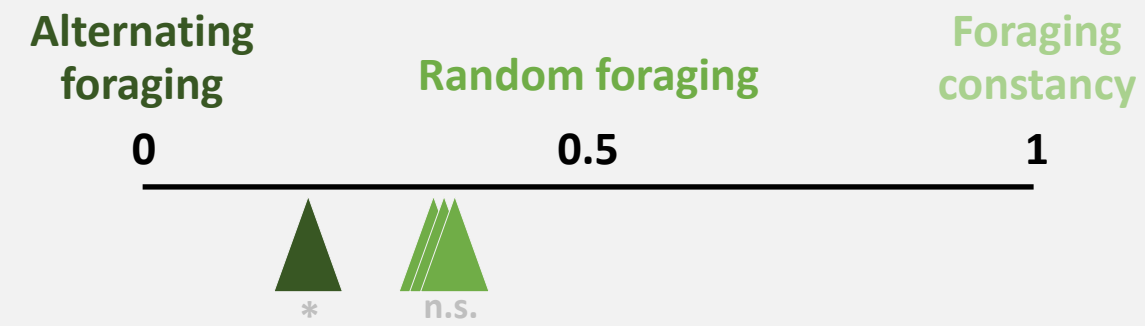
Main pollinators:

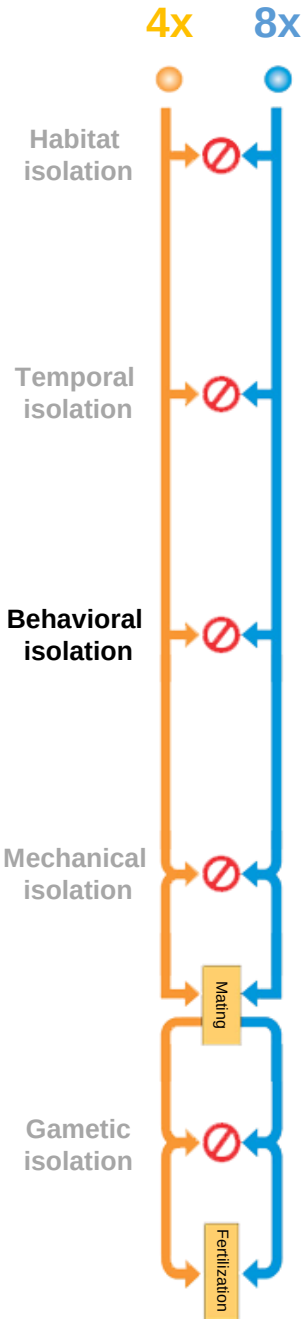
Anthidium florentinum
Anthophora sp.
Bombus pascuorum
Bombus terrestris
Colletes sp.

- Pollinator behaviour does not prevent **inter-cytotype pollen exchange**

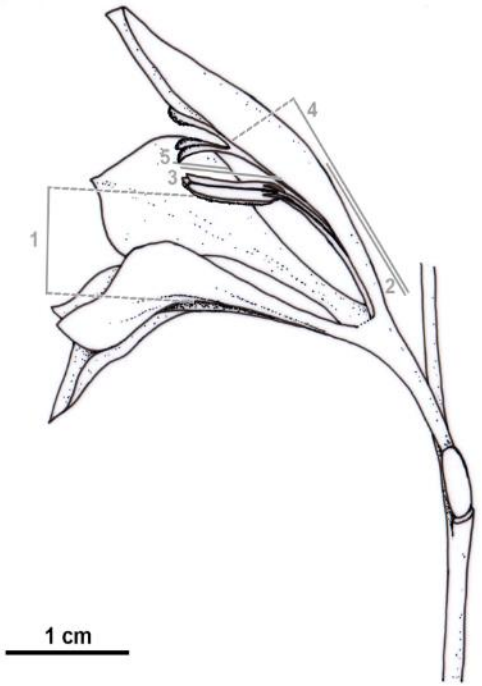
Floral preference index:

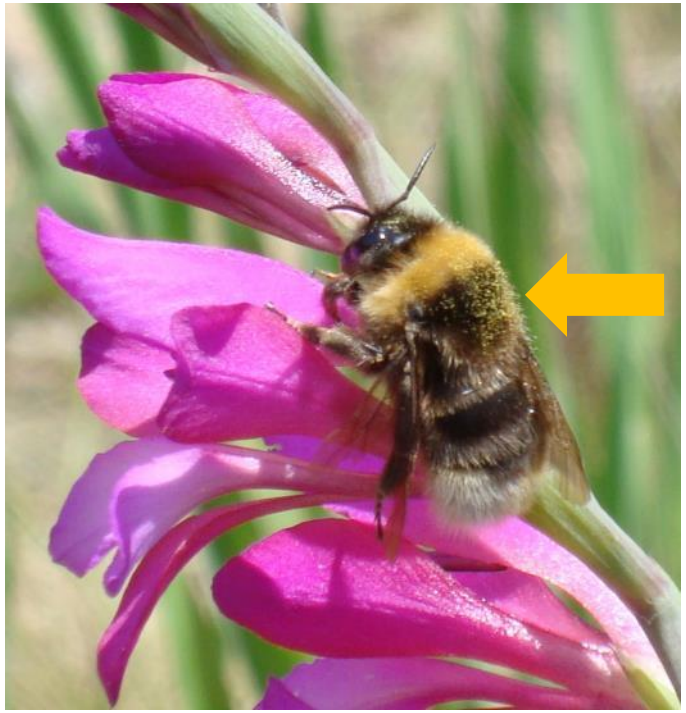
Floral constancy index:

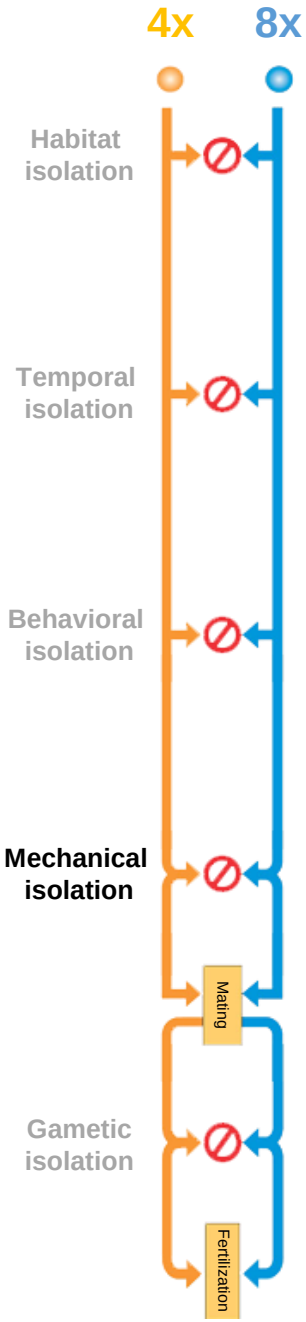




Floral morphological isolation

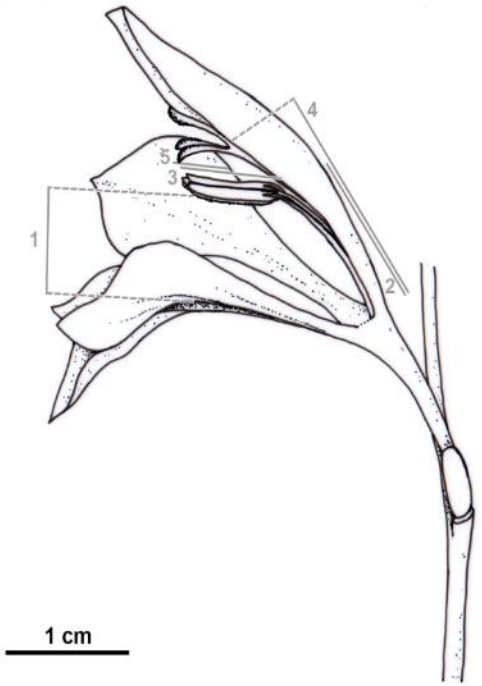


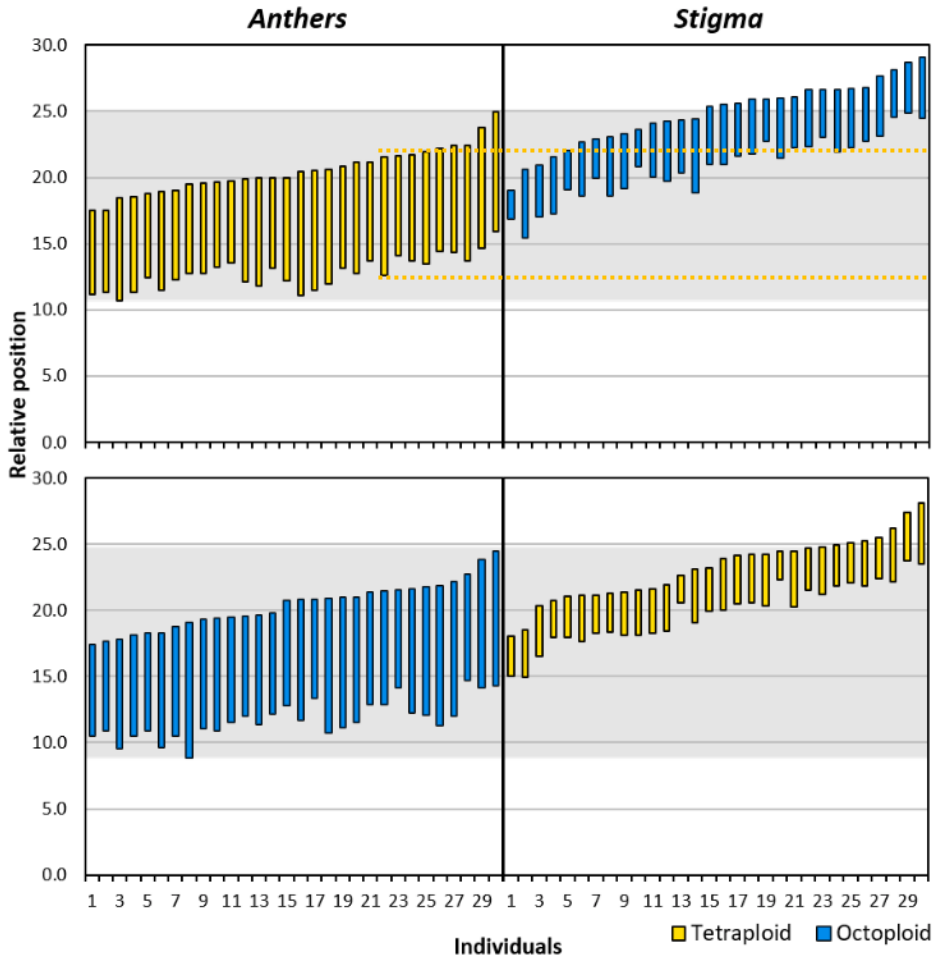


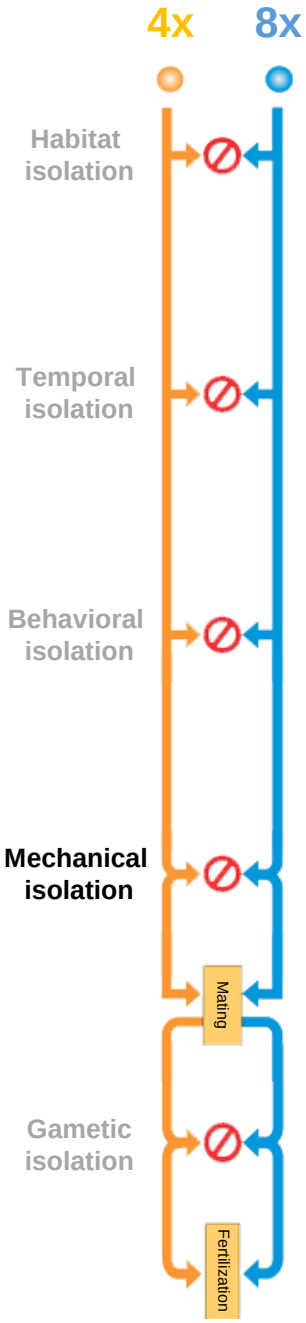


Floral morphological isolation

- **high degree of overlap in sexual organs length** between cytotypes



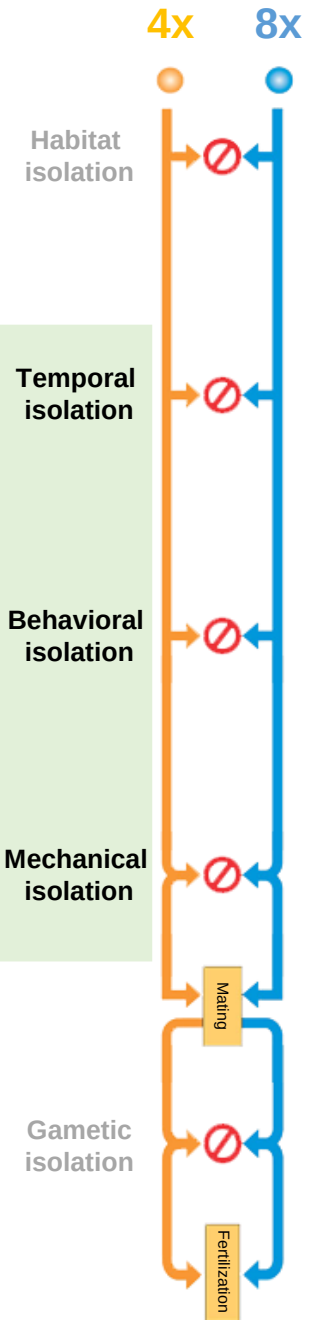




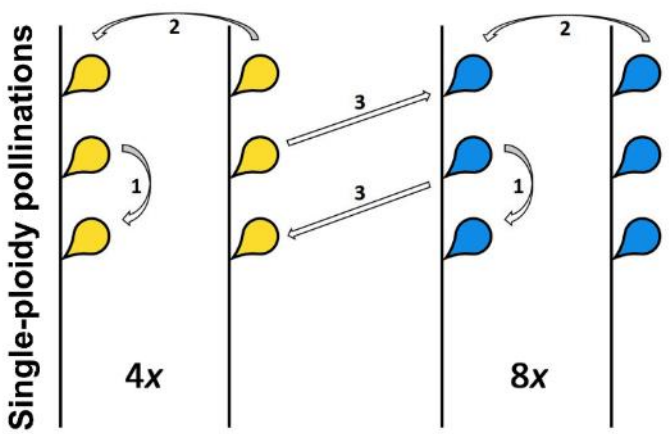
Pre-pollination barriers

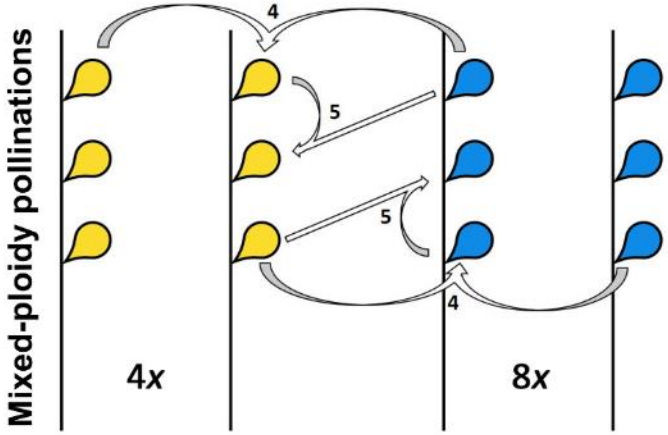
… in mixed-ploidy populations

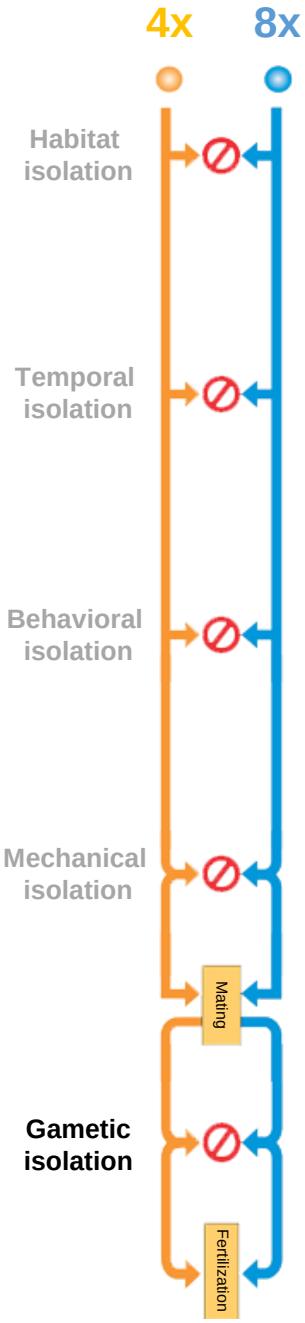
Weak pre-pollination isolation



Post-pollination interactions





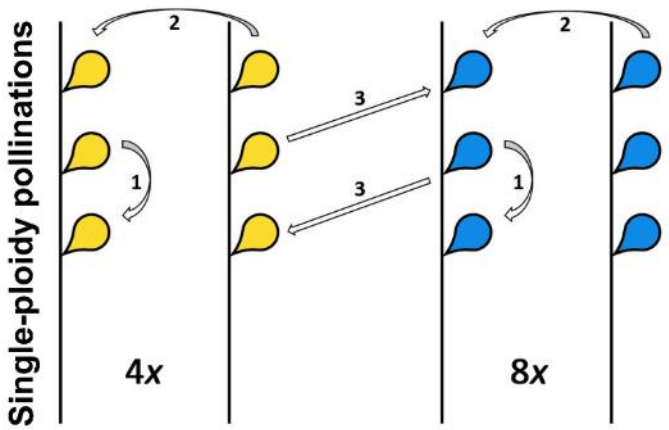


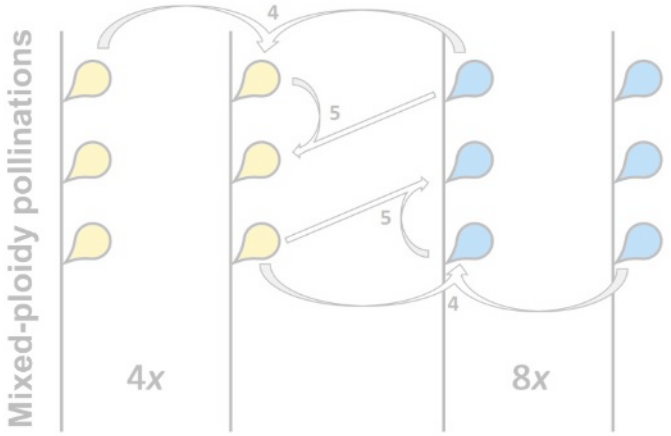
Experimental hand-pollinations, excluding pollinators → Fruit and seed production and offspring ploidy

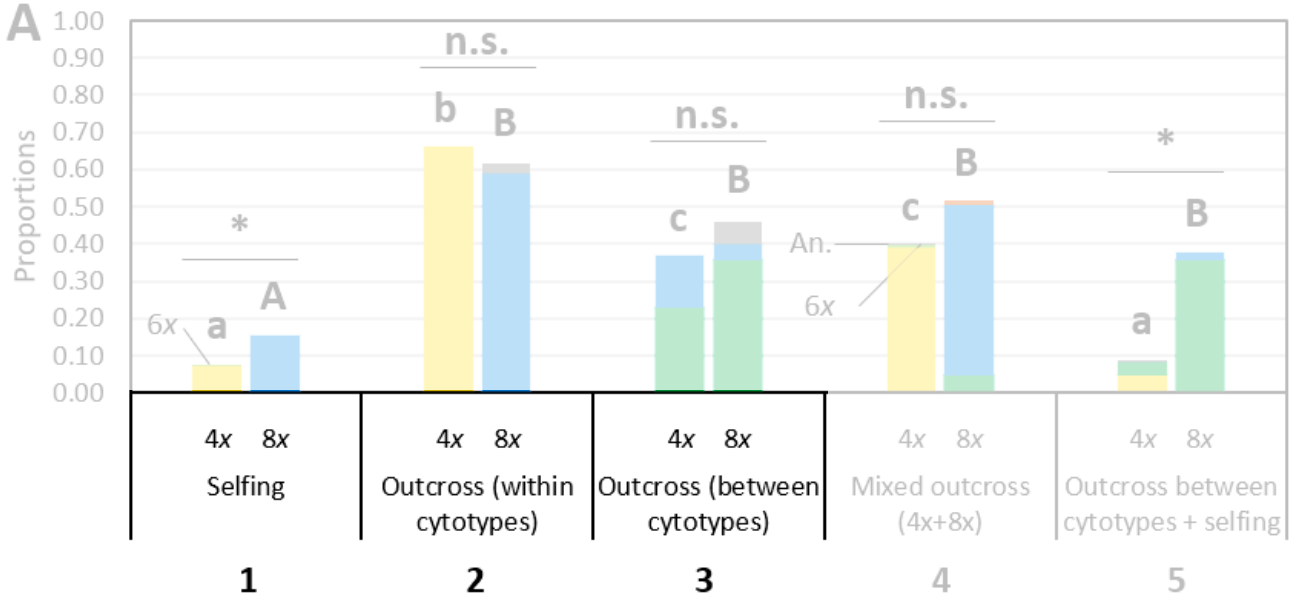




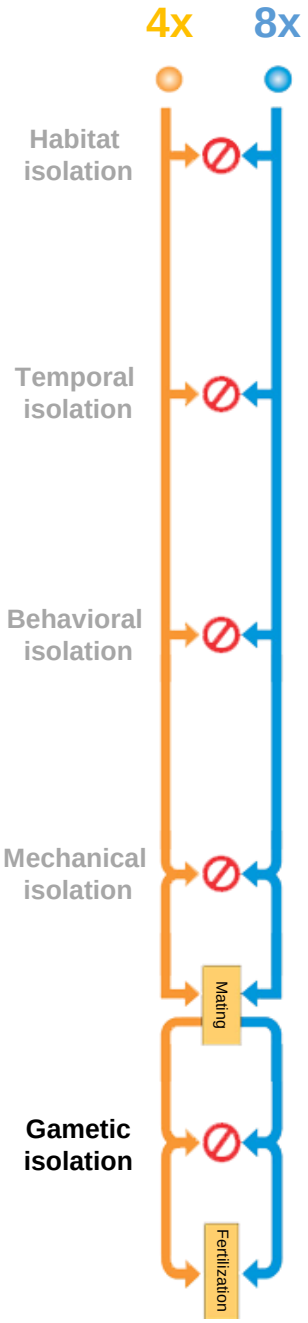
Post-pollination interactions



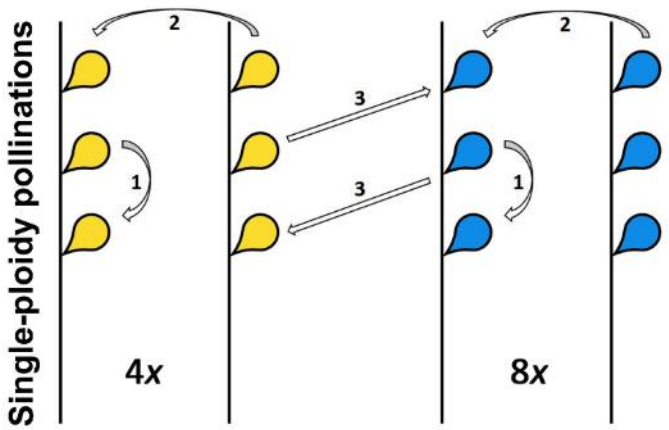


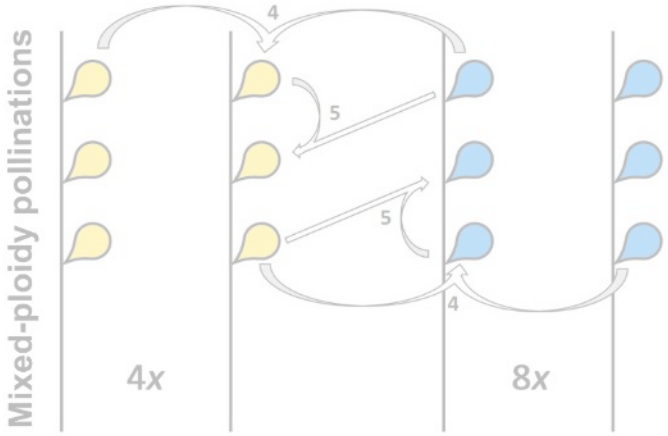


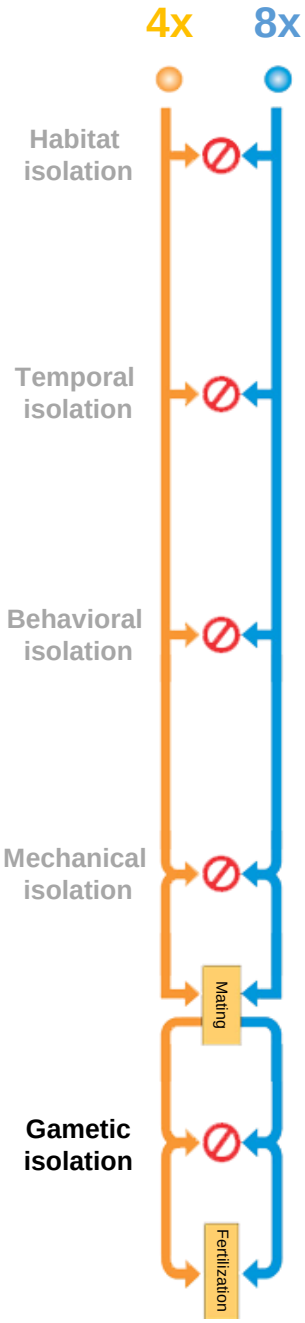
1. **Selfing**
2. **Outcross – within-cytotype**
3. **Outcross – between-cytotype**

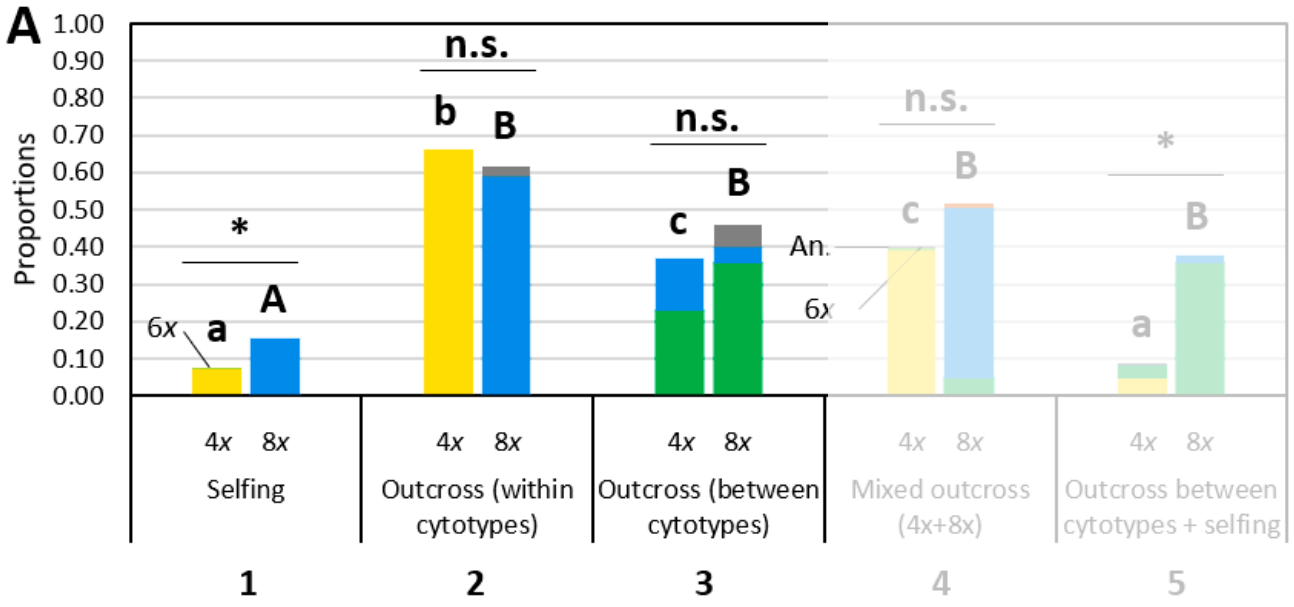


Post-pollination interactions



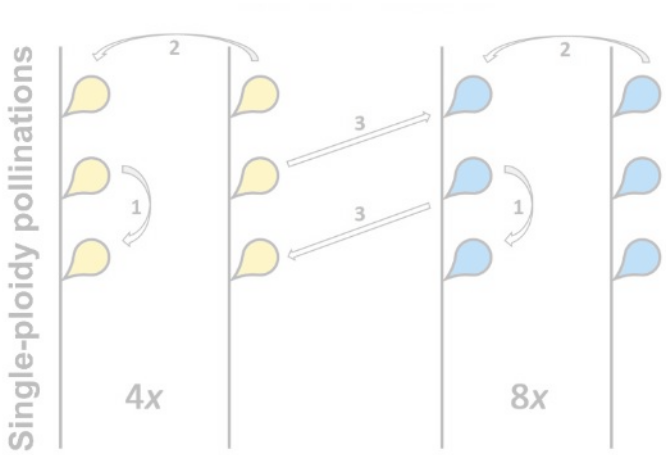


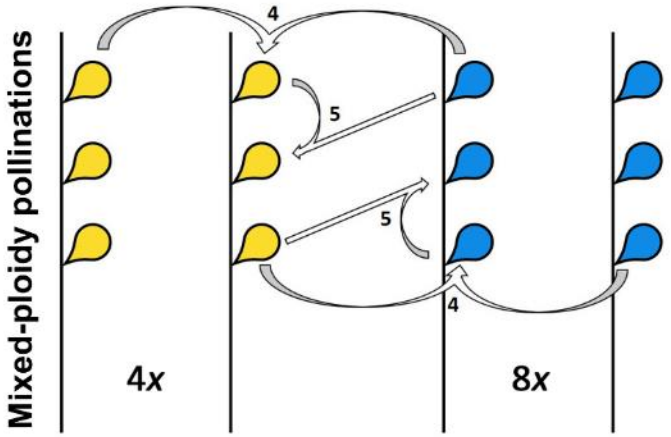


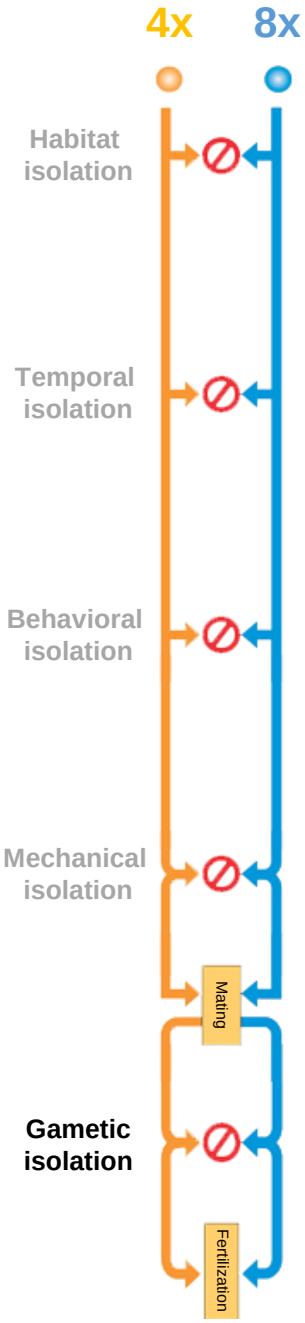


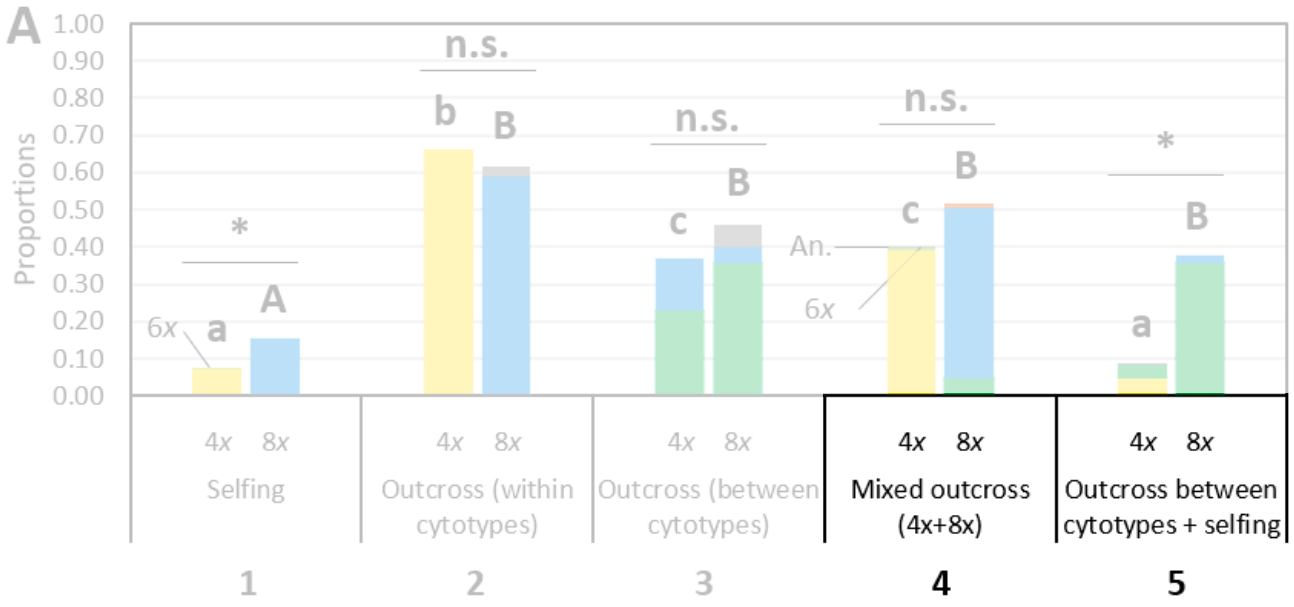
- **Cytotypes are able to cross** and produce hexaploid offspring

Post-pollination interactions





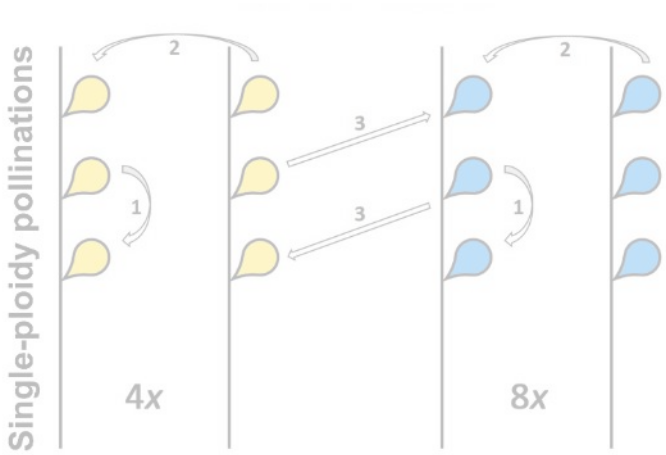


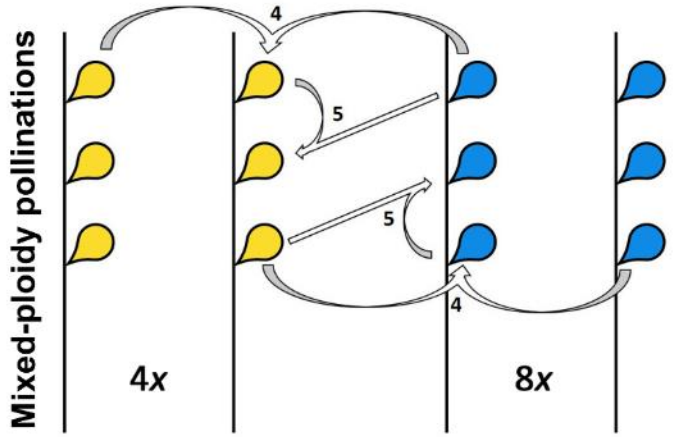


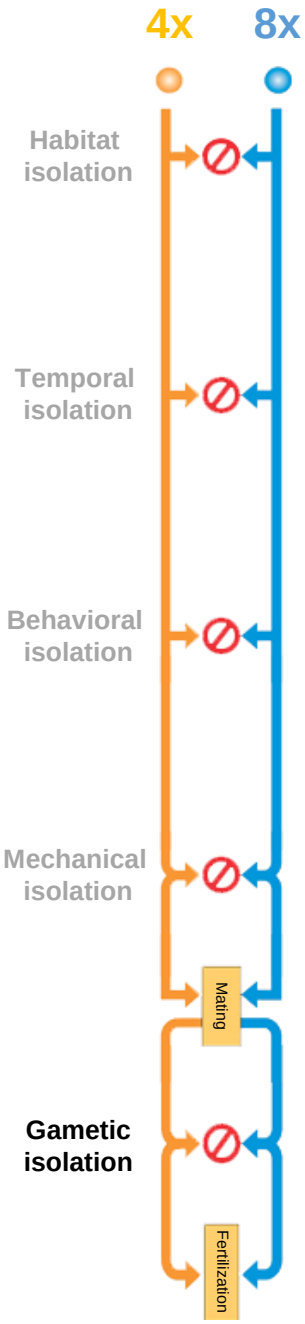
4. **Mixed outcross (4x + 8x)**
5. **Outcross – between-cytotype + Selfing**

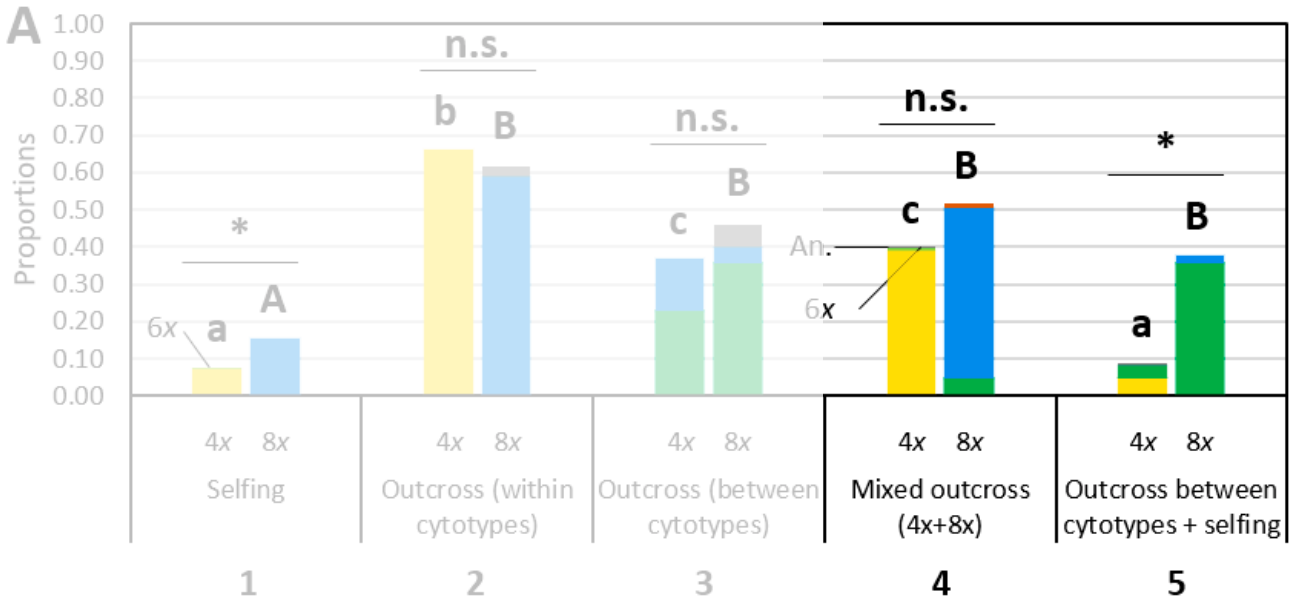
An.
Others
Octo
Hexa
Tetra

Post-pollination interactions







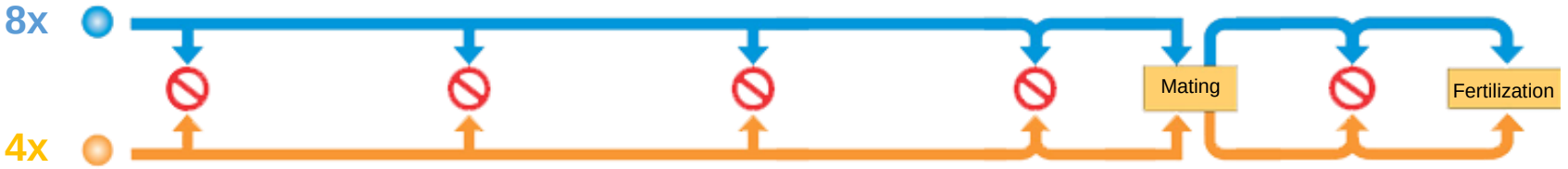


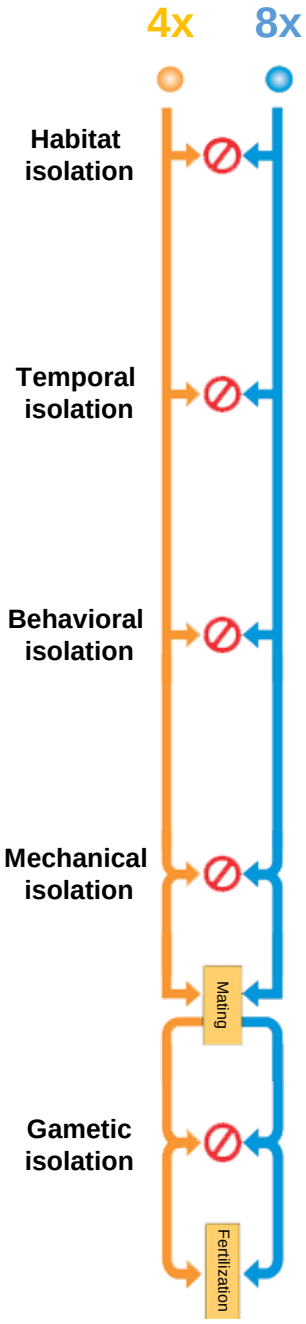
- **Strong gametic interactions** drive reproductive isolation between cytotypes

An.
Others
Octo
Hexa
Tetra

Theoretical cumulative effect

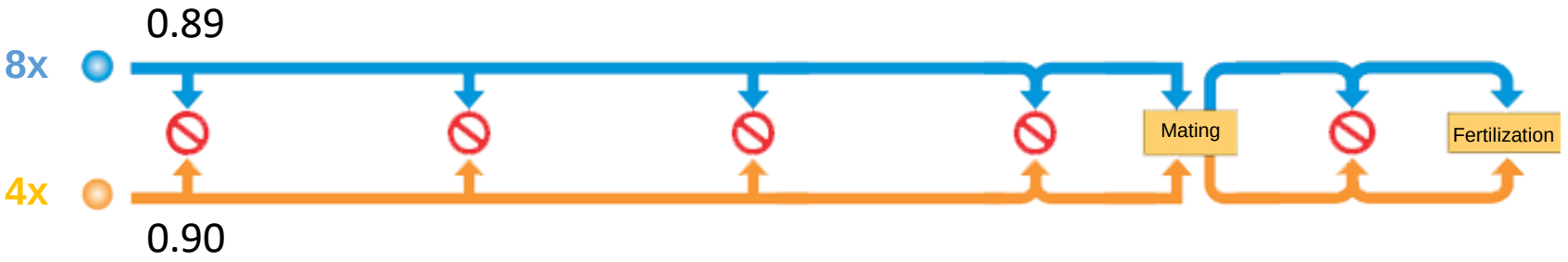
… can we sum up all this and provide reproductive isolation values?



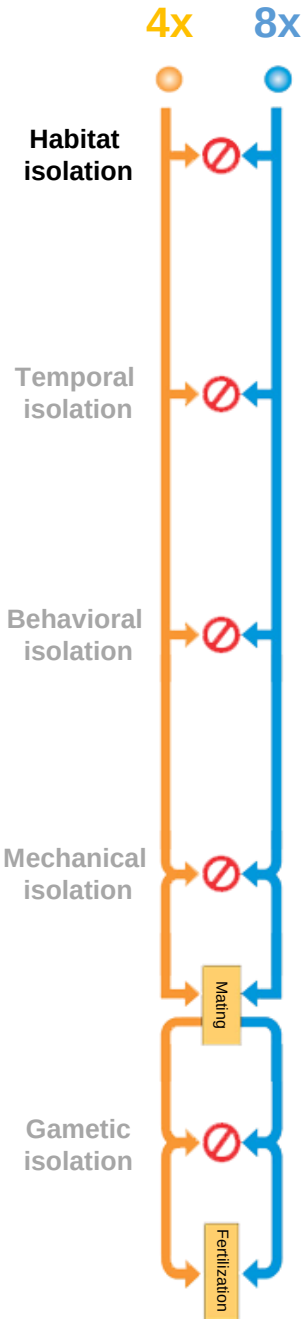


Theoretical cumulative effect

… can we sum up all this and provide reproductive isolation values?

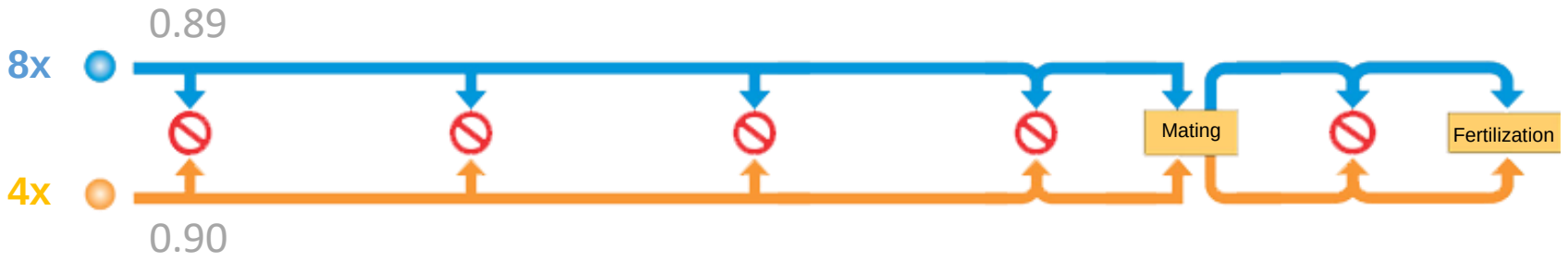


Habitat isolation

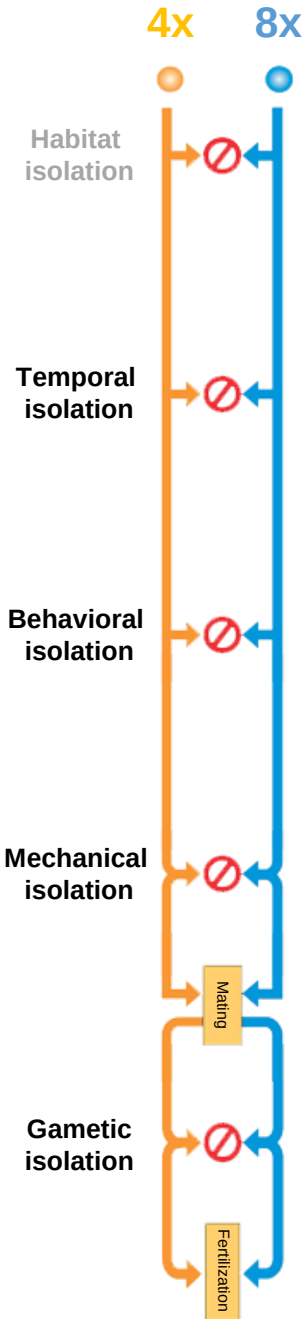


Theoretical cumulative effect

… in mixed-ploidy populations

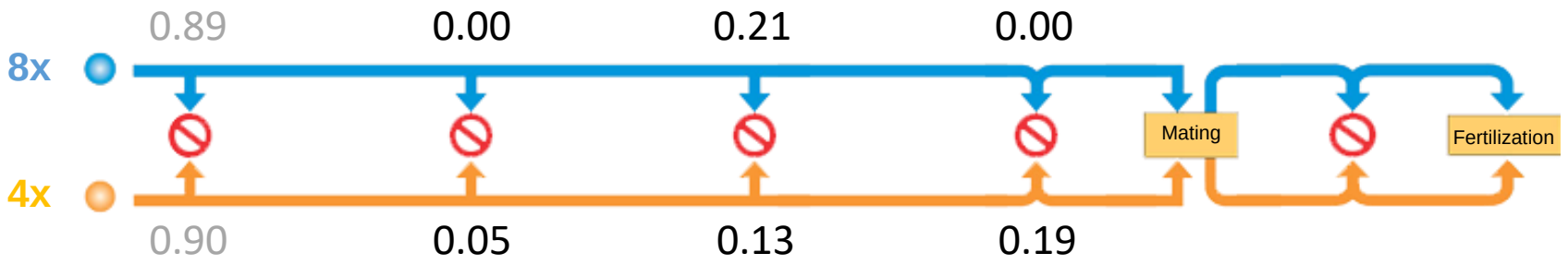


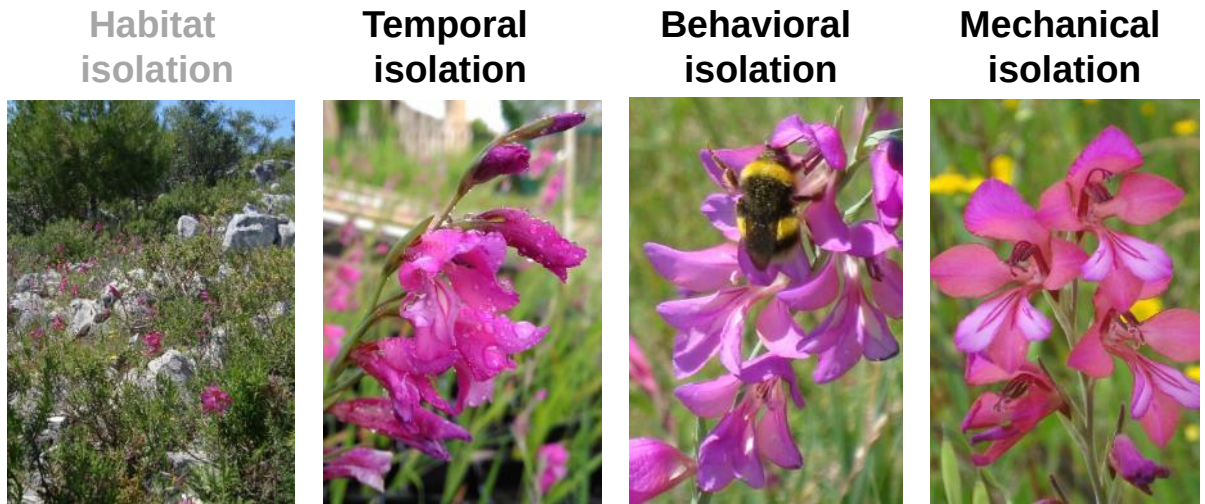
Habitat isolation

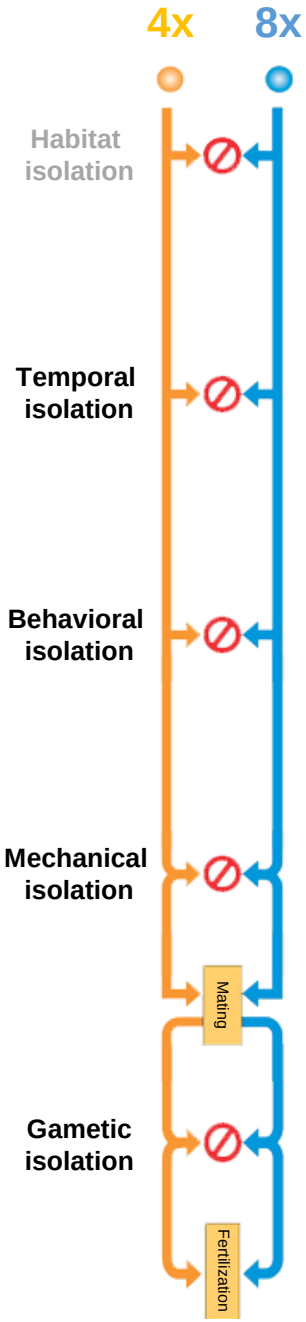


Theoretical cumulative effect

… in mixed-ploidy populations

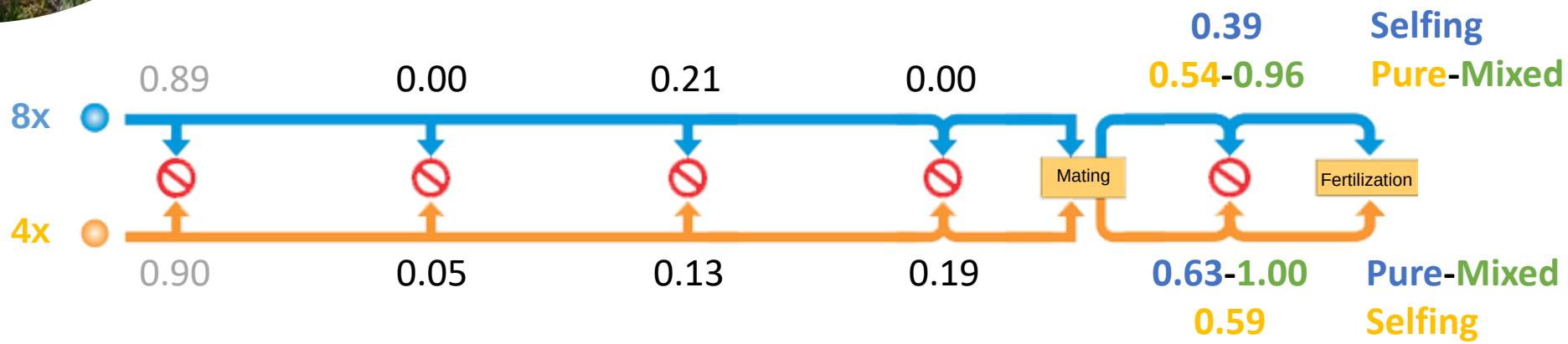


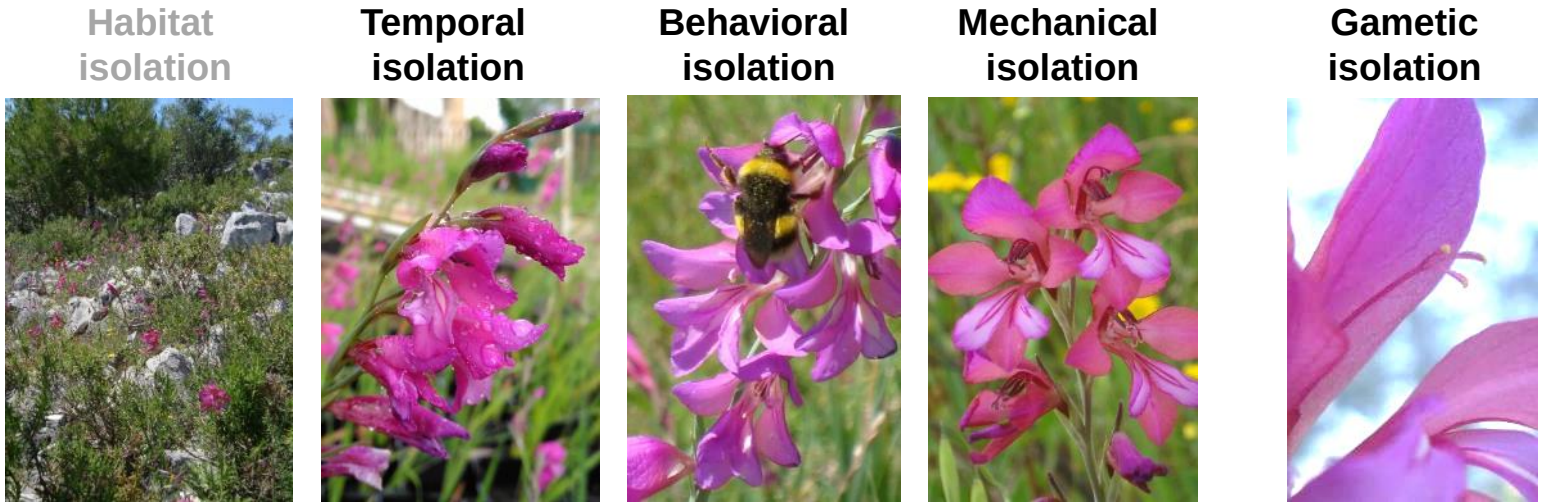


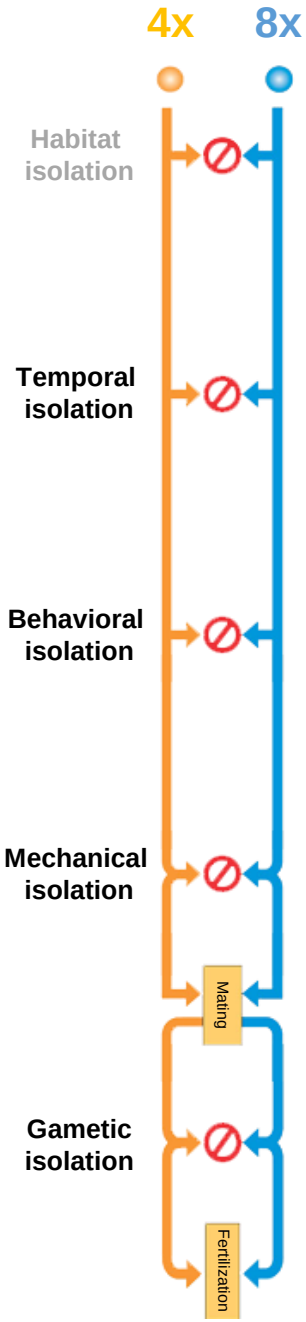


Theoretical cumulative effect

… in mixed-ploidy populations



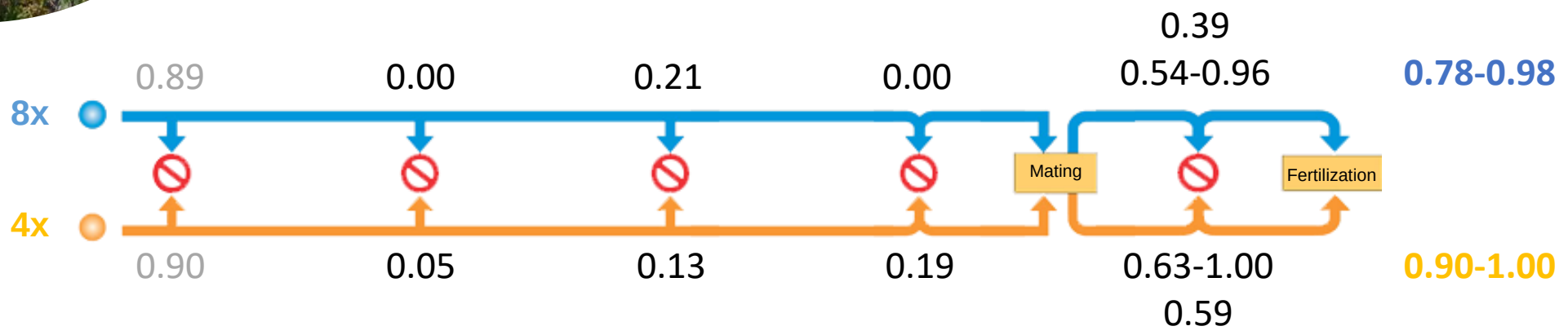




Theoretical cumulative effect

… in mixed-ploidy populations

RI = 0.86 – 0.99



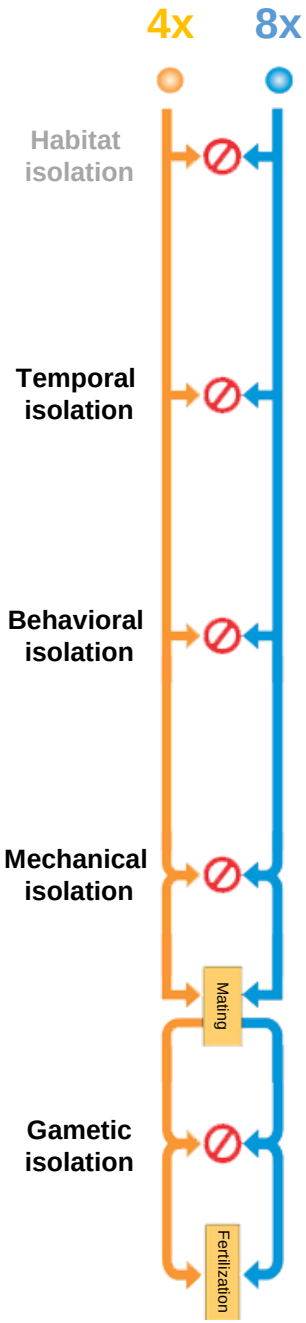
Habitat isolation

Temporal isolation

Behavioral isolation

Mechanical isolation

Gametic isolation



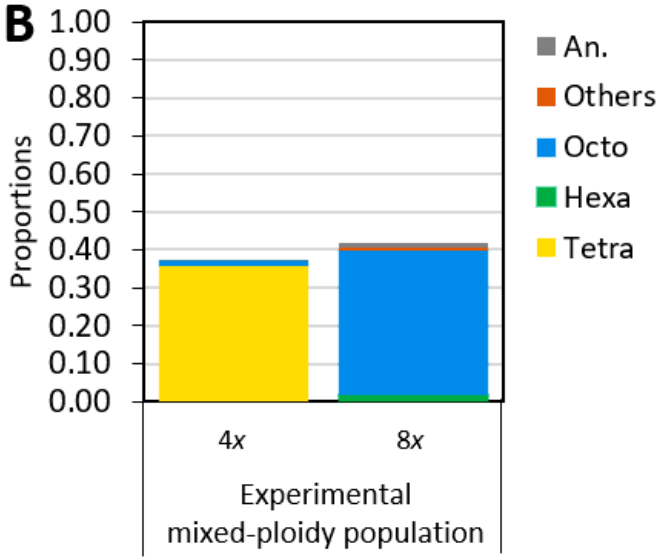
Experimental cumulative effect

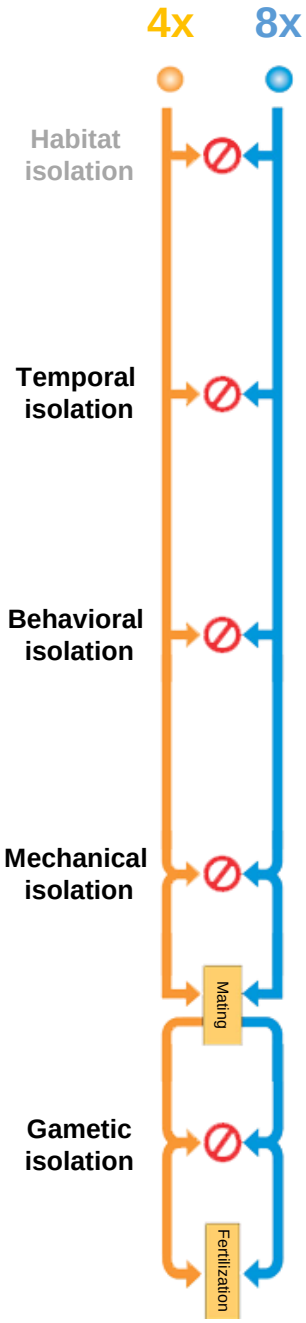
… does it work under real condition?

- Experimental mixed-ploidy population

- **high RI values** for both cytotypes

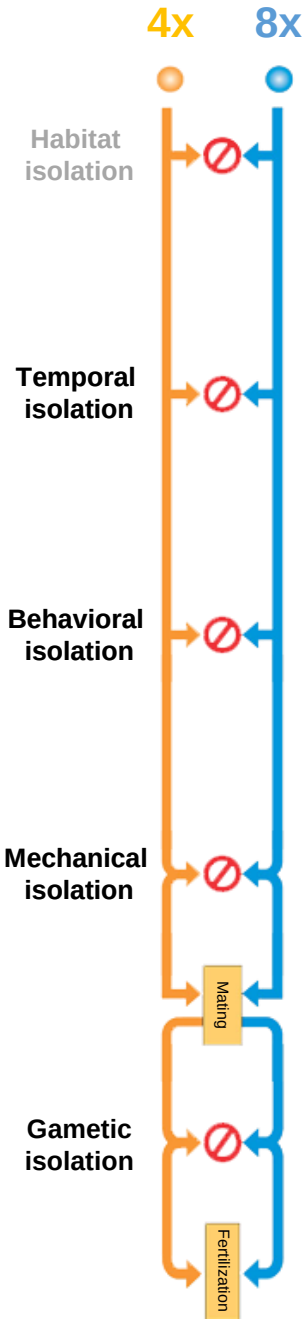
$RI_{4x} = RI_{8x} = 0.99$





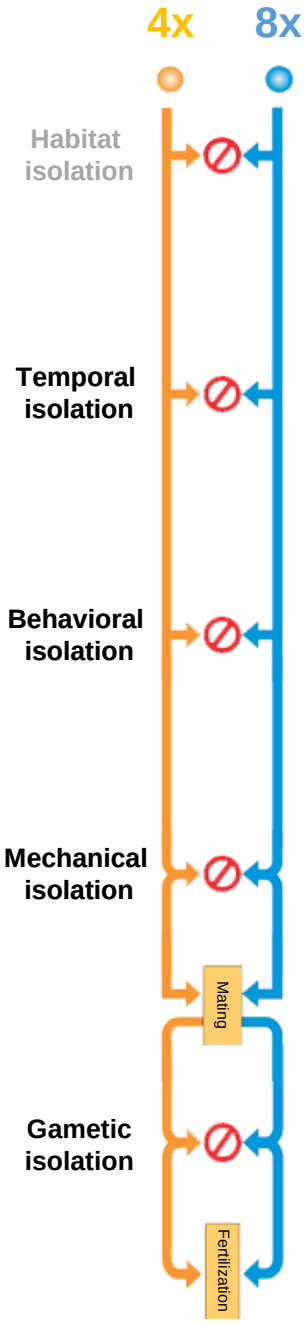
Concluding remarks

- In sympatry, **post-pollination gametic barriers** are key reproductive barrier in this complex
- Strong **gametic selection** against alternate cytotype under mixed-ploidy pollen loads may **maintain tetraploid-octoploid populations**



Concluding remarks

- In sympatry, **post-pollination gametic barriers** are key reproductive barrier in this complex
- Strong **gametic selection** against alternate cytotype under mixed-ploidy pollen loads may **maintain tetraploid-octoploid populations**
- However, **pollen load composition** determines the magnitude of reproductive isolation
- Because pollen loads composition determines both fitness and offspring ploidy, and contact zones are characterized by different mixed-ploidy spatial arrangements, the **interactions between cytotypes are expected to be complex** in natural contact zones
- Finally, octoploids relative fitness may increase with **unreduced gamete** formation, **hexaploid** production and higher **selfing** success than tetraploids



TOPIC 3. **Plant breeding systems and pollen dispersal**

Reproductive Barriers

Questions?

Thank you!