# Sexual dimorphism in dioecious plants: Is dioecy an evolutionary suicide?

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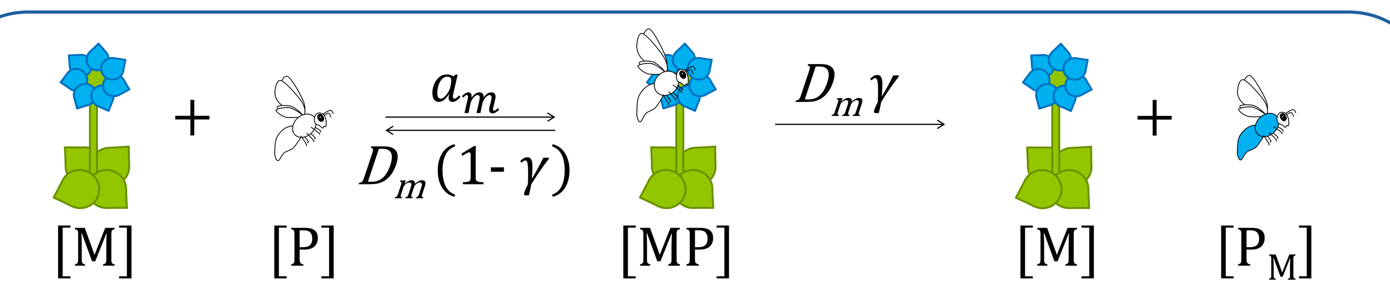
## Introduction

Sexual dimorphism is widespread among dioecious species[1,2] and when it concerns floral traits, it may affect pollinator behavior and reduce pollen transfer from male to female flowers[3]. Yet, the demographic impact of dimorphism, and its potential feedback on attractiveness evolution have received little theoretical attention[3]. In this study, we investigate:

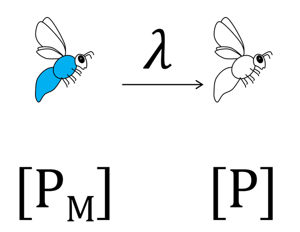
**How does sexual dimorphism evolve when the interaction with pollinators is explicitly taken into account?**

**How does sexual dimorphism impact plant and pollinator demography?**

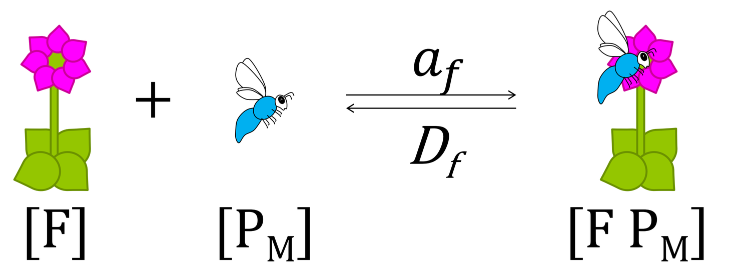
## Plant-pollinator interactions




Pollinators gather pollen on a male ($M$) with probability $\gamma$.




Pollinators lose pollen (rate $\lambda$).




Seed production is assumed to increase only with visits on females by pollinators that carry pollen ($V_{FM}$)

Visitation rate by pollinators on an individual plant depends on plant attractiveness ($a_m$ or $a_f$) and on how fast pollinators leave the plant (dissociation rate $D_m$ or $D_f$):

- Visits on an individual $i$ ($F$ or $M$):

$$V_i = \left(\frac{a_i}{1+(a_f/D_f)F+(a_m/D_m)M}\right) P$$

- Effective visits on a female:

$$V_{FM} = \left(\frac{a_f}{1+(a_f/D_f)F+(a_m/D_m)M}\right)\left(\frac{a_m\,\gamma\, M}{\lambda + a_m\,\gamma\, M}\right) P$$

## Demography

Seed production increases with effective visits on females. Pollinator benefit of pollination increases with all types of visits.

$$\begin{cases} \frac{dM}{dt} = \frac{1}{2} r\, F \frac{V_{FM}}{h+V_{FM}} - d_m M \left(1+\frac{M+F}{K}\right) \\ \frac{dF}{dt} = \frac{1}{2} r\, F \frac{V_{FM}}{h+V_{FM}} - d_f F \left(1+\frac{M+F}{K}\right) \\ \frac{dP}{dt} = \rho\, P\left(1-\frac{P}{\kappa}\right) + n_m V_M M + n_f V_F F \end{cases}$$

## Attractiveness evolution

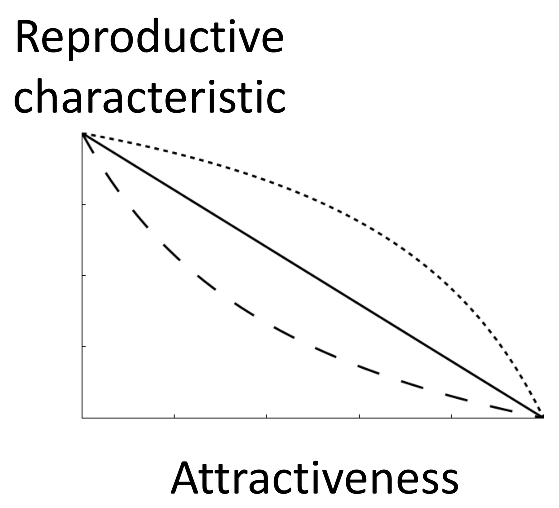
Within the plant population, a rare mutation appears and affects only one sex (traits with subscript x). Mutants have the following per capita fitness:

male mutant: $W_{M_x} = \frac{1}{2} r\, F \frac{V_{FM_x}/M_x}{h+V_{FM}} - d_{m_x}\left(1+\frac{M+F}{K}\right)$,

female mutant: $W_{F_x} = \frac{1}{2} r_x \frac{V_{F_xM}}{h_x+V_{F_xM}} - d_{f_x}\left(1+\frac{M+F}{K}\right)$,

We look for the CSS and ESS (Adaptive Dynamics).

## Resource limitation




Plants invest either into attractiveness or into reproduction: pollen transfer for males and ovule production for females.

Fig. 1: Shapes of the trade-off. The same dashing patterns is used in Fig. 2.

## Dimorphism with fixed pollen limitation

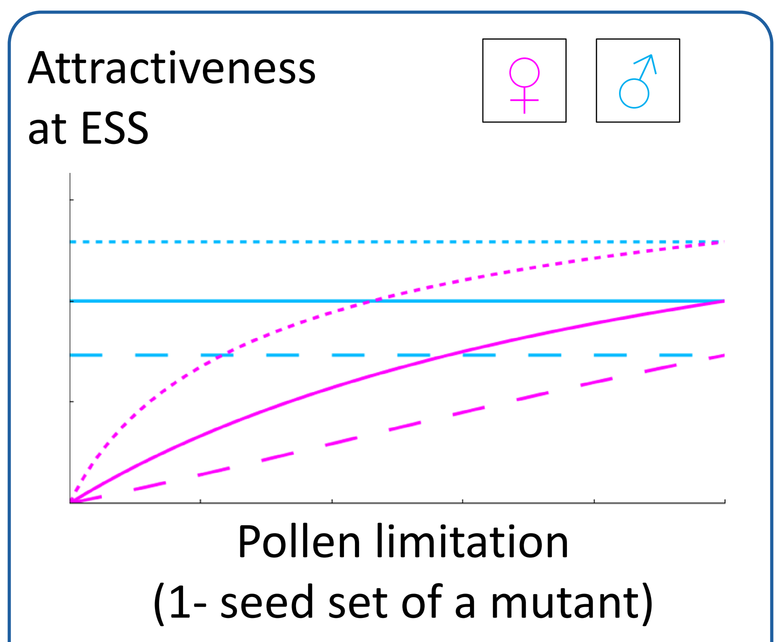



Fig. 2: Evolutionary outcome of male (blue) and female (pink) attractiveness as a function of pollen limitation.

With fixed densities:

- The lower the pollen limitation (higher plant and pollinator densities, lower need of pollen of females), the higher the female investment in seed production, and the lower their attractiveness.
- Male strategy is only determined by male-male competition (no impact of female strategy).

- Males always invest more into attractiveness than females when pollen limitation is high. Females can be more attractive only if pollen limitation is high and trade-off shapes differ between sexes.

## Dimorphism with variable pollen limitation

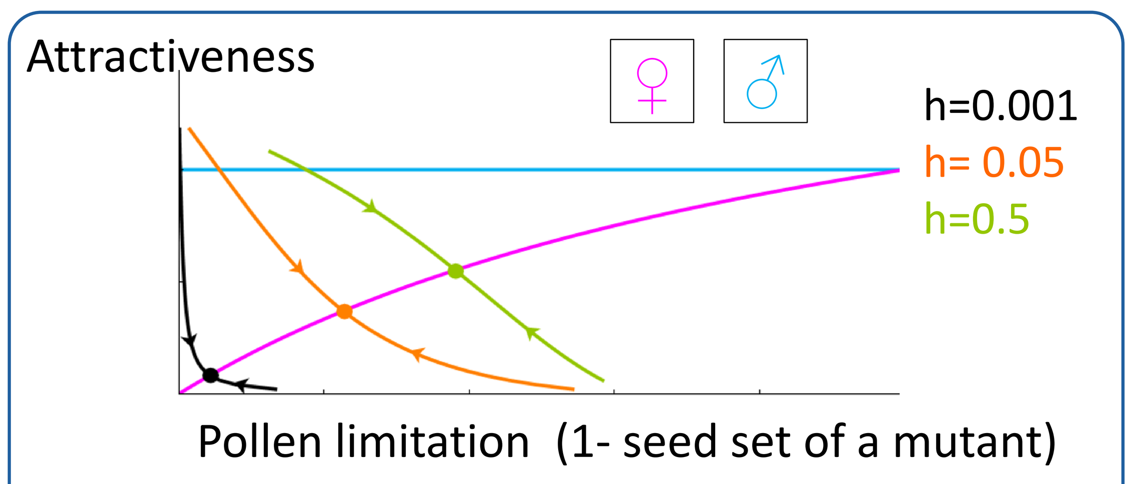



Fig. 3: Evolutionary trajectories of females depending on their need of pollen (h). Female evolutionary outcomes are depicted by dots. Males are at ESS.

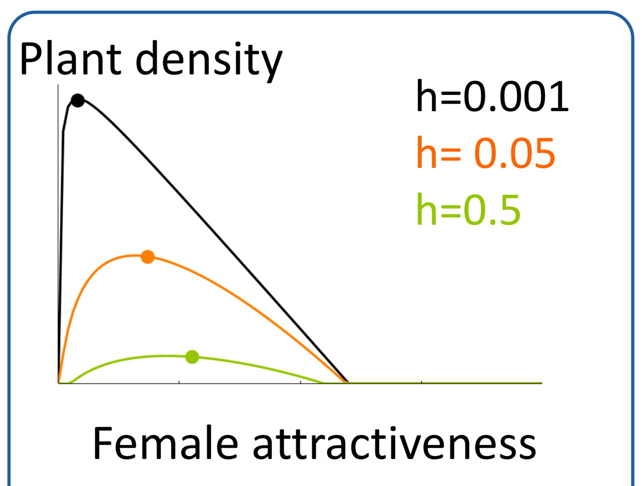



Fig. 4: Plant density depending on female attractiveness. Female ESS are depicted by dots.

- Evolution of dimorphism can be hampered because of an increase in pollen limitation with lower female attractiveness.
- High dimorphism (♂ > ♀) evolves in large population with little pollen limitation.
- The high pollen limitation needed to evolve to a dimorphism with ♀ > ♂ is not demographically viable.

## Conclusion and perspectives

The occurrence of dimorphism in dioecious species could threaten small populations[3]. However, feedbacks between evolution of attractiveness and demography hamper the evolution of dimorphism (♂ > ♀) in small populations and prevent evolutionary suicides. Our model does not predict dimorphism with ♀ > ♂, and this patterns remain to be investigated.

## Literature cited

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