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

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 \( D_f \)):

\[
V_i = \frac{a_i}{1 + (a_f / D_f) + (a_m / D_m)M} \]

Effective visits on a female:

\[
V_{FM} = \frac{a_f}{1 + (a_f / D_f) + (a_m / D_m)M} (\frac{a_m \gamma M}{\lambda + a_m \gamma M})^p
\]

Demography

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

\[
\frac{dM}{dt} = \frac{1}{2} F \left( \frac{V_{FM} - d_m M}{F + V_{FM}} \right) + d_m M \left( 1 + M + F \right)
\]

\[
\frac{dF}{dt} = \frac{1}{2} F \left( \frac{V_{FM} - d_f F}{F + V_{FM}} \right) + d_f F \left( 1 + M + F \right)
\]

\[
\frac{dP}{dt} = \theta F (1 - \frac{P}{P_i}) + m_P V_{FM} M + n_P V_{FM} F
\]

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: \( \nu_{mx} = \frac{1}{2} F \left( \frac{V_{FM} - d_m M}{F + V_{FM}} \right) + d_m M \left( 1 + M + F \right) \)

female: \( \nu_h = \frac{1}{2} F \left( \frac{V_{FM} - d_f F}{F + V_{FM}} \right) + d_f F \left( 1 + M + F \right) \)

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

Dimorphism with fixed 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

- Evolution of dimorphism can be hampered because of an increase in pollen limitation with lower female attractiveness.

- High dimorphism \( (\varphi > \gamma) \) evolves in large population with little pollen limitation.

- The high pollen limitation needed to evolve to a dimorphism with \( \varphi > \gamma \) 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 \( (\varphi > \gamma) \) in small populations and prevent evolutionary suicides. Our model does not predict dimorphism with \( \varphi > \gamma \) and this patterns remain to be investigated.

Literature cited