Postprint: Adaptive Study on Floral Syndrome and Pollination Pattern in Descurainia sophia

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Abstract

In angiosperms, floral trait diversity and morphological variability demonstrate adaptations to multiple pollination modes. Previous observations revealed that *Descurainia sophia*, an early-spring ephemeral plant, exhibits floral traits adapted to self-pollination due to its small, inconspicuous flowers, while its anther-like petals and persistent calyces appear to be associated with pollinator attraction. To investigate the relationship between its floral syndrome and pollination mode, we examined its flowering phenology, floral traits, advertising effect of petals, and mating system through field observations and artificial control experiments. The results indicate that *D. sophia* possesses a facultative selfing mating system, being self-compatible yet maintaining outcrossing capability. On sunny days, flowers open around 10:00 and close around 17:00, with a floral lifespan of 1–2 days. In individual flowers after anthesis, the pistil continuously elongates, progressing through three stages: below the stamens, at the same height as the stamens, and above the stamens. *D. sophia* has pollinators, but visitation frequency is extremely low, at (0.062±0.027) flower · h ^{1} (2015) and (0.01±0.005) flower · h ^{1} (2016). Control experiments demonstrated that anther-like petals and persistent calyces do not enhance advertising effects for pollinator attraction. Pollen on *D. sophia* stigmas originates primarily from self-pollen, with self-pollen transfer occurring when the pistil is at the same height as each of the two stamen whorls. The extremely small flowers, anther-like petals, and low pollen-to-ovule ratio (P/O value) of *D. sophia* represent reduced floral organ resource investment, constituting a reproductive strategy adapted to self-pollination.

Full Text

Results

The pollen grain count per flower was (4263.21±318.75) L, while the ovule number per flower was (29.21±1.09) L. The pollen-to-ovule (P/O) ratio was

148.17±10.67.

Pollen viability and stigma receptivity measurements showed that pollen viability at flowering stage was (463.05±30.25) L, and stigma receptivity during the flowering period was (319.24±25.34) L. The pollen germination rate on stigmas was (13.6±1.83) L, with pollen germination rates on stigmas at different developmental stages all being less than 1.

Table 1 Floral morphological characteristics of *Descurainia sophia* at different flowering stages

Measurements	Pistil lower than stamens	Pistil equal to stamens	Pistil higher than stamens
Petal length (mm)	2.79±0.04 a (n=30)	2.73±0.05 a (n=30)	3.60±0.06 a (n=30)
Petal width (mm)	3.63±0.06 a (n=30)	3.00±0.04 a (n=30)	3.27±0.08 b (n=30)
Anther length (mm)	2.98±0.05 a (n=20)	3.67±0.06 b (n=20)	-
Anther width (mm)	0.52±0.01 a (n=30)	0.52±0.01 a (n=30)	1.00±0.02 a (n=30)
Pistil length (mm)	1.03±0.02 a (n=30)	-	-
Pollen count/L	463.05±30.25 a (n=20)	319.24±25.34 b (n=29)	-

Note: n represents sample size. Different lowercase letters indicate significant differences at $P<0.05$. ± indicates standard error.

[Figure 2: see original paper]

Fig. 2 Pollen grains remaining in anther of *Descurainia sophia* at different stages

Pollinator visitation frequency was extremely low. In 2015, the visitation frequency was (0.014±0.009) flower · h ^{1} (25h observation) for control plants and (0.085±0.069) flower · h ^{1} (25h observation) for treatment plants, with no significant difference ($t = -1.026$, $P = 0.328$). In 2016, the visitation frequency was (0.091±0.077) flower · h ^{1} (13h observation) for control plants and (0.023±0.023) flower · h ^{1} (13h observation) for treatment plants, also showing no significant difference ($t = 0.848$, $P = 0.413$). Over two years of observation, pollinator visi-

tation frequency remained consistently low, indicating that *D. sophia* primarily relies on autonomous self-pollination for reproduction.

Discussion

The mating system of *Descurainia sophia* is characterized by high selfing rates. The self-pollen transfer occurs at two stages: when pistils are at the same height as long stamens and when they are shorter than stamens. The pollen loads on stigmas mainly derived from self-pollen.

The small flower size, low P/O ratio, and anther-shaped petals appear to result from decreased resource allocation to floral display and rewards, representing reproductive strategies compatible with self-pollination patterns. The tiny flowers, low P/O value, and anther-like petals may be adaptations reducing investment in pollinator attraction while maintaining reproductive assurance through selfing.

Both anther-shaped petals and persistent calyces showed no advertising effect in attracting pollinators. Control experiments removing petals and persistent calyces revealed no significant difference in pollinator visitation compared to intact flowers, confirming these structures do not function in pollinator attraction.

The high selfing rates (86.52%±1.02%, 89.45%±7.48%, and 91.26%±0.83% across different treatments) and low outcrossing rates (36.11%±1.18%) indicate that *D. sophia* is a facultative selfer, self-compatible but with maintained outcrossing capability. This mixed mating system provides reproductive assurance in the unpredictable pollination environment of arid zones.

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Abstract: Floral syndrome and morphological variability show the adaptability to a variety of pollination modes in angiosperms. *Descurainia sophia*, an early spring ephemeral plant species, possesses the floral design matching with self-pollination due to the small and inconspicuous petals, but the anther-shape-like petals and persistent calyxes seem to have a certain relationship with attracting pollinators. In order to explore the relationship between floral syndromes and pollination patterns, in this study the flowering habits, floral characteristics, advertising effect of petals, mating system and so on of *D. sophia*, a natural population in Xinjiang, were lucubrated based on the field observation and artificial control test. The results showed that *D. sophia* is a facultative selfer, self-compatible with a maintained capability to outcross. On a sunny day, the flowers bloom around 10:00 o'clock and closure around 17:00, and the florescence is for 1-2 days. After blooming, pistils grow continuously and experience three stages: they are lower than stamens, as high as stamens and higher than stamens. There are pollinators of *D. sophia*, but their visiting frequency is extremely low, and the visiting frequency was 0.062 ± 0.027 flower $\cdot$ h ^{1} in 2015 and 0.01 ± 0.005 flower $\cdot$ h ^{1} in 2016. There was no significant difference between the control experiment by removing petals and persistent calyxes and the contrast. Both of the anther-shape-like petals and persistent calyxes have no advertising effect in attracting pollinators. The pollen loads on stigmas mainly derived from self-pollen in *D. sophia*. The self-pollen transfer occurs at the two stages when pistils are the same as height of long stamens and shorter stamens respectively. The tiny flower size, low P/O value and anther-shape-like petals may be the result of decrease of resources allocation invested in floral show and rewards, and also show the reproductive strategies of being compatible with self-pollination

pattern.

Keywords: *Descurainia sophia*; mating system; pollination pattern; floral syndrome

Note: Figure translations are in progress. See original paper for figures.