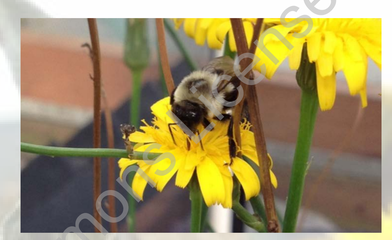

First encounters in a warming world: Floral constancy and shifting plant phenology affect reproductive success of competing plants

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Introduction

Individual bees often show flower constancy, learning to specialize on a floral resource and reluctant to switch to newly available resources[1]. Plant phenologies are shifting in response to climate change, and this may alter the precedence of floral resources bees encounter[2]. Therefore, climate change may indirectly affect the reproductive success of competing flowering plants that are dependent on bee visitation.

We asked whether pollinator visitation and seed set to a plant species increases when it blooms before a competitor.

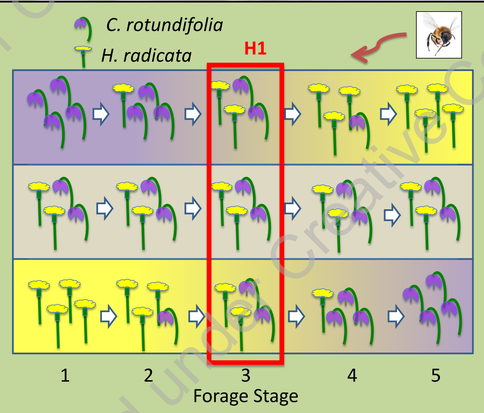
Hypotheses

1. **The overall rate of bee visitation plants receive depends on whether they are introduced first or second.**
2. **There is a time delay for bees start foraging on the second introduced plants.**
3. **Seed set is higher when the plants are introduced first.**

Methods

We used two sympatric plant species, *Hypochaeris radicata* and *Campanula rotundifolia,* whose flowering phenology overlaps in nature. We created three treatments representing 3 phenological progressions of 5 stages, and allowed *Bombus impatiens* to forage on these treatments in greenhouse floral arrays.

Phenology treatments



***C. rotundifolia* first:** 100% *C. rotundifolia,* with gradual increase of *H. radicata* and decrease of *C. rotundifolia*

Simultaneous: equal frequencies of both flower species

***H. radicata* first:** 100% *H. radicata,* with gradual increase of *C. rotundifolia* and decrease of *H. radicata*

40 flowers= 100%

Bee foraging

- 6 bees used in each treatment, 2 bees from each of 3 colonies
- Released for one forage bout at each forage stage, mean duration= min

Seed set

At each forage stage of each treatment, a minimum of 5 flowers of each plant species were marked and bagged after bees finished foraging bout.

Results

1.) When *H. radicata* and *C. rotundifolia* were present at equal frequencies, bee visitation rate were significantly higher to the plant that was introduced first.

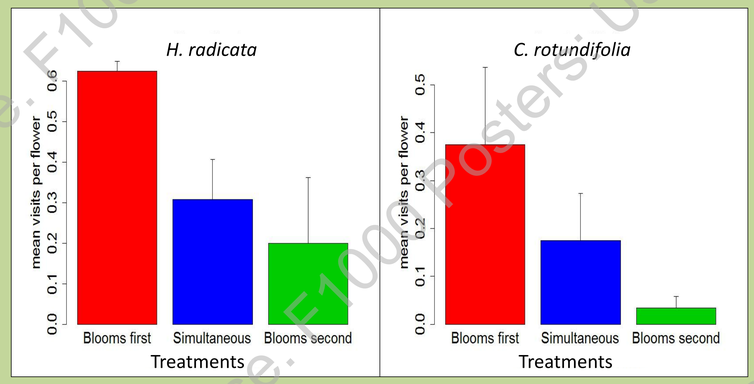
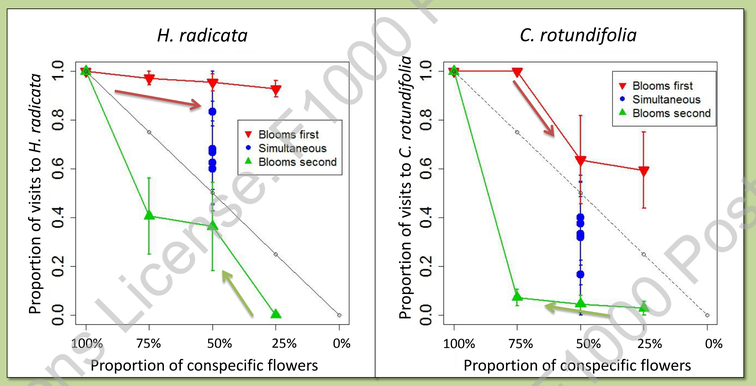


Figure 1. At Forage Stage 3 (50% *C. rotundifolia*/50% *H. radicata)*, mean bee visitation per flower for two flower species when introduced first, second, and simultaneously. For both species, bee visitation was significantly higher than control when introduced first. When *C. rotundifolia* was introduced second, the bee visitation it received was significantly lower than control.

2.) There was a time delay for bees to start foraging on the flower introduced second.

Figure 2. Proportion of bee visits to each flower species with different proportions of competing flowers, when introduced first, second and simultaneously ($P<0.01$). The arrows indicate the direction of Forage Stage.
For both species, when introduced first, the proportion of bee visitation remained higher although the frequency was decreasing. When introduced second, the bee visitation increased slowly and never reached as high as when introduced first.



3.) *H. radicata* seed set was higher when *H. radicata* was introduced first.

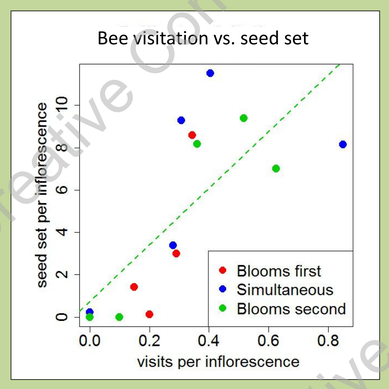


Figure 3. There was a positive correlation between the bee visitation and the seed set to *H. radicata*.

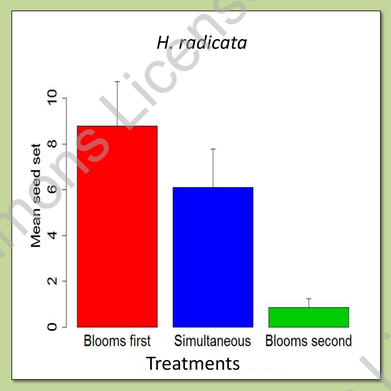
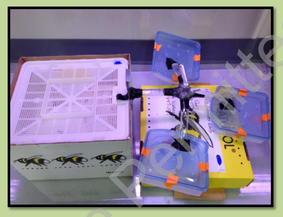


Figure 4. *H. radicata* seed set when introduced first, second and simultaneously. The seed set was significantly higher when *H. radicata* was introduced first than when it was introduced second or simultaneously.

Conclusion

If climate change alters phenological precedence of plant flowering, this may affect the rate of bee visitation and seed set of forbs.

- Bees forage differently in response to the same resources when flower phenological precedence is shifted. Phenological precedence affected visitation more strongly for the less preferred forage species, *C. rotundifolia,* than for *H. radicata*.
- The first plant species to bloom gains an advantage in visitation rate and seed set. Even when the first resource they encounter is eventually less preferred than the second, bees lag in switching to an alternative resource.



Future Questions

- Is it common for phenological precedence of flower species blooming time to switch in nature?
- After the first introduced floral resources become unavailable, will bee visitation rate to the second introduced flowering species eventually achieve the same bee visitation rate as when introduced first?
- If the first introduced flower species is reintroduced after the second introduced floral resources was dominant for a period of time, would the bees switch back the first introduced flower species?

References

1.Waser, N. (1978) Interspecific pollen transfer and competition between co-occurring plant species. *Oecologia* 36:223-236.
2.Cleland et. al. (2007) Shifting plant phenology in response to global change. *Trends in Ecology and Evolution* 22.:357-365.

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