Pollen Thieves (When Good Things Go Bad!)

By: Matt Pieri

Pollination is crucial because it ensures diversity, reproduction and also successful production of fruit. As a matter of fact, the U.S. Forest Service estimates that crops that are pollinated are valued at roughly $10 billion dollars per year! As you can tell, pollination is important not only to the plants and pollinators it benefits, but to us humans as well.

On a surface-level, pollination may seem like a simple phenomenon: visitors pollinate plants and help promote plant reproduction. But not so fast; it's actually way more nuanced than that. Because plants can't move, they need help moving their pollen to have offspring. Pollen can be moved by something abiotic like wind, or something biotic like bumblebees. The current belief is that the more pollen is delivered, the more successful the plant will be in reproducing (Ashman et al 2004).

If a plant does not receive enough pollen, however, it will have difficulty producing offspring, something that is termed "pollen limitation" (Ashman et al 2004). If a plant is subject to said pollen limitation, that essentially means that the plant isn't getting enough pollen or good quality pollen. That is why there's so much interest in seeing how pollen limitation affects plant offspring and diversity. Furthermore, a bulk of scientists' work is dedicated to studying how plants may be able to evolve in order to lower the potentially damaging effects of pollen limitation. If these pollination-dependent plants lose their pollinators, this could lead to decreased reproduction in flowering plants, diversity, and potentially even extinction one day!

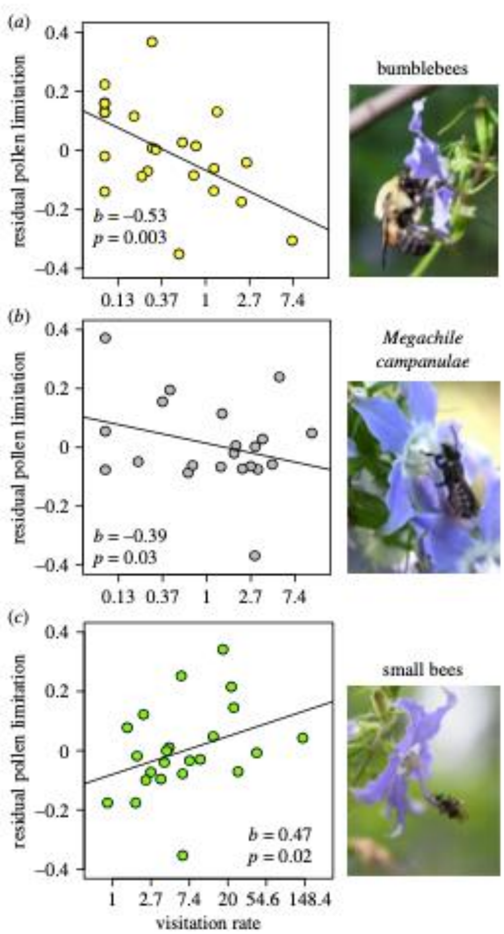
But why does pollen limitation even happen? Some experts suggest that this might have to do with the introduction of foreign plants that compete to be pollinated or loss of local pollinators which normally pollinate a certain area (Ashman et al 2004). Specifically, loss of generalist pollinators (pollinators that are able to pollinate more than one species of plants) poses a great threat because they pollinate many types of plants. The breaking up of a specific habitat, termed habitat fragmentation, may also separate pollinators from recipient plants and leave them stranded. This can occur by pollution, deforestation, and also urbanization, three direct ways in which we humans are jeopardizing pollination. Climate change and other such anthropogenic problems in plant habitats are other potential factors facilitating pollen limitation. In particular, climate change can cause bees and plants to be out of sync where plants bloom earlier than bees emerge from dormancy.

Koski et al 2018 point out that many flowering plants are pollinated by generalist pollinators. However, they also warn that not all pollinators are created equal. In this case, small bees take more pollen than they give to plants! Because of this, the experimenters wanted to better understand how this pollen thievery by small bees impacts plants as well as the visitors that follow after them.

Koski et al 2018 studied the flowering herb *C. americana* and its interaction with the parasitic small bee pollinator. *C. americana* exhibits a phenomenon called protandry, meaning that the plant is first male and then becomes female later. These herbs change from male in the morning to female later on as pollen is collected by visitors and the stigma of the flower begins to curl (Koski et al 2018). Protandry exists to avoid plants from self-pollinating (when a plant's flower is pollinated by its own pollen) due to the fact that self-pollination decreases diversity. As I stated earlier, diversity is highly favorable; thus, protandry makes sure that only pollen from other plants is being used to boost diversity in offspring. Koski et al 2018 also suggest that for such plants that are both male and female, visitors that come to take pollen might prefer those male flowers because they can give good amounts of pollen to visitors without suffering the consequences as much as female plants would (Koski et al 2018).

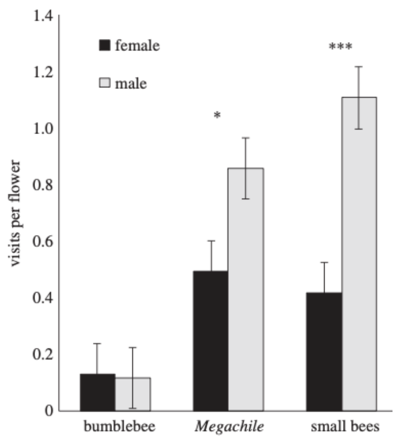
In this study, Koski et al 2018 look not only at the small solitary bee, but also bumblebees and the bellflower resin bee (*Megachile campanulae*) and see how they compare in terms of pollination. Specifically, they investigate how much pollen each species is able to drop off/take away, as well as how this relates to the aforementioned idea of male vs. female phase flowers (how popular it was for the visitors to come to either the male or female). Most importantly, they wanted to see how this impacts their survivability.

The researchers looked at every visitor that came to the plant in a 15-minute time interval from those 3 groups (bumblebee, resin bee, or small bee, as shown in the figure) over 36 hours.



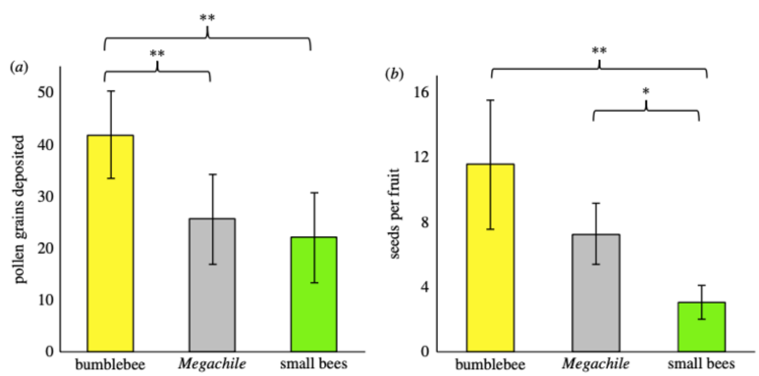
To look more closely at exactly how much pollen was being placed by visitors, they took flowers while they were males, stripped them of pollen, covered the stigmas using a plastic straw with the opposite end sealed, uncovered the flowers when they became females, and looked at how much pollen was placed by visitors. The next step was to look at pollen removal by visitors by observing how many pollen grains were on untouched flowers beforehand. Afterwards, the investigators looked at how many pollen grains remained after visitation. Additionally, they looked at the effect of the pollen left behind by visitors on the plant's fitness by counting how many grains were deposited onto flowers.

The three graphs shown above help illustrate the relationship between pollinator visitation and subsequent pollen limitation. This means that the small bees posed a disadvantage to the plants by taking more pollen than what they were giving, due to the fact that pollen limitation increased as they visited. If you take a closer look at the slopes of each of the graphs, the bumblebees had the steepest line, followed by the small bees, with the resin bees having the least steep line. The steepness of the line refers to how much each bee was able to impact the plant. Essentially, we can note that the bumblebee had a strong impact in reducing pollen limitation, while the small bees had a strong impact in facilitating pollen limitation. Here, decreasing pollen limitation means increasing how 'satisfied' the plants were with the amount/quality of pollen, while increasing pollen limitation decreased their satisfaction with the amount/quality of pollen.



In terms of the sex of the flower, two of the species preferred one sex over the other. Specifically, the resin bee and small bees preferred male plants and visited them more often, while bumblebees had no preference, according to the small grayscale graph to the left. Koski et al 2018 note that sex-specific visitation may be a factor that impacts pollen limitation and the pollination capacity of subsequent visitors to flowers. Because the small bees visit male flowers significantly more than female flowers, they may be exerting a pressure on the herb to change its ratio of floral sex ratios and/or reproduction through evolution.

One of the major trends seen was that, in general, the more pollen that was deposited, the better reproductive success the flower had, as measured by the amount of seeds. You can see this trend really clearly in the pair of graphs provided below: bumblebees deposited the most amount of pollen (left graph), resulting in the most amount of seeds per fruit (right graph), while small bees deposited the least amount of pollen, resulting in the least amount of seeds. In terms of the quantity of the pollen given, bumblebees actually gave 74% more pollen than the other two species, which means that out of these three bees, bumblebees were the most beneficial for this plant (Koski et al 2018).



Koski et al 2018 provide compelling evidence that the type of visitor matters – this can either hurt or help its partner plant! This work is important because it highlights the exploitative nature of the small bee, while demonstrating the beneficial role and importance of the bumblebee. The sex of the plant also did in fact have an effect on where bees decided to visit, as we saw with the data on individual visitor preferences. This may be imposing a pressure on the herb to evolve to avoid unequal visitation in the male phase by parasites like small bees, which may be drastically augmenting the effects of pollen limitation on protandrous plants. The small bee is affecting the potential diversity and reproduction of this herb. Koski et al 2018 also point out another potential issue: since small bees take more pollen than they give, how could they be affecting the capacity of other pollinators to effectively spread pollen? Could the exploitative behavior of the small bee be potentially harming other plants? Exploring these questions might also help to demystify the phenomenon of pollen limitation. By understanding exploitative organisms like the small bee and their effects on pollination, we'll be able to understand how this impacts plants that are dependent on pollination like our $10 billion-dollar crops!

References

Ashman, T., T.M. Knight, J.A. Steets, P. Amarasekare, M. Burd, D.R. Campbell, M.R. Dudash, M.O. Johnston, S.J. Mazer, R.J. Mitchell, M.T. Morgan & W.G. Wilson. 2004. Pollen Limitation of Plant Reproduction: Ecological and Evolutionary Causes and Consequences. Ecology **85**: 2408-2421.

Hargreaves, A. L., L. D. Harder, & S. D. Johnson. 2009. Consumptive emasculation: the ecological and evolutionary consequences of pollen theft. Biological reviews of the Cambridge Philosophical Society **84**: 259–276.

Koski, M. H., J. L. Ison, A. Padilla, A. Q. Pham & L. F. Galloway. 2018. Linking pollinator efficiency to patterns of pollen limitation: small bees exploit the plant-pollinator mutualism. Proceedings. Biological sciences **285**: 20180635.

Lau, J. A., & L. F. Galloway. 2004. Effects of low-efficiency pollinators on plant fitness and floral trait evolution in *Campanula americana* (Campanulaceae). Oecologia **141**: 577–583.

Why is Pollination Important? (n.d.). Retrieved January 14, 2021, from https://www.fs.fed.us/wildflowers/pollinators/importance.shtml

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