How can we use herbarium orchid specimens to track pollinator activity?

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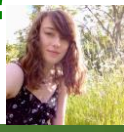


1) Background

Four members of the sexually-deceptive orchid genus *Ophrys* are found in the British Isles;

- *O. apifera* (bee orchid) – self-pollinating here
- *O. insectifera* (fly orchid) – cross-pollinated by *Argogorytes mystaceus* and *A. fargeii* (digger wasps)
- *O. sphegodes* (early spider orchid) – cross-pollinated by *Andrena nigroaenea*
- *O. fuciflora* (late spider orchid) – probably self-pollinating here

Ophrys flowers evolved to mimic female bees in their appearance, scent and texture, thereby attracting male insects. Whilst attempting to mate with the flower, pollen packages called pollinia can become attached to his body. Frustrated by the lack of reciprocity, he leaves to find another 'female'. Part of the orchid's success at tricking males into pseudocopulation comes from timing their flowering to coincide with the period when new naïve males have emerged, but new females have not. So although the male thinks he has come across another female with her head buried in a flower, he actually falls for the orchid again and deposits the pollinia, permitting cross-pollination.

However, environmental change may lead to phenological mismatches; where the timing of orchid flowering may fall out of sync with when most male pollinators are around if their responses differ. Hutchings et al (2018) found significant advances in phenology for one of these orchids and its pollinator. However the peak flight date of female *A. nigroaenea* advances more greatly than that of males', and the advancement of *O. sphegodes* is less than both of them, i.e. all three parties are becoming mismatched with warmer springs. With more female bees and fewer female-mimicking flowers around at the peak of male bee activity, males would encounter actual females more frequently and their attentions would divert away from the competing orchid flowers.

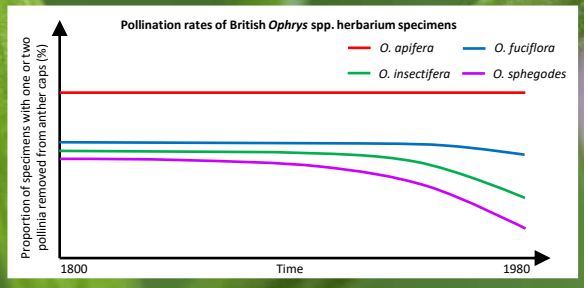
Pollination services might be expected to decline as a result, which could impact populations of cross-pollinating orchids. Breaking down these specific relationships could mean orchids have to:

- Increase their clonal vegetative reproduction rate, reducing the population's genetic quality
- Alter their appearance and scent composition to attract another insect species
- Or maybe even switch to self-pollination like *O. apifera*

Otherwise, failure to reproduce could lead to population decline and potential extinction.

2) How can we look at pollination services more directly?

Herbarium specimens represent a snapshot of historical pollinator activity.
By rehydrating the most basal flower from a specimen and examining it under a dissecting microscope, we can see how many pollinia are present and in which positions.
With over 200 specimens dating from the early 1800s to 1980s, we can directly look at pollinator activity itself, and how it varies, over time, rather than inferring disruption to pollination services from mismatching phenological means.
The graph below shows a simplified version of what we might expect.



We would expect no change in relatively efficient pollination rates of the self-pollinated *O. apifera*, but a decline in the cross-pollinated ones that depend on specific insects and are less efficient. This is because climate change, habitat degradation, land use change and increased pesticide usage etc has led to sharp declines in the abundance of many insect taxa accelerating after the Second World War. Whether *O. fuciflora* shows any decline will shed light on the extent it may be insect-pollinated, as we're not 100% sure it only self-pollinates here. Whether pollinator records nearby at the time of orchid collection can explain any mapped spatial variation in pollination services will also be explored.

3) But can trends in herbarium data apply across the British Isles?

It's all very well having a trend (or not) in data from herbarium specimens, however we can't generalise that to apply across the British Isles unless the specimens are a representative sample of true orchid distributions. Collection bias is rife in herbarium specimens (Daru et al., 2018), for instance sites close to the herbarium's location are usually over-represented whilst remote populations may hardly ever be sampled.
One way to test whether patterns derived from herbarium specimens reflect what is really out there would be to take a contemporary measure of pollinia positions in the field. **If anyone has any such data, it would be a great help to independently validate my models – please let me know!**
Alternatively, the accuracy of species distribution models (SDMs) trained using the herbarium specimens could be compared to SDMs trained with a random sample (to reduce spatial bias) of the BSBI's observational records. If the herbarium-trained model is significantly less accurate, then the collection isn't representative of true *Ophrys* spp. distributions. Therefore, we can't confidently say that patterns seen in the herbarium data reflect what has actually happened across the British Isles.

Please email me for more info or questions. Results will be coming next year!

Bee orchid (*Ophrys apifera*) whose pollinia have swung down from the anther caps, and with a bit of help from wind to conquer gravity, the pollinia will make contact the stigma.
Because this doesn't depend on insects, *O. apifera* can act as a control to compare the insect-dependent orchids to.

References:
Daru et al., B. H. (2017). Widespread biases in herbaria revealed from large-scale digitization. *New Phytologist* 217(2). 939-955.
Harrap, S. (2016). *A pocket guide to the orchids of Britain and Ireland*. London: Bloomsbury.
Hutchings, M. J., Robbirt, K. M., Roberts, D. L., & Davy, A. J. (2018). Vulnerability of a specialized pollination mechanism to climate change revealed by a 356-year analysis. *Botanical Journal of the Linnean Society* 186(4). 498-509.

Herbarium specimen of a fly orchid (*Ophrys insectifera*) collected in Dorset, July 1958. Both of its own pollinia have been removed, but a detached pollinium has been deposited.