Received: 6 January 2025 | Accepted: 14 April 2025

DOI: 10.1002/2688-8319.70045

Ecological Solutions and Evidence

DATA ARTICLE

A dataset of pollen production for 168 common flowering plants in the United Kingdom

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Funding information
Biotechnology and Biological Sciences Research Council (BBSRC); Department for Environment, Food and Rural Affairs (DEFRA); Natural Environment Research Council (NERC), Grant/Award Number: NE/L002434/1; Scottish Government; Wellcome Trust; The Lady Emily Smyth Scholarship Foundation from the University of Bristol

Handling Editor: Bethanne Bruninga-Socolar

Abstract

1. Nectar and pollen are the two main floral resources consumed by bees, hoverflies and some other flower-visiting insects. However, most existing datasets on floral resources focus on nectar production, and pollen is usually overlooked.
2. We quantified pollen production for 168 common plant species found in the UK.
3. Our dataset consists of pollen volume per flower, calculated from the number of pollen grains and the volume of a pollen grain. Detailed data collection protocols are presented.
4. *Practical implication.* This pollen dataset provides a means to identify the high pollen producing species for pollinator conservation purposes, and to estimate pollen production at larger spatial scales when combined with field surveys.

KEYWORDS
conservation, floral resources, floral traits, flowers, nectar, pollen, pollination, pollinators

1 | INTRODUCTION

Flowering plants and pollinators are engaged in a mutualistic relationship where both partners potentially benefit from interacting. Pollinators carry pollen grains between plants, thereby enabling plants to reproduce, while plants offer food resources, mainly nectar and pollen, needed by pollinators for nutrition. In conjunction with pesticides, a lack of floral resources is suspected to be one of the main causes of pollinator decline (Goulson et al., 2015). Pollinator conservation ideally requires measurement of the nutritional value of floral resources, both qualitatively (i.e. biochemical composition) and quantitatively (i.e. amount produced), to identify plant species best suited to feeding pollinators in order to design effective flower mixes (Hicks et al., 2016; Ouvrard & Jacquemart, 2018; Scheper et al., 2013). However, quantifying floral resources and their value to pollinators is not straightforward. Nectar and pollen production by plant species has been identified as the two floral traits with the most missing data in the literature (Lanuza et al., 2023).

After early studies documenting nectar production for a few species (Corbet et al., 1979; Petanidou & Smets, 1996), datasets became available for much larger species sets (Baude et al., 2016; Comba, 1999; Filipiak et al., 2022; Ion et al., 2018; Raine &

Chittka, 2007; Tew et al., 2023) which, when combined with floral surveys, make it possible to estimate community-level resource provision. Thus, Baude et al. (2016) provided a nationwide picture of the nectar sugar available to pollinators over time in the UK, and Timberlake et al. (2019, 2024) used this data to identify seasonal hunger gaps for pollinators in farmlands, and to test whether bumblebees use a greater range of plant species than expected if they foraged in proportion to resource availability.

In contrast to nectar, patterns of pollen availability in landscapes are usually derived from the pollen collected or stored by specific insect species (e.g. Bertrand et al., 2019; Danner et al., 2017; Kratschmer et al., 2020). With a few rare exceptions (e.g. Hicks et al., 2016; Jachuła et al., 2022; Wright et al., 2024), quantification of pollen production of landscapes is rare as the vast majority of landscape scale resource assessments have considered nectar alone. Pollen is arguably at least as important a resource; as while nectar may be the main source of energy for adult bees, pollen is essential for larval development (Nicolson, 2011; Vaudo et al., 2018). Moreover, while the nectar and pollen offered by a flower (or a floral unit) are correlated on average (Wright et al., 2024), there are notable exceptions. For instance, poppies (*Papaver* spp.) and meadowsweet (*Filipendula ulmaria*) provide substantial pollen resources for pollinators, but they produce little or no nectar.

Here we present a dataset of pollen production per flower for 168 common plant taxa found in the UK. These pollen production values match the nectar data provided in Baude et al., 2016 (most were collected at the same time, in the same places), allowing the two floral resources to be considered simultaneously. After describing the methods used to collect the data, we explore some general patterns and provide usage notes of the dataset.

2 | MATERIALS AND METHODS

Pollen production per flower was quantified as pollen volume, following a multi-stage protocol involving the collection of stamens, extraction of pollen grains from stamens, counting of pollen grains, and measurement of pollen grain size to estimate pollen grain volume (adapted from Kearns & Inouye, 1993; Potts et al., 2003).

2.1 | Plant taxa and field sites

Using the list identified in Baude et al. (2016) of the commonest plant species in the UK that potentially offer floral resources to pollinators, we collected stamens for 174 taxa, and we were able to quantify pollen production for 168 of them. The fieldwork took place in the south of England, mostly in Bristol or within a day's travel of Bristol (field sites where nectar collection was carried out). Fieldwork was conducted in agreement with local practitioners, but no licence or permit was required. Stamens of 105 plant taxa were collected from at least 2 locations (including 5 plant taxa from 3 locations) and 69 plant taxa from 1 location. 164 plant taxa were sampled in 2011 and/or 2012, and 10 were sampled in 2022.

2.2 | Stamen collection

Plant stems with a high number of buds were collected in the field and transported to the laboratory. After removing any open flowers, the stems with the remaining buds were placed in water. After 24–72 h, stamens ready to open or very freshly opened were cut from different flowers collected from the same location with microscissors or tweezers and transferred to a centrifuge tube containing 1000 μL 70% ethanol, taking care not to lose any pollen. For species with large stamens (ex. *Iris pseudacorus*, *Calystegia sepium*), a total of 1–30 stamens full of pollen were put into each tube, while for species with very small stamens (e.g. Asteraceae species such as *Taraxacum* or *Bellis* species), 10–30 whole florets were put into each tube. Two to 6 tubes were prepared for each species (a minimum of one tube per location).

2.3 | Pollen extraction

Pollen extraction from stamens was based on sonication and successive rinsing. Tubes were vortexed for 30 s and sonicated in an ultrasonic bath for a further 10 min to liberate pollen grains. The solution containing pollen grains was transferred by pipetting to a new tube. The remaining anthers were washed by adding 400 μL of ethanol into the tube, which was then vortexed again to put any remaining pollen grains into solution. This solution was added to the new tube and, if necessary, the process was repeated once more with 200 μL ethanol to wash any remaining pollen off the stamens. The stamens were then checked to ensure that they were free of pollen using a binocular microscope.

The tube containing the ethanol solution with pollen grains was centrifuged for 10 min at 14 rcf (relative centrifugal force) and the ethanol supernatant was poured off, leaving a pellet of pollen. These were placed in an oven at 60°C for 30–90 min to evaporate the alcohol. Tubes with a dried pellet of pollen were stored in a refrigerator until the counting stage.

2.4 | Pollen grain counting

A set volume of ethanol (60–1000 μL, judged by eye and depending on the size of the pollen pellet) was added to each tube containing dried pollen and these were vortexed and pipetted in and out to homogenise the solution. 20 μL of this solution was poured into a modified Fuchs-Rosenthal counting chamber, making sure that pollen grains were spatially well distributed and did not exceed 20 grains per grid square; samples were further diluted if this was the case.

Pollen grains were counted under ×100 magnification until a total of at least 500 grains was reached, when possible. The number

of grains counted was noted along with the corresponding number of small grid squares counted to reach this number. This counting process was repeated twice in order to provide two replicates per sample. These values were used to calculate the concentration of pollen grains per the suspension volume corresponding to the number of counted grid squares (i.e. 20 µL for a whole grid counted), and by extrapolation to calculate the quantity of pollen grains from the whole volume of solution contained in the tube. The mean number of pollen grains per stamen can then be estimated for each species.

2.5 | Pollen grain volume

The measurement of pollen grains was done with a light microscope equipped with a calibrated ocular micrometre under a minimum magnification of ×100. The length of major and minor axes was measured for five pollen grains from each species. Only undamaged grains were used, that is, if the grain was collapsed or deformed, it was not measured. All pollen grains were considered as ellipsoids (or spheroids if major and minor axes were equal). The volume of one pollen grain was then calculated according to the formula:

$$V = \frac{1}{6} \times \pi \times b^2 \times a$$

with the volume of one pollen grain noted V (in µm^3), the major (or polar) axis equal to 'a' (in µm), the minor (or equatorial) axis equal to 'b' (in µm). The mean volume of pollen grain was then calculated for each species (Roulston et al., 2000).

2.6 | Pollen volume per flower

The volume of pollen produced per flower was calculated by multiplying the average pollen grain volume by the number of pollen grains per stamen, and this, in turn, was multiplied by the mean number of stamens per flower (usually counted on five of the field-collected flowers, but occasionally values from the literature were used to fill the gaps). For dioecious species, a correction factor was applied to take account of the fact that female flowers produce no pollen; in the absence of better information, we assumed that 50% of flowers were female for these species.

3 | USAGE NOTES

This dataset provides a number of options for use:

1. The pollen data could be used to study the relationships among floral traits (Genty et al., 2023; Roddy et al., 2021), in particular between pollen and nectar.
2. Combined with floral longevity data (Song et al., 2022), the pollen volume data divided by the number of days a flower remains open can be used to estimate pollen production per plant species per unit time (e.g. Wright et al., 2024).
3. Combined with floral abundance counts, the pollen data can be used to estimate pollen production at a variety of spatial scales. Unlike nectar, this approach has been rarely used for pollen, except for some farm habitats (Dicks et al., 2015; Jachuła et al., 2022; Wright et al., 2024) and urban flower meadows (Hicks et al., 2016).
4. Considering pollen values, together with nectar and other floral traits related to flower attractivity, accessibility and phenology will improve tools for selecting functionally important plant species (e.g. Cresswell et al., 2019; Glenny et al., 2023; M'Gonigle et al., 2017) for inclusion in pollinator-friendly plant schemes for conservation, restoration or provision of multiple ecosystem services (Wäckers & Van Rijn, 2012; Windsor et al., 2021). Combined with the biochemical composition of pollen that is becoming available (e.g. Zu et al., 2021), pollen production values could be taken a step further to develop nutritionally balanced planting schemes (e.g. containing the essential amino acids, proteins or sterols) needed by insects.

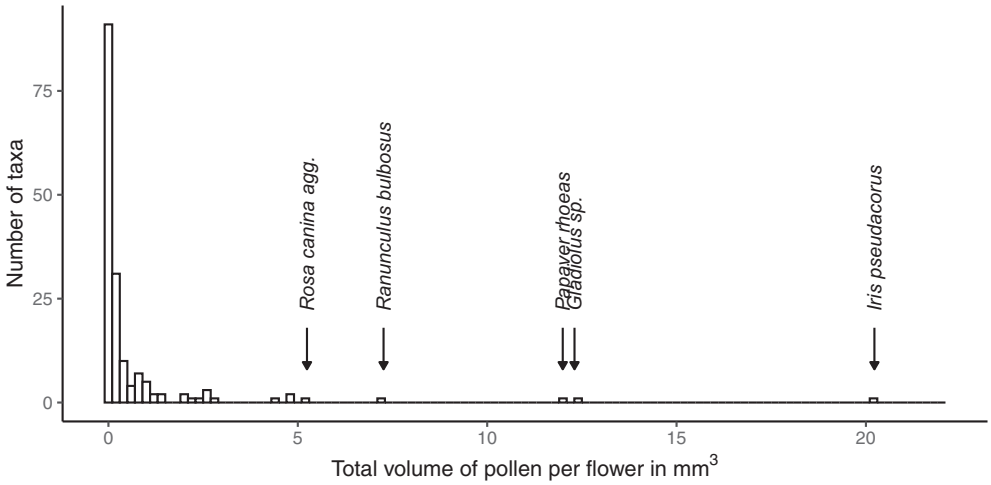

FIGURE 1 Total pollen volume produced per flower (in mm^3) of taxa (after dicliny correction).

4 | GENERAL PATTERNS

Our dataset includes pollen production values for 168 plant taxa belonging to 128 genera in 46 families. The median value for the total volume of pollen is 0.0774 mm^3/flower after correcting for the dioicous species (0.0906 mm^3/flower before correction) and its mean value is 0.7192 mm^3/flower after correction (0.7298 mm^3/flower before correction). Pollen production values ranged from a volume of 0.0003 mm^3 per flower for *Medicago lupulina* to 20 mm^3 per flower for *Iris pseudacorus* (Figure 1), a more than 60,000-fold range. This corresponds to 60 pollen grains per flower (6 per stamen) for *Medicago lupulina* and 85,196 pollen grains per flower (28,399 per stamen) for *Iris pseudacorus*. *Papaver rhoeas* and *Impatiens glandulifera* reached the maximum in terms of pollen grain number produced per flower with 1,932,588 and 941,622 grains, respectively (Figure 2). The volume of one pollen grain varied from 1.8406^{E+1} μm^3 for *Myosotis arvensis* to 1.3053^{E+6} μm^3 for *Epilobium hirsutum* (Figure 3), with a mean value of 3.65^{E+4} μm^3 (median = 1.08^{E+4}) across the species.

5 | RELATED WORKS

Most of the pollen data reported in this document were collected at the same time as the nectar sugar values in Baude et al. (2016), and consequently, a large number of taxa (157 taxa) are shared between the pollen and nectar datasets. The nectar data was deposited in the NERC Environmental Information Data Centre (https://doi.org/10.5285/69402002-1676-4de9-a04e-d17e827db93c) at the time of the publication of Baude et al. (2016).

Subsets of the data have been published as follows:

1. Data on three species were used for calculating potential pollen production of monospecific hedgerows of *Prunus spinosa* or

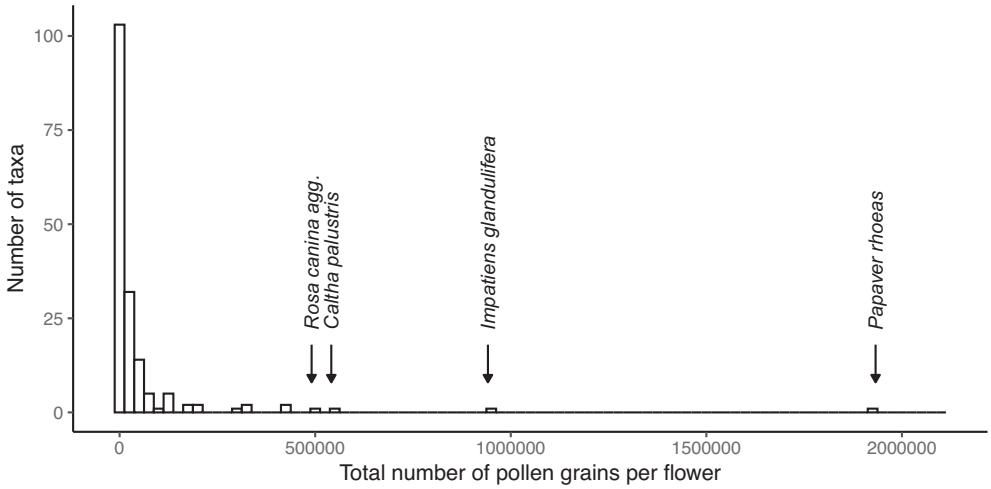

FIGURE 2 Total number of pollen grains per flower of taxa.

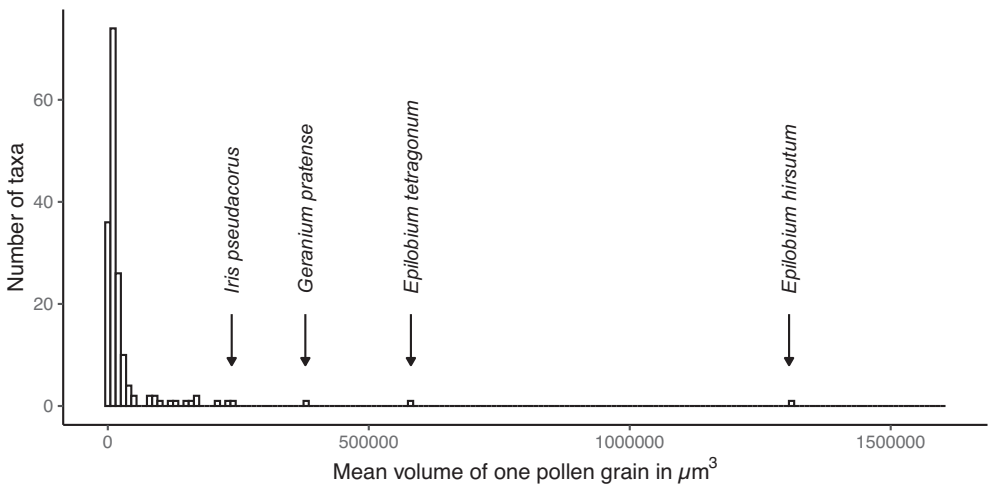

FIGURE 3 Mean volume of one pollen grain (in μm^3) of taxa.

Crataegus monogyna, and grass swards with *Trifolium pratense* by Dicks et al. (2015).

2. A subset of pollen dataset (53 species) was used to estimate seasonal pollen supplies on UK farms (Timberlake et al., 2020) and 38 species to analyse foraging patterns of bumblebees in relation to floral resources availability estimations (Timberlake et al., 2024).
3. In combination with floral longevity data, daily pollen production has been calculated for 72 species from this pollen dataset and has been used to calculate the pollen productivity of four farmland habitats (Wright et al., 2024).

AUTHOR CONTRIBUTIONS

William Kunin and Jane Memmott conceived the original ideas. Mathilde Baude, Jane Memmott and William Kunin designed the methodology. Mathilde Baude, Nancy Davies and Ellen Wright collected the pollen data. Mathilde Baude led the analyses and the writing of the manuscript. All authors contributed critically to drafts and gave final approval for publication.

ACKNOWLEDGEMENTS

This work was supported by the UK Insect Pollinators Initiative (IPI) 'AgriLand: Linking agriculture and land use change to pollinator populations' project, funded by the Biotechnology and Biological Sciences Research Council (BBSRC), Wellcome Trust, Scottish Government, Department for Environment, Food and Rural Affairs (DEFRA) and Natural Environment Research Council (NERC) under the auspices of the Living with Environmental Change partnership: grant BB/H014934/1 and by the Lady Emily Smyth Scholarship Foundation from the University of Bristol and the UK Natural Environment Research Council (NERC) through the NERC GW4+ Doctoral Training Partnership (NE/L002434/1).

CONFLICT OF INTEREST STATEMENT

The authors have no conflict of interest to declare.

PEER REVIEW

The peer review history for this article is available at https://www.webofscience.com/api/gateway/wos/peer-review/10.1002/2688-8319.70045.

DATA AVAILABILITY STATEMENT

The dataset associated with this publication, along with information for its use, is available from the NERC Environmental Information Data Centre https://doi.org/10.5285/0b454d53-dfe7-48fd-9e18-b683d004b159 (Baude et al., 2025).

RELEVANT GREY LITERATURE

You can find related grey literature on the topics below on Applied Ecology Resources: Conservation, flowers, pollination, pollinators.

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How to cite this article: Baude, M., Kunin, W., Davies, N., Wright, E., & Memmott, J. (2025). A dataset of pollen production for 168 common flowering plants in the United Kingdom. *Ecological Solutions and Evidence*, *6*, e70045. https://doi.org/10.1002/2688-8319.70045