

How does Pollination affect the Reproduction of Isolated Wild Plants in Arable Ecosystems?



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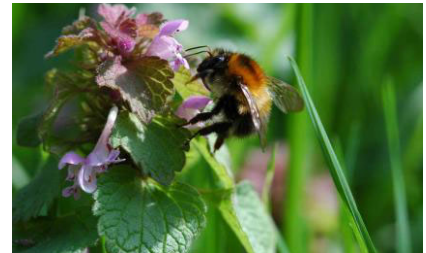
Penny Fletcher, John Cussans, Juliet Osborne (Plant And Invertebrate Ecology, Rothamsted Research), Alice Mauchline And Simon Potts (Centre For Agri-Environment Research, University of Reading)

Introduction

Threats to pollination services (1) have accompanied the significant biodiversity losses resulting from agricultural intensification (2). Such losses have included declines in insect-pollinated plants and their pollinators (3) Concerns about the long-term implications of this on the Earth's ecosystems and human well-being have led to increased research on various aspects of pollination biology and ecology as well as policy interest in conserving this essential ecosystem service (4).


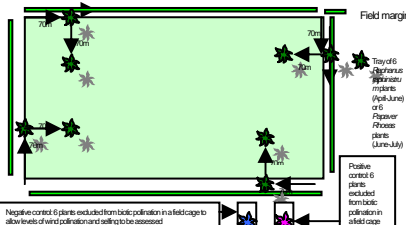



Plants in a range of ecosystems have been shown to have reduced seed outputs as a result of pollination deficit (5,6). This phenomenon is called 'Pollen Limitation and is defined as: 'An inadequate quantity or quality of pollen (that) can reduce plant reproductive success' e.g. as a result of fewer pollinator visits (7).

Wild plants of agricultural habitats have shown significant declines since the 1940s (2) and a significant number are now rare (8). Arable fields have increased in size as agricultural production has intensified and wild plant species growing in arable fields occur at low densities compared to the margins (9). This means arable plant individuals or small aggregations are often isolated from sources of pollen and pollinators (10). Several studies on pollen limitation indicate this makes such plants vulnerable to pollen limitation (5,7,11). This research will quantify for the first time the relationship between pollination and reproduction in wild arable plants that are growing in the body of an arable crop and will indicate whether isolation causes them to be pollen limited. The effect of different arable growing situations on this relationship and on long-term viability of populations will be investigated for two contrasting self-incompatible insect-pollinated plants.



Hypothesis

In my first field season I will be testing the hypothesis that reproductive output is reduced as a result of pollination deficit in isolated individuals of wild plant species in arable fields.

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| <p><i>Raphanus raphanistrum</i> (Wild Radish)</p>  | <h3>Method</h3> <p>Manipulative field experiments will be carried out to determine the effect of distance from the field edge on pollinator visitation and plant fecundity. Small aggregations of glasshouse-raised <i>Raphanus raphanistrum</i> and <i>Papaver rhoeas</i> plants will be placed at different distances from the edges of weed-free winter wheat fields, as shown in figure 1.</p>  <p>Figure 1: Experimental design. This will be replicated in four fields in the St. Albans area over approximately 8 weeks. Further replication will be achieved by placing 2 consecutive sets of each species in the arrangement shown - i.e. Weeks 1-2: <i>R. raphanistrum</i>; Weeks 3-4: <i>R. raphanistrum</i>; Weeks 5-6: <i>P. rhoeas</i>; Weeks 7-8: <i>P. rhoeas</i>.</p> | <p><i>Papaver Rhoeas</i> (Field Poppy)</p>  |
| <ul style="list-style-type: none"> • Cruciferae (Brassicaceae) • Common annual weed in UK • Tap root and white or yellow cruciform flowers (4-10 per plant; flowers last a day) • Flowers between May and October • Variety of different pollinators including social and solitary bees, wasps, flies and occasionally butterflies and other pollinators (Clapham et al., 1987). • Pod-like fruits produce 1- 12 seeds  | <h3>Observing insect visitation rates to assess pollinator activity</h3> <p>Each set of experimental plants will be exposed to pollinators in the experimental fields for 2 weeks.</p> <h3>Measuring seed-set to determine effect on plant fecundity</h3> <ul style="list-style-type: none"> • In experimental plants Seeds will be collected from marked pods/capsules of experimental plants. The significance of any observed differences in seed-set from isolated vs. non-isolated plants will be determined. • In control plants Field-caged control plants excluded from animal pollinators will be placed in the margins of each field to allow the contribution of biotic pollination to the observed differences in seed-set between the isolated and non-isolated plants to be determined. One patch of field-caged plants will be hand-pollinated and the seed-set measured to indicate the maximum potential of pollination to influence fecundity. The other patch will be left without any cross-pollination to determine levels of seed production occurring in the absence of biotic pollination (i.e. through selfing and/or wind). <h3>In natural aggregations of poppy</h3> <p>Seed-set will also be measured in naturally occurring isolated and non-isolated aggregations of poppy in non-experimental cereal fields. Seed collected from bagged individuals in each patch will provide minima and maxima pollination levels as in the experiments. This will demonstrate the contribution of biotic pollination to wild poppy fecundity</p> | <ul style="list-style-type: none"> • Papaveraceae family • Native species commonly found growing as a weed in arable fields • Slender tap root and branched stems, ranging in height from 20 to 60cm. • Solitary flowers; June to October; usually scarlet. • Pollinated by various bee species; <i>Halictus sexnotatus</i>, <i>H. flavipes</i>, <i>H. longulus</i>, <i>H. cylindricus</i>, <i>H. maculatus</i>, <i>Andrena dorsata</i> and <i>A. fulvicrus</i>; • Other visiting insects observed included a Syrphid species and various herbivorous Coleoptera and Orthoptera (Müller, 1883). • Capsule-like fruits produce c. 1300 seeds (Salisbury, 1961)  |

Future work

The effect of other factors of growing situation on pollination efficiency will be investigated in subsequent seasons of field experimentation. The impact of apparency above the crop, the type of background crop and size of wild plant aggregation will be measured and the results integrated into plant population dynamics models to improve the accuracy of their predictions about the long-term viability of plant populations.



Significance and Wider Context

Information obtained about the occurrence and extent of pollen limitation in wild arable plants in different growing situations will contribute to our understanding of the population dynamics of rare wild plants. Ultimately this can lead to the development of agri-environment initiatives that help ensure their long-term survival and their ability to provide essential resources to other important biodiversity such as BAP-targeted Farmland Birds.

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References
 1. Buchmann, S.E. and G.P. Nabhan, 1996. Washington D.C.: Island Press.
 2. Robinson, R.A. and W.J. Sutherland. *Journal of Applied Ecology*, 2002. 39(1): p. 157-176.
 3. Biesmeijer, J.C., et al. *Science*, 2006. 313(5785): p. 351-354.
 4. Dias, B.S.F., A. Raw, and V.L.L. Fonseca 1999. Brazilian Ministry of the Environment: Brasilia.
 5. Agren, J., Population size, pollinator limitation, and seed set in the self-incompatible herb *Lytium salicaria*. *Ecology*, 1996. 77(6): p. 1779-1790
 6. GAGUILAR, R., ASHWORTH, L., GALETTO, L. & AIZEN, M. A. (2006) Plant reproductive susceptibility to habitat fragmentation: review and synthesis through a meta-analysis. *Ecology Letters*, 9, 968-980.
 7. Ashman, T.L., et al. *Ecology*, 2004. 85(9): p. 2408-2421.
 8. JNCC. *JNCC Annual Review 2005-2006*. Soft cover. 2006. p. 64pp.
 9. Marshall, E.J.P. *Journal of Applied Ecology*, 1989. 26(1): p. 247-257.
 10. Cussans, R.D. et al. *Weed Science*, 2002. 50(4): p. 542-546.
 11. Gibson, R.H., et al., Pollinator webs, plant communities and the conservation of rare plants: arable weeds as a case study. *Journal of Applied Ecology*, 2006. 43(2): p. 246-257.