Sustainable Pollination Services for UK Crops

A BBSRC funded study

Insects as pollinators

Insects are pollinators of more than 80% of crop species in Europe, including most fruits, many vegetables, and some biofuel crops. Globally this pollination service has an economic value of approximately £120 billion and a value to the UK alone in the region of £690 million each year.

Wild vs managed pollinators

Crop pollination services can be provided by wild pollinators (bees, hoverflies, moths, flies, beetles) or managed bee species (most frequently the honey bee). Globally, western agriculture has traditionally relied on the honey bee as a pollinator species, a strategy that is not without its risks as honey bees are increasingly vulnerable to pathogens and environmental pressures, with a 54% decline in colonies observed between the years 1985 to 2008. An impact of this is the decrease in colonies available for crop pollination. In contrast with the US for instance, where hives are specifically managed to provide pollination services, in the UK most bee-keeping is small scale and geared towards honey production. There are only enough honeybee hives within the UK to pollinate a third of crops, therefore the main pollinators are wild insects[1].

Wild pollinators, living in agricultural landscapes, have long provided 'free' crop pollination services that have been largely taken for granted. The value of wild insects to pollination of agricultural crops is difficult to quantify, but several studies have demonstrated that diverse native pollinator communities make a greater contribution to crop production than honeybees, and wild bees are more efficient pollinators than honey bees for some crops. As observed with managed species of bee, there is evidence for geographically widespread declines in solitary bees, bumblebees, and some hoverflies, but little is known about how changes in insect density or diversity affect the level of crop pollination provided.

Implications of pollinator decline

The observed declines in both wild pollinators and in managed honey bees have significant potential implications for UK agricultural production yet, perhaps surprisingly, there exists a lack of basic information on how diversity and abundance of pollinating insects contribute to seed/fruit yield and quality, and how climate change will affect pollination service need and provision.

Image provided by Jake Bishop.

Crop production

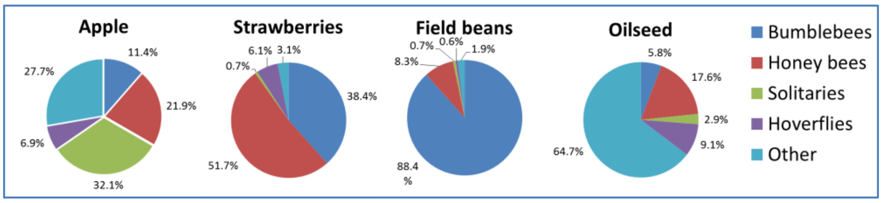

Figure 1. Percentage of visits made by different pollinators to flowers of four crops (data from Garratt M.P.D., et al., (2014)[1] and Garratt M.P.D. (2013)[2]

In order that mitigation measures can be appropriately targeted, it is necessary to establish which insects are primarily responsible for the pollination of different crops. The first part of this study, therefore, aimed to determine which pollinators, wild and managed, contribute to the pollination of four key UK crops: apples; strawberries; field beans; oil seed rape. As illustrated in Figure 1, left, pollinator surveys conducted on farms across the UK demonstrated that there exists much variation in the insects responsible for pollination of these crops. Some crops, such as apples, appear to utilise a diverse range of pollinators, while others, such as field beans, are primarily visited and pollinated by bumblebees. Pollinator communities also appear to be very crop-specific, explained partially at least by the different morphology of the flowers on these plants.

Crop yield, quality, and economic value

Apples are one of the major fruit crops to rely on insect pollination, with wind- and self-pollination of little significance in this crop. It is estimated that through pollination services wild insects contribute a total of £36.7 million per annum to Cox and Gala production in the UK[3]. Despite this, previous studies have focussed on the benefits of pollination to crop yield, with the benefits to quality, and how this translates in economic terms, largely ignored. Identifying and addressing the cause of any pollination deficit could result in improvements in not only yield but also quality and value.

In this study, the influence of insect pollination on yield and quality of two varieties of UK apple was quantified to determine if either is limited by sub-optimal pollination. Blossoms were assigned to one of three treatments: pollination by hand; pollination by the natural insect community; exclusion of insect pollinators. The number of apples 'setting' on each experimental branch was subsequently recorded, and data was collected on apple weight, seed number, maximum width, firmness, and brix (sugar content).

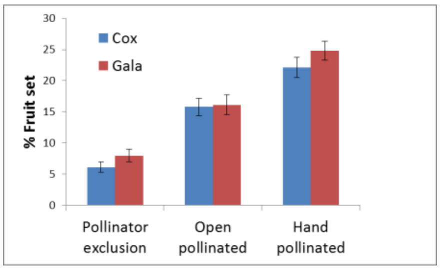

Figure 2. The effect of pollination method on fruit set at harvest. Garratt M.P.D., et al., (2014)[3].

The fundamental importance of insect pollination to UK apple production is illustrated (figure 2) by the reduction in the percentage of fruit set following pollinator exclusion in both apple varieties. Effects on quality are, in contrast, variety-specific, with Gala apples, but not Cox, showing improvements in size and weight following insect pollination.

Adding value

Continued pollinator decline is likely to have serious financial consequences for the apple industry but there exists scope to improve the quality of production through management of wild pollinators. For Gala apples, given the influence of pollination on both yield and quality, a potential pollination deficit has been found and there exists the potential for improved insect pollination services to increase UK output by up to £5.7 million per year[3].

Mapping landscapes

An understanding of the distribution of insect pollinators is essential for estimating their availability to pollinate crops, but existing knowledge of where these pollinators occur is limited. Using records of wild and managed pollinators, plus agricultural data, bioclimatic, topography and pesticide usage data, species distribution models for crop pollinators were developed. The map in figure 3 shows the UK pollination service available to field beans from wild pollinators. Areas where there is a geographical mismatch between crop pollination demand and the availability of pollinators are evident; these areas are potentially vulnerable to low service provision and this is where mitigations actions should be targeted.

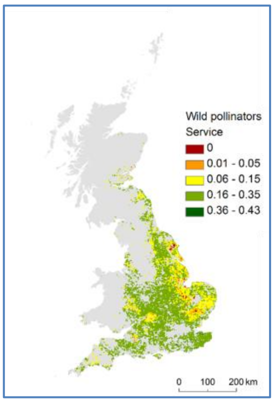

Figure 3. Total potential pollination service to field beans from wild pollinators. Polce, C., et al. 2013[4].

Insect-friendly landscapes for the future

Insects need a place to nest and resources to support them throughout their active adult life. The more diverse a landscape the more ecological niches it will contain and the more diverse a pollinator community it will support. Lack of a suitable landscape is a limiting factor in ensuring that sufficient insect pollinators are available to meet the demands of many commercially important UK crops. Identifying the contributions of insect pollinators to the success of different crops, in conjunction with the development of species distribution models for crop pollination, can provide a tool for identifying suitable strategies to ensure that crop pollination services are maintained at a level sufficient to meet the needs of the UK agricultural industry. Reducing pollination deficits will be dependent on ensuring that mitigation strategies are matched to crop type[5] and is likely to include promoting pollinator-friendly management practices on farms and in the wider landscape to improve crop pollination services.

[1]Breeze T.D., Bailey A.P., Balcombe K.G., Potts S.G. (2011) Pollination services in the UK: how important are honeybees? Agriculture, Ecosystems and Environment 142: 137–143.

[2]Garratt M.P.D. (2013) Sustainable pollination services for UK crops. Antenna. 37 (1): 39-41.

[3]Garratt M.P.D., Breeze T., Jenner N., Polce C., Biesmeijer J.C., Potts S.G. (2014) Avoiding a bad apple: insect pollination enhances fruit quality and economic value. Agriculture, Ecosystems and Environment 184: 34-40.

[4]Polce C., Termansen M., Aguirre-Gutierrez J., Boatman N. D., Budge G. E., Crowe A., Garratt M. P., Pietravalle S., Potts S. G., Ramirez J. A., Somerwill K. E., and Biesmeijer J.C. (2013) Species distribution models for crop pollination: A modelling framework applied to Great Britain. PLOS ONE 8 (10): e76308

[5]Garratt M.P.D., Coston D.J., Truslove C.L., Lappage M.G., Polce C., Dean R., Biesmeijer J.C., Potts S.G. (2014) The identity of crop pollinators helps target conservation for improved ecosystem services. Biological Conservation 169: 128-135