Seasonal wastage of nectar and pollen

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Half the nectar and pollen produced by autumn-flowering ivy is uncollected by bees and other flower-visiting insects.

Honey bees obtain almost all of their food supply from flowers in the form of nectar and pollen. The main exception to this is honeydew, the sugary excretions of aphids and other sap-feeding insects. In some parts of Europe, honeydew can be a major resource and lead to honey crops from flowerless trees such as larch or pine.

Nectar and pollen resources probably set an upper limit to bee abundance. Although other insects also visit flowers for food, it is not their total food source. For example, caterpillars normally feed on leaves while (only) the adult butterflies and moths visit flowers, which are mainly an energy source. By contrast, bee larvae also feed on pollen and nectar, collected from flowers by the adults, whether placed directly into brood cells, as with many solitary bees and bumblebees, or indirectly in the form of brood-food secretions made by the workers, as in the honey bee.

There is currently much interest and concern about the bee food supply. This is understandable given the reductions in wild flowers that have occurred in Britain. There are now fewer hay meadows, hedgerows, heather moors and agricultural weeds. But when do bees need food and when is the food in short supply? Is it all year round and constant, or variable between months and seasons? Is it ever in surplus?

Clearly, bees do not need flowers all year round as there is essentially zero bee foraging in winter, when there are very few or no flowers. Both the flowers and the insects are adapted to our temperate climate and each other. Honey bees are one of the few flower-visiting insect species that forage in winter. However, this is a minor activity and occurs mainly on non-native garden plants during the few days warm enough for bees to venture out. Not being able to forage in winter is not a problem to honey bees as they have evolved the ability to store large amounts of honey to take them through the cold flowerless period. But what about the seasons of spring, summer and autumn when bees and other flower visiting insects are actively foraging, and flowers are available? Is it equally challenging for bees to find food in these three seasons?

Seasonal variation in food supply and demand has been a focus of much LASI research for over ten years. The first project to address this question involved decoding honey bee waggle dances made by workers in colonies housed in observation hives over two years from spring to autumn (Couvillon et al, 2014). The results showed that, on average, honey bee foragers flew further to flowers in summer (2.2km) than in either spring (0.5km) or autumn (1.3km). Given that bees prefer to forage close to the hive, the conclusion (surprising to many people) was that summer is a more challenging foraging season than spring or autumn.

Summer foraging

Summer has better weather generally than spring or autumn, and also longer days and more foraging hours. But this does not mean that the foraging is easier or more profitable in terms of the amount of food collected per foraging bee per hour. In particular, in summer there are more insects on the wing searching for nectar and pollen, so resources are under more pressure. Furthermore, summer is not the period of main bloom. For sheer flower abundance, spring is the best season, with large numbers of dandelions, tree and shrub blossom, oilseed rape and many other garden and wild flower species. If you walk around in spring looking at flowers, it can seem that there are many flowers but few insects visiting them.

Further LASI research has investigated the seasonal food supply question in various ways. In one project we determined the energetics of foraging bumblebees and honey bees in high summer on five species of flowers (Balfour et al, 2021). It turned out that the bees were on a very challenging energetic tightrope. Approximately half the energy they obtained from the nectar collected was consumed simply in moving around the flower patch. In summer, a flower has little time to secrete nectar before it is revisited by another insect, meaning that the amount of nectar in each flower can be very small, with the nectar being gathered almost as soon as it is secreted.

In an August project studying bee foraging on lavender, which has flowers that are highly attractive to bees, flowers had only

minute amounts of nectar in them, 0.007 microlitres (Balfour et al, 2015). A honey bee would need to visit several thousand to fill its crop. In fact, it would have to visit many more than this as much of the nectar sugar would be used as fuel to fly from flower to flower. The volume of nectar per flower was so low that few honey bees visited lavender flowers and those that did soon flew off, presumably after figuring out it was not worth bothering. Basically, the honey bees could not make a profit in energy terms. By contrast, with their longer tongues and ability to visit flowers more quickly (Balfour et al, 2013), bumblebees could make an energy profit and were outcompeting the honey bees, reducing the nectar levels to a point where honey bees were not interested. However, when we excluded bumblebees from patches of lavender, the amount of nectar per flower doubled and within one day the numbers of honey bees had increased more than ten-fold.

In another project we caused lavender flowers to bloom earlier, in spring, by keeping them in a glasshouse before taking them outdoors (Wignall et al, 2020). Spring-blooming lavender flowers had more nectar in them than summer-blooming ones as there were fewer bees on the flowers in spring. These projects show that summer is not necessarily an easy time to gather nectar.

1 **In summer there may be more flowers – but also more competition**
2 **Autumn ivy is available in abundance**
3 **Ivy bee (*Colletes hederae*)**

Autumn foraging

Autumn is a season that is easy to overlook but it is important to many bees and other flower-visiting insects. Many species are still on the wing in autumn, though fewer than in summer. Bumblebees, for example, are much less abundant in autumn than summer as most colonies will by then have died out after completing their annual cycle. New colonies are founded the following spring by overwintered queens which are already mated. By contrast, honey bees are active in autumn, rearing brood, foraging and storing honey. The whole colony overwinters and has thousands of workers even in mid-winter. Autumn is an important season.

In autumn 2020 and 2021, we directly studied nectar and pollen wastage on ivy (*Hedera helix*). Ivy is an extremely common plant in Britain and much of western Europe. Its open flowers produce both pollen and nectar and are accessible to many types of insect. Any type of flower-visiting insect active in autumn is likely to forage on ivy. These include honey bees, ivy bees (*Colletes hederae*), wasps, and hoverflies, plus a few bumblebees, butterflies, and other flies (Garbuzov and Ratnieks 2014; Hennessey et al, 2021).

Ivy is very important to honey bees. Two LASI projects had already shown that 90% of the pollen pellets taken from pollen traps on hives in autumn came from ivy (Garbuzov and Ratnieks, 2014; Hennessey et al, 2021). Important though the pollen was, observations of honey bees foraging on ivy flowers showed that most were gathering nectar only, not pollen or pollen and nectar. Ivy is a complete and abundant diet and the mainstay of autumn bees and flower-visiting insects. It is unusual for just one flower species to be the main food supply for a whole season – approximately three months from early September to late November and sometimes even early December. This could not be more different to spring and summer when many species of flowers are in bloom, often in succession, so that no single flower species is dominant in the way ivy is in autumn.

In these autumn projects on ivy, while supervising field exercises by Sussex University undergraduate students studying the foraging rate of different insect species on ivy flowers, Garbuzov and Ratnieks (2014) noticed that ivy flowers often had easily visible large drops of nectar on them. They also noticed that these nectar drops often dried out to form a white or grey sugar-crystal residue on the surface of the flowers. This meant that the liquid nectar had not been gathered and had dried, therefore being wasted. This gave us (Ratnieks and Harris) the idea of a project to investigate and quantify wasted ivy nectar. But we did not stop at nectar. We also quantified pollen wastage, given that ivy also produces much pollen which is vital to the bee food supply.

The project (Harris et al, 2023) was carried out in autumn 2020 and autumn 2021 on ivy growing in Sussex, mainly in Falmer village next to the University of Sussex. It was done with the help of three Sussex

Photos: Richard Rickitt, Francid Ratnieks

University undergraduate students, Hannah Ferguson, Ethan Millward and Nadia Sheikh, plus Phoebe Ney, an undergraduate from the University of Cumbria who was visiting LASI.

Gathering the evidence

Key to any project are the methods used to gather data. So how does one quantify how much pollen and nectar are wasted? To quantify pollen wastage, we gently shook ivy inflorescences, each with many flowers, causing the old stamens to fall onto a sheet of paper. Any pollen these contained was wasted as far as the bees were concerned because the stamens would simply fall to the ground. The stamens were then stored in a freezer. Later, by vibrating (sonicating) the inflorescences in 70% ethanol (alcohol), any remaining pollen was dislodged and then counted under a microscope using a haemocytometer slide, a simple apparatus used for counting blood cells and other small particles. The number per fallen stamen could then be compared with the numbers in stamens that were collected just as they were opening and therefore had a full pollen load.

To quantify nectar wastage, the volume of nectar present in ivy flowers, with and without mesh bags placed over them, was determined using microcapillary tubes. The bagged flowers showed how much nectar in total was secreted, while the unbagged flowers, which were accessible to foraging insects, showed how much was uncollected.

Overall, we determined that approximately half the floral resources – 59% of the nectar and 44% of the pollen – were uncollected by the autumn-flying flower-visiting insects, including honey bees, ivy bees and other species. More importantly and generally, given that ivy flowers supply most of the available nectar and pollen in autumn, the results showed that a large proportion of all floral resources available in autumn are unused. In other words, autumn is a season in which the supply of food outstrips the ability of bees and other insects to collect it. In addition, our data were gathered after the ivy bee, *Colletes hederae*, had colonized Sussex and become extremely abundant – more numerous in fact than honey bees (Hennessey et al, 2021). Wastage was occurring despite this additional bee species, which feeds almost exclusively on ivy nectar and pollen. In particular, female ivy bees gather large amounts of pollen which they use to provision their brood cells. Even with this additional pollen-hungry and abundant species of bee, nearly half the pollen was wasted.

3 Crystallised nectar on ivy flowers
4 Honey bee gathering ivy nectar and pollen
5 Painted lady butterfly nectaring on ivy

Optimal bee-friendly planting

The results show that thanks largely to flowering ivy, autumn is a season in which there is no shortage of food for flower-visiting insects. Of course, there is no harm in providing more flowers in autumn. However, this might be wasted effort if the goal is to help bees. Efforts to improve the bee food supply in summer would be more useful.

Our results also illustrate an important general point. Helping bees can benefit from both research and common sense. There is a great deal of public, commercial and official interest in helping nature and wildlife. But some schemes are quixotic and may even waste effort, money, time and enthusiasm. For example, it has been noted that schemes to plant trees can be wasted effort if, as happens, the trees are not looked after following planting, and so die. Gardeners are encouraged to plant bee-friendly plants that bloom when the food supply is adequate, or even in winter when very few bees or flower-visiting insects are active. Hives are sometimes placed on the roofs of buildings in cities to 'help the endangered honey bee', even though the city already has many hives and adding more, especially to make an ill-considered gesture, will likely do more harm than good.

Our results are also encouraging. If we know in which months or seasons bees do not face food shortages, it will be possible to focus attempts to increase the food supply in periods when there is a shortfall. LASI is also making direct studies of pollen and wastage in spring, with the focus on oilseed rape, and in summer on bramble and late-flowering oilseed rape, so we hope to expand our picture in the next year or two.

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