TREES FOR BEES CORNER

STAR PERFORMERS PART 9: *CITRUS* FOR NECTAR AND HONEY

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Trees for Bees has produced a series of fact sheets showcasing the 'best of the best' bee plants that will maximise nutritional benefits for your bees. In this issue of the journal, the team explains why *Citrus* trees are 'star performers. For more information, see www.treesforbeesnz.org.

Citrus trees, such as lemons, limes, oranges and grapefruits, have flowers that are highly attractive to bees and produce fantastic honey.

Citrus species and hybrids are outstanding star performers because their prolific nectar generates prize-winning honey. When Paul Badger was beekeeping in Gisborne, he repeatedly won honey competitions for his *Citrus* honey at national conferences.

With copious nectar available, *Citrus* flowers are highly attractive to honey bees. The flowers are conspicuous to bees because the sweetly scented white flowers contrast against the background of dark-green foliage (Figure 1). Bees have a great preference for *Citrus* flowers, but it is for nectar and not necessarily for pollen—which can be absent or compromised in some cultivars.

Many *Citrus* species and hybrids are grown worldwide for their edible fruit and culinary properties in both tropical and subtropical regions (Crane & Walker, 1984, p.44). The climate of New Zealand is only marginally subtropical, which limits production to only those varieties suitable for cooler climates because of lack of summer heat and frost issues (Mooney, 2011). *Citrus* has been grown in New Zealand for over 100 years, with many different cultivars and hybrids introduced or developed for gardeners and orchardists.

In New Zealand, the most important *Citrus* are lemons, limes, oranges, mandarins, tangelo and grapefruit (Table 1). In 2018, *Fresh Facts* reported 320 growers produced 30,692 tonnes of citrus fruit on 1,660 ha.

Figure 1. Profuse flowering on lemon tree (Citrus limon).

FRUITING TIMES	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lemon	1	1	1	1	1	1	1	1	1	1	1	1
Satsuma Mandarin				1	1	1	1	1				
Other Mandarin	1	1	1	1					1	1	1	1
Grapefruit	1				1	1		1	1	1	1	1
Navel Orange						1	1	1	1	1	1	1
Valencia Orange	1	1									1	1
Tangelo									1	1	1	1
Limes			1	1	1							

Table 1. Fruiting times for Citrus *species and cultivars in New Zealand. Information based on Citrus New Zealand data (Citrus New Zealand, 2020).*

The sales value was $56.9 million domestic and $9.3 million export (Horticulture New Zealand & The New Zealand Institute for Plant and Food Research, Ltd, 2018). The major production areas are Northland, Bay of Plenty, and Gisborne with minor production in Auckland, Hawke's Bay, Taranaki, Waikato and Nelson. New Zealand's contribution to global production is minor—less than 0.05% (Mooney, 2011). Information about the species and cultivars can be found at the Citrus New Zealand website: https://www.citrus.co.nz/.

Flowers

Citrus flowers are produced in great profusion on small trees or shrubs. In most *Citrus* species, the flowers open seasonally in one big flush in the spring but some lemons tend to flower less abundantly throughout most of the year (McGregor, 1976, p.479; Citrus New Zealand, 2020). Species are highly interfertile with many hybrid cultivars, such as tangelo and Meyer lemon, used in commercial production (Mooney, 2011). Despite the seasonal profusion of flowers, the rate of fruit set and progression to mature fruit is variable and often quite low. Biennial bearing is common among many cultivars, which orchardists can manage by various means.

The flowers are similar across all species but differ in size (McGregor, 1976; Free, 1993). The *Citrus* flower has four to eight bright white petals (Figure 2), except lemons sometimes have pink or purple petals.

In a young flower the stigma is not visible at first, but in a mature flower the style elongates to extend the stigma up to the same level as the anthers. Since the anthers can then touch the stigma, self-pollen can be transferred within the flower. If the cultivar is self-compatible then fruit and seed will form without the aid of bee pollen transfer.

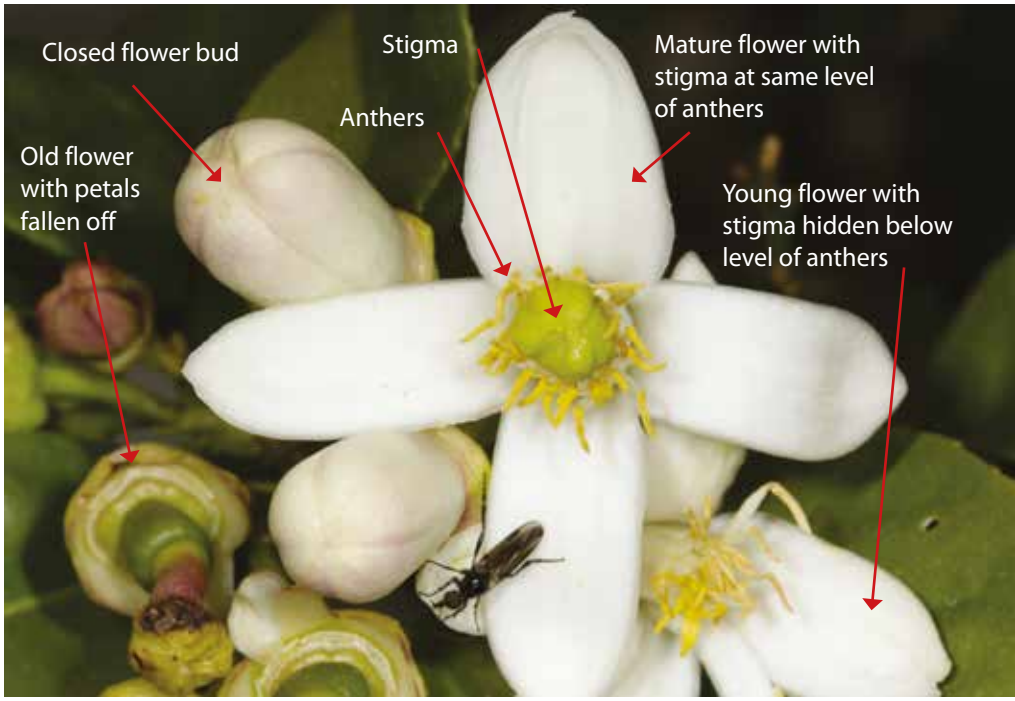

Figure 2. Citrus *flowers of different ages: young flower with stigma hidden below the anthers; mature flower with stigma emergent to the level of the anthers; and old flower with all petals fallen off and stigma turning brown.*

After four to five days all the petals fall off by abscission and the stigma turns brown.

Pollen

Beekeepers prize *Citrus* flowers primarily as a nectar source—not for pollen. Yet, the nutritional contribution to bee health via pollen can be good if fertile pollen is present. However, many cultivated types of *Citrus* have sterile (empty or dysfunctional) pollen or the anthers are defective or missing from the flower (McGregor, 1976; Free 1993; Barry, 1995). In cultivars with fertile pollen, the protein content of pollen can be excellent; for example, ranging from 21% to 25% in lemon *(Citrus limon)* (Trees for Bees unpublished data).

Bees avidly collect *Citrus* pollen, which is produced in a whorl of 20 to 60 stamens that are partially united at their base and surround the ovary. When the flower bud first breaks open, pollen is already mature, and anthers are dehisced (opened up) to present the pollen (Figure 3). You can tell if the pollen is fertile by the colour and shape of the bright yellow anthers and their ability to open (Figure 4). If the pollen is defective it is usually misshapen, and the anther is pale coloured and may remain closed (Barry, 1995). If there is no pollen present, then the anthers will be very pale cream or white and remain closed and empty.

The value of *Citrus* pollen to bees therefore depends on the species and cultivar (McGregor, 1976; Free, 1993). For example, navel oranges have dysfunctional pollen (Mooney, 2011). Such species and cultivars will be unable to self-pollinate in the same flower, or even the same tree if all the flowers are male sterile.

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Figure 3. Bee collecting pollen in a young flower bud just breaking open in Citrus limon. *The anthers have already dehisced and are presenting the mature golden yellow pollen.*

Figure 4. Close-up of anthers already opened up to present mature fertile pollen in Citrus limon.*This flower is young since the stigma has not yet emerged through the centre of the whorl of stamens.*

Figure 5. Bee taking nectar from between the stamens and the ovary in a mature flower. Note the stigma is emerging to the level of the anthers.

Nectar

The strongly perfumed *Citrus* flowers produce an aromatic and delicious honey. The nectar is produced even before flower buds open and continues for the life of the flower, from three to five days. Abundant nectar is secreted in the disc-shaped nectary located around the base of the ovary just inside the ring of stamens (McGregor, 1976; Free, 1993). Reports on the quantity of nectar produced varies from 25 to 80 mg per flower per day (Barry, 1995; see also McGregor, 1976; Free, 1993). This is a substantial amount of nectar compared to small flowers like alfalfa, which usually only produce a few mg per day (Free, 1993).

For bees, access to nectar is easier in mature flowers where nectar will have accumulated and the petals have spread open. This is at the time when the stigma is just emerging (Figure 5). A younger flower is a tighter fit as the petals have not spread out yet (Figure 3 at left). The bee works its way down to the base of the flower and inserts its proboscis in between the base of the stamens and the ovary where the nectar disc is located (Figure 6).

In cultivars with spring flushes, the profusion of flowers with copious nectar attract bees away from competing flowers. For the beekeeper, finding whole orchards of *Citrus* with suitable nectar yielding flowers can generate a good monofloral honey crop (e.g., in Gisborne or Northland). Some mandarin orange cultivars do not seem to yield good

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Figure 6. Bee working its way between the stamens and the ovary to extract the accumulated nectar from the nectary disc at the base of the stamens. All photos by Jean-Noël Galliot © Trees for Bees.

quantities of nectar, according to Barry Foster, so there is variation and once again, it depends on the species and cultivar.

Selection of cultivars and the role of bees

Beekeepers generally do not charge any pollination fee when placing beehives in a *Citrus* orchard because they gain a valuable honey crop. In *Citrus* growing areas globally, beekeepers seek out *Citrus* orchards; for example, in Florida (Sanford, 2011), and South Africa (Barry, 1995). Bees have been beneficial to the production of many *Citrus* cultivars because their pollination services increase the rate of fruit set, the size of fruit, and juiciness of fruit (Free, 1993; Barry, 1995).

Nevertheless, current trends in consumer demand for seedless fruits have changed the value of bee pollination services. In Florida, many orchardists now discourage nearby beekeeping, since cross-pollen coming into a crop of seedless *Citrus* can cause too many seeds to develop in the fruit (The Xerces Society, 2016, p.182), thereby decreasing their market value.

The focus in modern cultivars is to have easy peel and seedless fruit (Mooney, 2011), such as in mandarins. To circumvent the need for or consequences of bees, growers rely on auto-pollination with self-pollen and more importantly, on cultivars that can generate fruit without any pollen fertilising the ovules, a process of embryo development called parthenocarpy (Barry, 1995); for example, navel oranges which are completely seedless (Barry, 1995).

What does this mean for planting *Citrus* trees for bee nutrition? First, if the proposed bee forage plantation is near commercial *Citrus* orchards, it will be helpful to consult neighbouring orchardists about what consequences your selection of *Citrus* cultivars could have on their crop quality.

Many different types of parthenocarpic or self-pollinating *Citrus* are available so there will be a variety of risks to their crops.

Second, it is important to ascertain the pollination requirements for the species or cultivars that you select, so that you will be able to obtain good fruit set and fruit quality for your purposes.

Third, it is useful to know what the flowers will deliver for your bees—nectar only or both pollen and nectar (Figure 7).

Planting advice

Citrus has been established in Trees for Bees demonstration farms in farm 'home orchards', along with other pipfruit and stone fruit species. As with all bee forage planting, the key considerations are the timing of flowering, and whether you require the flowers for pollen and/or nectar.

Citrus grows best in soil with a pH of 6 to 6.5 and the correct pH will ensure your trees can access the nutrients they need to grow well. Choose a site free from frost, in a sunny location, sheltered from strong winds if possible and not too wet. If necessary, plant the tree on a mound to support drainage.

If shelter planting is required, Italian alder *(Alnus cordata)* is a good option, because it is fast growing, nitrogen-fixing and deciduous, which allows more sun penetration in winter and plenty of leaves to add to the soil. Alder also provides spring pollen for bees.

For a large orchard, the spacing and layout as well as cultivar selection is critical for commercial production. Tree canopies and height vary with each type and cultivar of *Citrus* and market factors such as the need for seedlessness or easy peel should be considered. It is best to consult with experts in the Citrus New Zealand organisation for specialist advice.

Figure 7. Bee in Citrus limon *flower taking nectar while also collecting a pollen load from the flower. Photo: Jean-Noël Galliot © Trees for Bees.*

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