Glasshouse strawberry pollination using native stingless bees

Project update from 'Stingless bees as effective managed pollinators for Australian horticulture' PH16000

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Meeting the high demand for strawberries entails measures to ensure year-round production, including in protected cropping environments. Most varieties require insect pollination to increase yield and fruit quality, which is achievable in a field setting, but more challenging in polytunnels and glasshouses that exclude wild pollinators, and therefore suffer from a pollination shortfall.

Honeybees (*Apis mellifera*) are not well adapted to use in protected cropping environments and the use of managed bumblebees (*Bombus* spp.) is not available to Australian growers because they are not native to Australia. In addition, both honeybees and bumblebees often pose a health risk to workers in such environments, and honeybees themselves may suffer if the mite *Varroa destructor* ever establishes in Australia.

Australia has 11 species of stingless bees, so named due to their lack of a stinger, commonly also known as sugarbag bees. At least 3 species can be managed in man-made hives and have proved effective in pollinating multiple fruit, vegetable and nut crops (including raspberry and blueberry).

However, we know less about the effectiveness of Australian stingless bee species in improving the yield and marketability of strawberry fruits, nor whether this can be achieved under protected cropping.

One strawberry variety commercially grown in Australia is 'Red Rhapsody', a cross between the Department of Agriculture and Fisheries (DAF) breeding line '2005-063' and 'Suncoast Delight'. This variety has superior taste and vigour and is resistant to pests and fruit bruising. In the open field, it produces early season crops (May-August) and in a protected environment can also produce a late season crop (September-December).

We are investigating how two species of native stingless bee, *Tetragonula carbonaria* and *Tetragonula hockingsi*, perform in a glasshouse facility on the Western Sydney University Hawkesbury campus in Richmond, NSW, where we are growing 'Red Rhapsody' strawberries. We tested whether visitation by either of these species can improve yield and fruit quality, and the number of visits required to produce the highest quality fruits.

We grew crops in two experimental glasshouse chambers (88 m^2; 8 m x 13 m x 6 m) with 480 strawberry plants in each chamber. We introduced hives of *T. carbonaria* into both chambers. After sufficient trials were conducted, we removed these and introduced *T. hockingsi*. Here, we present some preliminary results from our glasshouse experiment.

First, 400 primary flowers were bagged, prior to opening, with organza bags, which still allow airflow and light to the flowers. Bags were removed from 100 flowers once they opened to allow unlimited access to bees during the receptive period (open pollination, OP).

As a negative control (BP), another 100 flowers remained bagged to exclude all foragers from accessing the flowers. As a positive control, an additional 200 flowers were hand pollinated, 100 with pollen from the same variety (HP), and 100 crossed with a different variety ('Valor', CP). This polliniser variety was developed in California, USA. Fruits are conical shaped and reasonably large, with firm texture, attractive red colouration and prominent seeds. Red Rhapsody flowers that were used for hand pollination were re-bagged immediately after treatment to prevent the bees from pollinating these flowers. All bags were removed from flowers ten days later, when flowers were no longer receptive to pollination, to reduce any bag effects on fruit development.

Second, we wanted to test how many visits were needed to ensure most flowers produced high quality, marketable fruits. We allowed both stingless bee species (*T. carbonaria* and *T. hockingsi*) different numbers of visits to strawberry flowers: 1, 2, 5, 10 and 15 visits. A total of 500 flowers (100 for each number of visits) were used for this. Flower buds were again bagged. When the flowers opened, bees were then allowed to land on a flower for the required number of visits and then we re-bagged immediately to prevent further pollination. Bags were again removed ten days later when flowers were no longer receptive to pollination.

Fruits were harvested when ripe (i.e. when more than 90% of the fruit surface was red). Physical fruit characteristics were then recorded in a number of ways. Fresh weight, basal circumference and length were taken to determine fruit size.

Fruits were also graded by their uniformity of shape, based on industry standards: Grade Extra, Grade A, Grade B, Grade C and Grade D. Grade Extra and Grade A constitute highly marketable fruits, while Grade C were of lowest marketable quality and Grade D were non-marketable (Figure 1).

Early signs indicate that stingless bee visitation to glasshouse strawberry crops clearly improves fruit quality. For both stingless bee species, the open pollination treatment (OP) had a higher percentage of high-quality fruits than negative controls (BP, Figures 2 & 3).

Hand pollination (positive control), both with the same variety (self-pollination, HP) and crossed with the polliniser variety 'Valor' (CP), produced the highest quality fruits from these trials. Fruit quality also increased with a greater number of bee visits, with 15 visits yielding 84% high quality fruits (Grade 'Extra class' and Grade 'A') from *T. carbonaria* (Figure 2) and 96% high quality fruits from *T. hockingsi* (Figure 3). The percentages were similar for both hand pollination treatments.

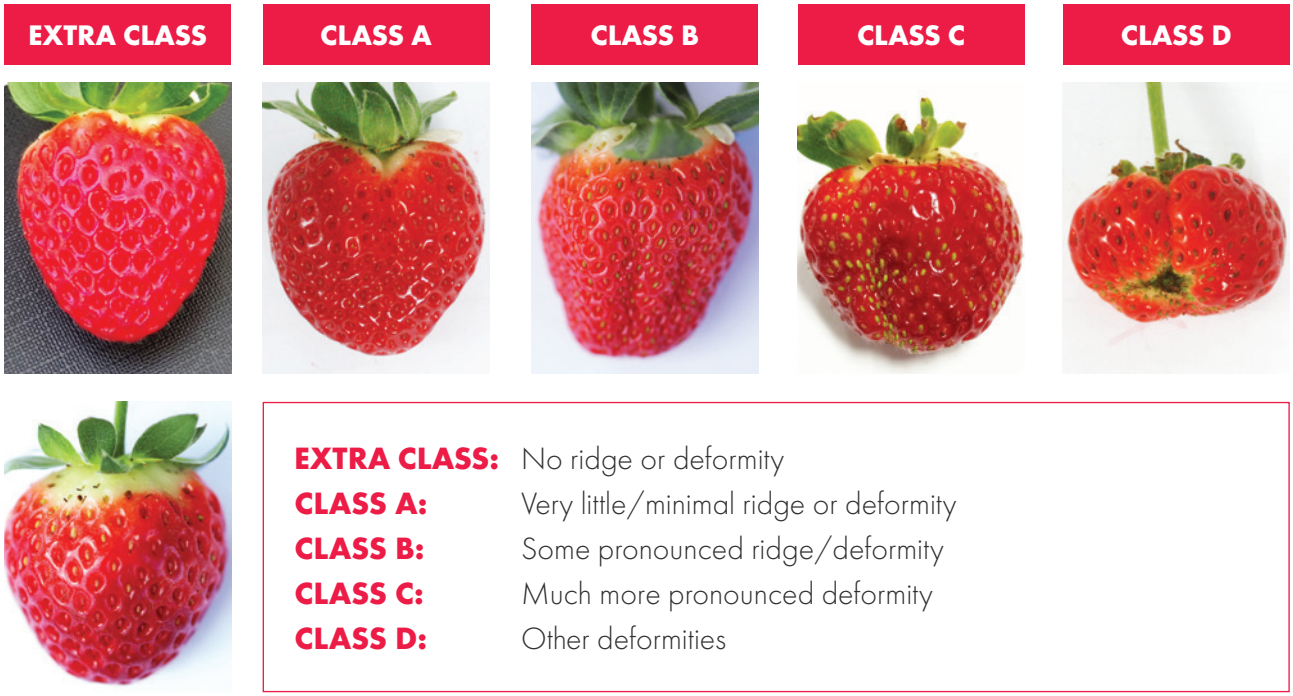
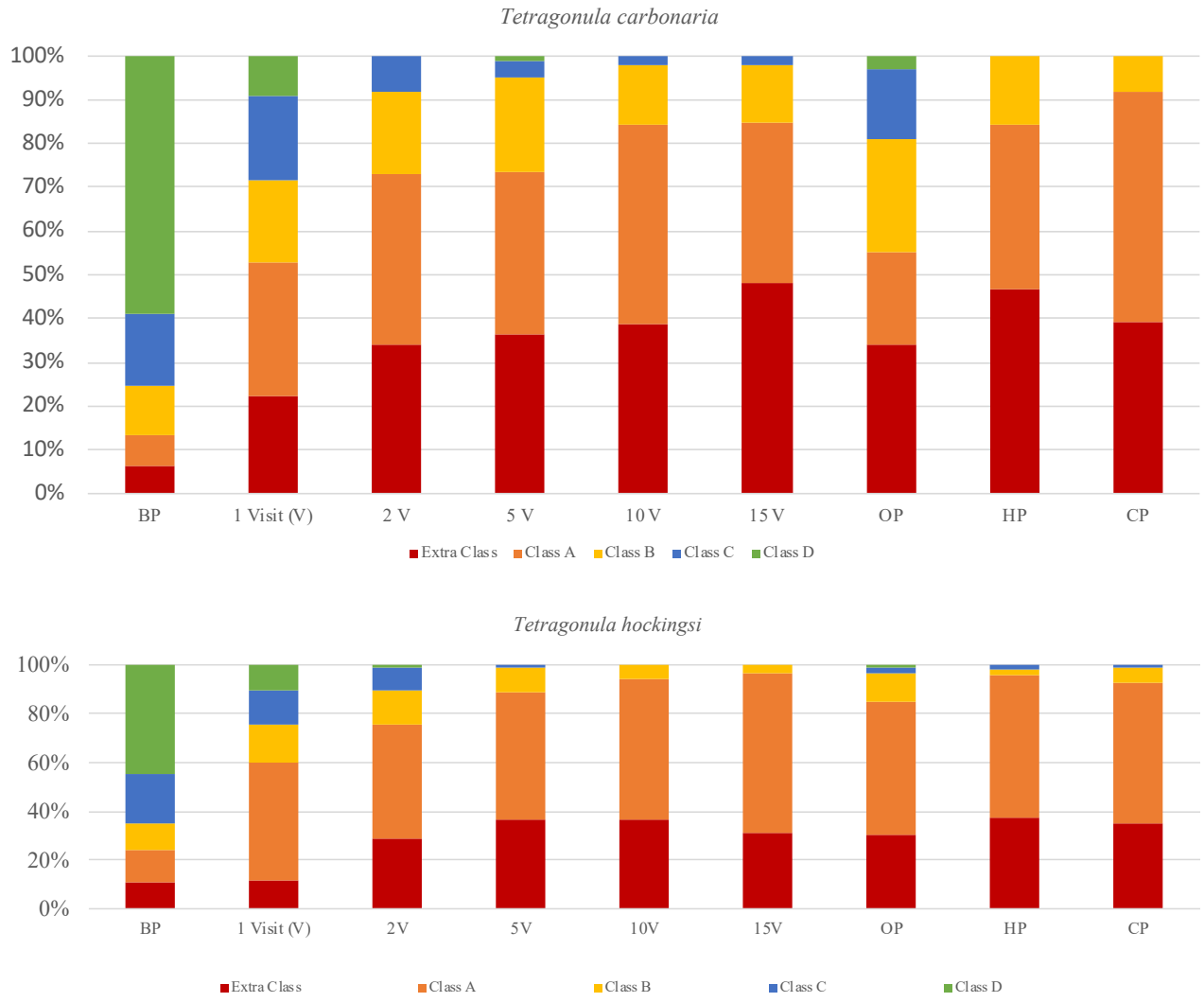


Figure 1. Examples of strawberry fruit classified under each quality grading
Photo credit: Onyeka Nzie



Figures 2 & 3: The percentage of fruit of different quality grades for each treatment type: bagged pollination (BP), 1, 2, 5, 10 and 15 bee visits, open pollination (OP), hand pollination treatments with the same strawberry variety (HP) and cross-pollinated with variety "Valor' (CP). Records presented for visits by *Tetragonula carbonaria* (Figure 2) and *Tetragonula hockingsi* (Figure 3).
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Our results also indicated that the quality of fruit from open pollination (unlimited bee visits) was lower than the quality of fruit from 10 and 15 visits (Figures 2 & 3). We believe this is a result of excessive bee visitation causing flower damage. We will repeat surveys this year with fewer hives to test optimal hive stocking rates in such environments. We are also unsure what the optimal number of visits is, so will increase the number of visits allowed in the next trial, to determine if fruit quality continues to improve, or we reach a saturation or even a tipping point. Finally, our results also indicate that the sugar content of strawberry fruits is higher with bee visitation compared with no bee visits. We will continue to investigate this and other chemical properties of strawberry fruits under glasshouse pollination conditions.

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Mark Hall is a Postdoctoral Research Fellow, Robert Spooner-Hart & Markus Riegler are Associate Professors, James Cook is a Professor and Onyeka (Peter) Nzie is a PhD student; the glasshouse experiments form part of his PhD project supervised by the other authors.