



## Climate change may disrupt crop pollination in the Neotropics: rising temperatures lead carpenter bees to avoid pollinating passion fruit flowers

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### Introduction

Global warming has been identified as a potential factor in compromising crop pollination due to thermal stress on pollinators (Brown *et al.* 2016; Trunschke *et al.* 2024). Limited evidence has been produced for tropical regions, and there is a lack of information on whether bees can effectively pollinate wild and cultivated plants under even higher temperatures (Bezerra *et al.* 2019; Giannini *et al.* 2025).

### Methodology

This study was carried out in Sítio São José, Maranguape – CE, Brazil using thermal imaging and bagging/unbagging experiments to investigate how rising temperatures affect the foraging activities of the carpenter bee *Xylocopa frontalis* and fruit set in two cultivated species of passion fruit (*Passiflora edulis* and *P. cincinnata*), which have distinct pollination requirements (Fig.1a,b,c,d). The study also determined the bee's critical and lethal temperatures through controlled temperature increments in laboratory experiments (Fig 1e,f).

**Figure 1-** *Xylocopa frontalis* visiting flowers of *Passiflora edulis* (a) and *P. cincinnata* (b), collecting bee temperature on flowers using the thermal camera (c), analyzing passionfruit fruits (d), caged bee (e) for determination of *X. frontalis*' critical and lethal temperatures (f).



### Main results and conclusions

Results revealed that the bees avoided foraging on passion fruit flowers as both ambient temperatures and their own body temperatures increased throughout the day. This led to a significant ( $p < 0.05$ ) reduction in the number and duration of flower visits during the hottest hours of the day, as well as a decline in foraging activity from the rainy season (milder temperatures) to the dry season (higher temperatures) (Fig. 2). Consequently, a deficit in natural pollination was observed, resulting in fruit set, fruit weight, pulp weight, and seed number falling below the yield potential during the hottest period of the year (Table 1, Fig.3). The study determined the critical ( $42.2 \pm 1.31^\circ\text{C}$ ) and lethal ( $47.3 \pm 1.79^\circ\text{C}$ ) temperatures for *X. frontalis*. These findings demonstrate that rising average temperatures during foraging under the sun, particularly during periods of the day or year when temperatures approach or exceed the critical threshold for *X. frontalis*, significantly affect the bee's foraging behavior on passion fruit flowers. This reduces its efficiency as a pollinator, particularly for *P. edulis*, whose flowers open at midday and have only a few hours in the afternoon to be pollinated.

**Figure 2-** Number of visits by the carpenter bee *Xylocopa frontalis* to the flowers of *Passiflora cincinnata* and *P. edulis* throughout the day according to the temperature and season of the year.

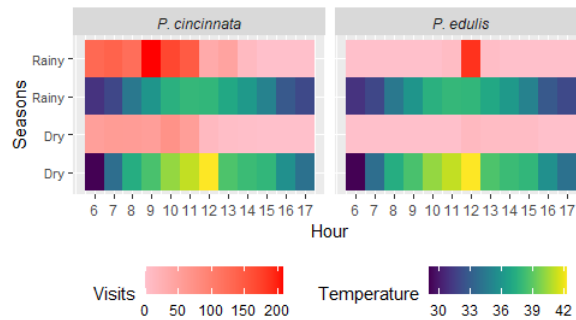


**Table 1 -** Fruit set, fruit weight, pulp weight, and number of seeds of *Passiflora edulis* and *P. cincinnata* according to three types of pollination.

| Type of pollination | N  | <i>Passiflora edulis</i> |                                  |                                 |                                  | <i>Passiflora cincinnata</i> |                                  |                   |                                  |
|---------------------|----|--------------------------|----------------------------------|---------------------------------|----------------------------------|------------------------------|----------------------------------|-------------------|----------------------------------|
|                     |    | Fruit set                | Fruit weight (g)                 | Pulp weight (g)                 | Number of seeds                  | Fruit set                    | Fruit weight (g)                 | Pulp weight (g)   | Number of seeds                  |
| Restricted          | 30 | 0                        | -                                | -                               | -                                | 0                            | -                                | -                 | -                                |
| Open                | 30 | 6                        | 107.80 $\pm$ 57.58 <sup>a</sup>  | 40.70 $\pm$ 29.89 <sup>a</sup>  | 194.60 $\pm$ 147.19 <sup>a</sup> | 7                            | 84.49 $\pm$ 156.94 <sup>a</sup>  | 51.83 $\pm$ 12.14 | 277.29 $\pm$ 465.92 <sup>a</sup> |
| Manual              | 30 | 23                       | 218.15 $\pm$ 137.68 <sup>a</sup> | 101.74 $\pm$ 17.34 <sup>a</sup> | 399.70 $\pm$ 112.93 <sup>a</sup> | 17                           | 105.23 $\pm$ 113.82 <sup>a</sup> | 60.30 $\pm$ 9.58  | 346.29 $\pm$ 155.07 <sup>a</sup> |

**Figure 3-** *Passiflora cincinnata* and *P. edulis* resulting from hand pollination and free pollination by *Xylocopa frontalis*: *P. cincinnata* fruits from hand pollination (a), and open pollination (b), pulp from *P. edulis* fruit from hand pollination (c), pulp from *P. edulis* fruit resulting from open pollination (d).



### Practical implications for beekeepers

The pollination services provided by *X. frontalis* to *P. edulis* and *P. cincinnata* are already compromised during periods of higher temperatures and beekeepers should be aware that potential increases in average ambient temperatures could compromise pollination services in the Neotropics.

### References

- Bezerra, A.D.M. *et al.* (2019) Agricultural area losses and pollinator mismatch due to climate changes endanger passion fruit production in the Neotropics. *Agricultural Systems* 169: 49–57.
- Brown, M.J.F. *et al.* (2016) A horizon scan of future threats and opportunities for pollinators and pollination. *PeerJ* 4, e2249.
- Giannini, T. C. *et al.* (2025) Predicting climate change impacts on crop pollinators in Brazil. *Sociobiology*, 72(2), e11277.
- Trunschke, J. *et al.* (2024) Effects of climate change on plant-pollinator interactions and its multitrophic consequences. *Alp Botany* 134, 115–121.

### Acknowledgements



## PP-545 [Pollination and Bee Flora]

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**Background/purpose** - Global warming has been identified as a potential factor in compromising crop pollination due to thermal stress on pollinators. **Problem description** - Limited evidence has been produced for tropical regions, and there is a lack of information on whether bees can effectively pollinate wild and cultivated plants under even higher temperatures. **Methodology** - This study used thermal imaging and bagging/unbagging experiments to investigate how rising temperatures affect the foraging activities of the carpenter bee *Xylocopa frontalis* and fruit set in two cultivated species of passion fruit (*Passiflora edulis* and *P. cincinnata*), which have distinct pollination requirements. The study also determined the bee's critical and lethal temperatures through controlled temperature increments in laboratory experiments. **Results and conclusion** - The results revealed that the bees avoided foraging on passion fruit flowers as both ambient temperatures and their own body temperatures increased throughout the day. This led to a significant ( $p < 0.05$ ) reduction in the number and duration of flower visits during the hottest hours of the day, as well as a decline in foraging activity from the rainy season (milder temperatures) to the dry season (higher temperatures). Consequently, a deficit in natural pollination was observed, resulting in fruit set, fruit weight, pulp weight, and seed number falling below the yield potential during the hottest period of the year. The study determined the critical ( $42.2 \pm 1.31^{\circ}\text{C}$ ) and lethal ( $47.3 \pm 1.79^{\circ}\text{C}$ ) temperatures for *X. frontalis*. These findings demonstrate that rising average temperatures during foraging under the sun, particularly during periods of the day or year when temperatures approach or exceed the critical threshold for *X. frontalis*, significantly affect the bee's foraging behavior on passion fruit flowers. This reduces its efficiency as a pollinator, particularly for *P. edulis*, whose flowers open at midday and have only a few hours in the afternoon to be pollinated. **Practical implications for beekeepers** - The pollination services provided by *X. frontalis* to *P. edulis* and *P. cincinnata* are already compromised during periods of higher temperatures. Beekeepers should be aware that potential increases in average ambient temperatures could compromise pollination services in the Neotropics.