

Supporting information

Title: Alien balsams, strawberries and their pollinators in a warmer world

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Tables

Table S1 Pollinators recorded from flowers of cultivated *Fragaria × ananassa*, highly invasive alien *Impatiens glandulifera* and invasive alien species *I. parviflora* in Experiment 1. The table also includes Formicidae, which is known to include nectar thieves.

| Plant species | Taxon | N records |
|-------------------------------|---------------------------------|-----------|
| <i>Fragaria × ananassa</i> | Syrphidae | 600 |
| | Formicidae | 69 |
| | <i>Episyrphus balteatus</i> | 24 |
| | Apidae | 16 |
| | <i>Bombus pascuorum</i> | 11 |
| | Muscidae | 8 |
| | Symphyta | 7 |
| | Piophilidae | 7 |
| | <i>Bombus lucorum</i> -complex | 7 |
| | <i>Eupeodes corollae</i> | 5 |
| | <i>Lasioglossum</i> | 5 |
| | Empididae | 5 |
| | <i>Bombus terrestris</i> | 3 |
| | <i>Apis mellifera</i> | 3 |
| | <i>Psithyrus vestalis</i> | 2 |
| | <i>Bombus humilis</i> | 2 |
| | Tenthredinoidea | 2 |
| | Chloropidae | 1 |
| | Syrphini | 1 |
| | Buprestidae | 1 |
| | Nematocera | 1 |
| | Geotrupidae | 1 |
| | <i>Bombus pratorum</i> | 1 |
| Chloropidae | 1 | |
| Calliphoridae | 1 | |
| <i>Vespula vulgaris</i> | 1 | |
| Vespidae | 1 | |
| | Total number of records: | 786 |
| <i>Impatiens glandulifera</i> | <i>Bombus lucorum</i> -complex | 1180 |
| | <i>Bombus pascuorum</i> | 485 |
| | <i>Bombus terrestris</i> | 206 |
| | <i>Apis mellifera</i> | 107 |
| | <i>Vespula vulgaris</i> | 15 |
| | Apidae | 13 |
| | Vespidae | 11 |
| | Syrphidae | 4 |
| <i>Panorpa communis</i> | 1 | |
| | Total number of records: | 2022 |
| <i>Impatiens parviflora</i> | Syrphidae | 407 |
| | Muscidae | 6 |
| | <i>Episyrphus balteatus</i> | 5 |
| | Apidae | 4 |
| | Tenthredinoidea | 2 |
| | <i>Psithyrus vestalis</i> | 2 |
| | Formicidae | 2 |
| | Drosophilidae | 1 |
| | Sciaridae | 1 |
| | <i>Eupeodes corollae</i> | 1 |
| <i>Lasioglossum</i> | 1 | |
| Calliphoridae | 1 | |
| | Total number of records: | 433 |

Table S2 Base, candidate and best-fit models in Experiments 1 and 2. The selected best-fit model (bolded) had the lowest corrected Akaike information value AICc.

Models for the number of pollinators ('N pollinators') as a target variable counted per plant individual in particular surveys (Experiment 1).

| Model | AICc value |
|--|----------------|
| <u>Base model:</u> N pollinators ~ Variant and species + Stem height + N flowers + Temperature + (1 Plants ID) + (1 Time intervals) | 3666.15 |
| <u>Candidate models:</u> N pollinators ~ Variant and species + Stem height + Temperature + (1 Plants ID) + (1 Time intervals) | 3659.16 |
| N pollinators ~ Variant and species + Stem height + N flowers + (1 Plants ID) + (1 Time intervals) | 3655.44 |
| N pollinators ~ Variant and species + Stem height + (1 Plants ID) + (1 Time intervals) | 3648.71 |

Models for the number of revisits ('N revisits') as a target variable counted during a single pollinator flight (Experiment 2).

| Model | AIC value |
|---|----------------|
| 2019: | |
| <u>Base model:</u> N re-visits ~ Temperature + Pollinator + Cloud cover + Temperature*Pollinator + (1 Plant ID) | 1977.26 |
| <u>Candidate models:</u> N re-visits ~ Temperature + Pollinator + Temperature*Pollinator + (1 Plant ID) | 1978.40 |
| N re-visits ~ Temperature + Pollinator + (1 Plant ID) | 1976.70 |
| N re-visits ~ Temperature + Pollinator + Cloud cover + (1 Plant ID) | 1975.20 |
| 2020: | |
| <u>Base model:</u> N re-visits ~ Temperature + Day time + Pollinator + Gender + Size + Sun radiation + Flower area + Temperature*Pollinator + Temperature*Gender + Temperature*Size + (1 Plant ID) | 3795.56 |
| <u>Candidate models:</u> N re-visits ~ Temperature + Day time + Pollinator + Gender + Size + Sun radiation + Flower area + Temperature*Gender + (1 Plant ID) | 3790.88 |
| N re-visits ~ Temperature + Pollinator + Gender + Flower area + Temperature*Gender + (1 Plant ID) | 3788.38 |
| N re-visits ~ Temperature + Day time + Pollinator + Gender + Flower area + Temperature*Gender + (1 Plant ID) | 3787.00 |

Table S3 Stem height of individuals of cultivated *Fragaria × ananassa*, highly invasive alien *Impatiens glandulifera* and invasive alien species *I. parviflora*. Data on the profile area of flowers of *I. glandulifera* (see Fig. S4) are also included.

Experiment 1

| Species | N individuals | Stem height [cm] | | |
|-------------------------------|---------------|------------------|---------|---------|
| | | Minimal | Maximal | Average |
| <i>Fragaria × ananassa</i> | 62 | 7 | 28 | 12 |
| <i>Impatiens glandulifera</i> | 42 | 65 | 177 | 149 |
| <i>Impatiens parviflora</i> | 45 | 20 | 54 | 38 |

Experiment 2

| Species | N individuals | Stem height [cm] | | | Flower area [mm ²] | | |
|-------------------------------|---------------|------------------|---------|---------|--------------------------------|---------|---------|
| | | Minimal | Maximal | Average | Minimal | Maximal | Average |
| <i>Impatiens glandulifera</i> | 60 | 70 | 182 | 128 | 337 | 782 | 556 |

Table S4 GLM model testing factors correlated with an *Impatiens glandulifera* individual being the first to be chosen by visiting bumblebees. The number of first choices for each plant was a target variable, while the stem height, flower size, flower hue and location were fixed effects.

| Effect | χ^2 | df | p |
|-------------|----------|----|-----|
| Stem height | 0.84 | 1 | 0.4 |
| Flower area | 0.02 | 1 | 0.9 |
| Flower hue | 1.73 | 2 | 0.4 |
| Location | 0.004 | 1 | 0.9 |

Figures

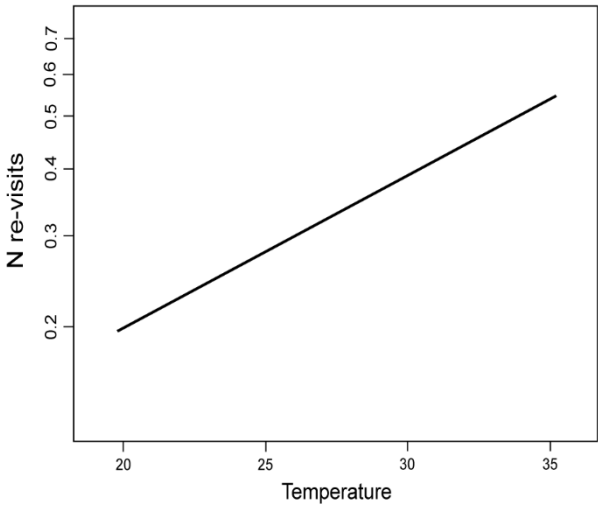


Fig. S1 Effect of air temperature on the estimated number of revisits of flowers of *Impatiens glandulifera* by bumblebees (*Bombus lucorum complex*, *B. pascuorum* and *B. terrestris*).

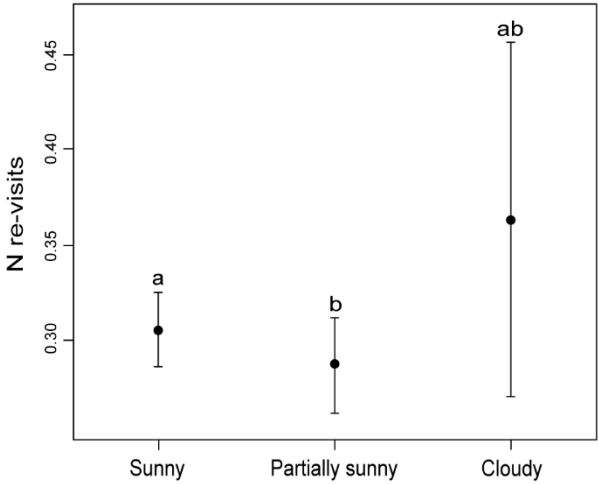


Fig. S2 Effect of cloudy cover on the mean number of revisits (\pm SE) of flowers of *Impatiens glandulifera* by bumblebees (*Bombus lucorum complex*, *B. pascuorum* and *B. terrestris*).

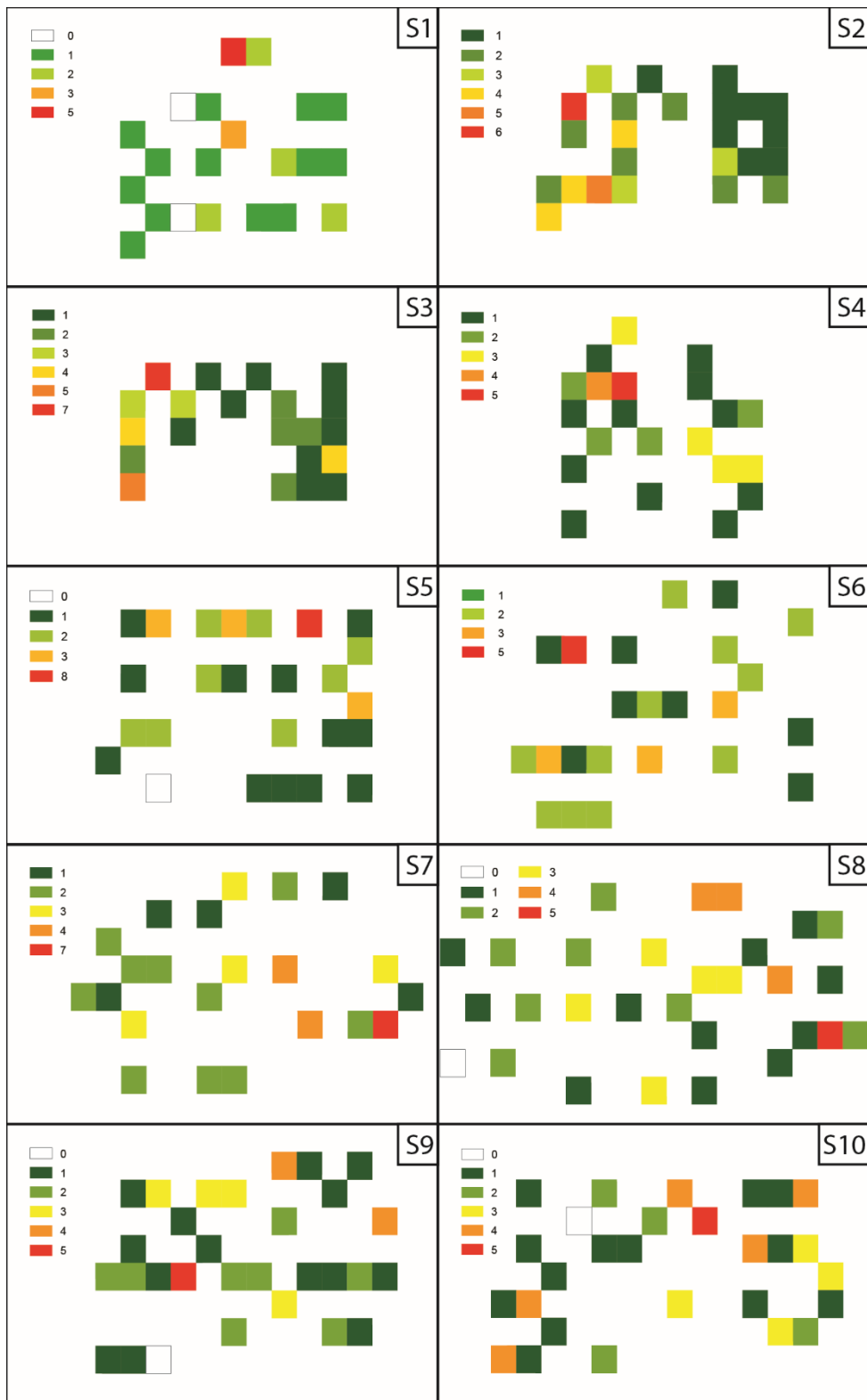


Fig. S3 Spatial array of *Impatiens glandulifera* individuals chosen by bumblebees as first to be visited.

In each survey (S1-S10), the total number of first visits per particular plant is demonstrated using a colour scale.

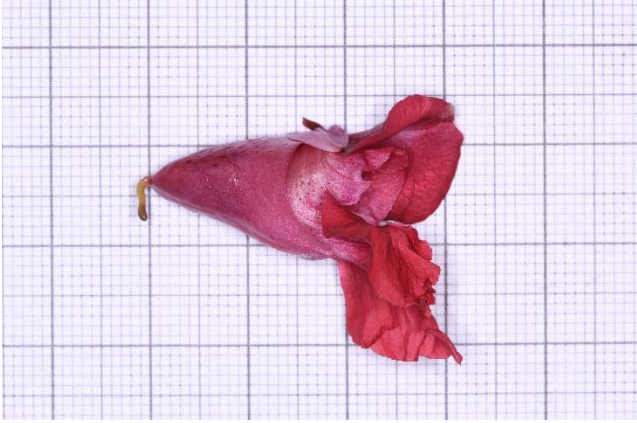


Fig. S4 Profile of the *Impatiens glandulifera* flower against a millimetre paper.