# Temperature rise and water stress modify floral signals of bee-visited plants

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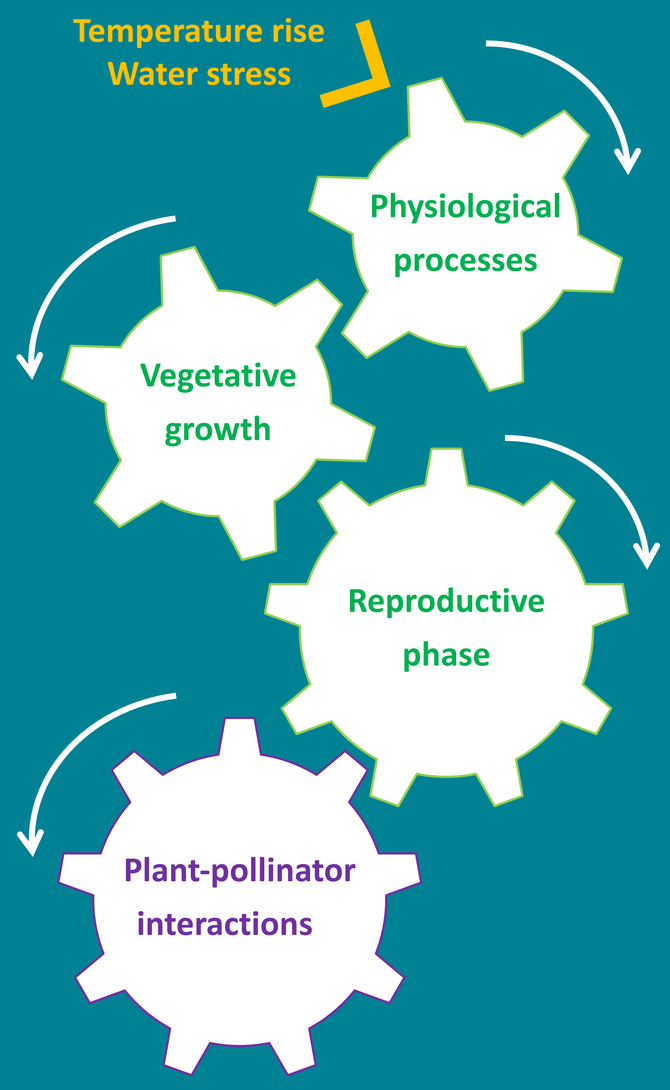
## Interactions among plants and their pollinators depend on floral signals and rewards

- Temperature rise and water stress are two abiotic constraints that plants face in the context of climate changes. The plant reproductive phase is particularly sensitive to these abiotic stresses. We focused the study on the impact of these stresses on floral signals and rewards.
- Flower modifications can disrupt plant-pollinator interactions by reducing the attractiveness and the rewards of flowers. These rewards are essential for Apoidea (Hymenoptera) that depend exclusively on pollen and nectar for the development of their colonies.




## We applied abiotic stresses on several bee-visited plants

- The plant species were selected based on their attractiveness for pollinators and for their high flower-reward production : *Borago officinalis*, *Echium vulgare*, *Impatiens glandulifera.*
- Plants were placed in three growth chambers. Six treatments were applied combining three temperatures and two watering regimes for 5 weeks.

| | Well-watered | Water-stressed |
|---|---|---|
| 21°C | 21 WW | 21 WS |
| 24°C | 24 WW | 24 WS |
| 27°C | 27 WW | 27 WS |

## The number of flowers decreased

This parameter seemed to be more affected by water stress than by temperature rise. The decrease of the number of flowers per plant reduced the floral display, which is an attractive element for insects.

### Number of flowers/plant

| Treatments | *B. officinalis* | *E. vulgare* | *I. glandulifera* |
|---|---|---|---|
| 21WW | 17 ± 5 | 56 ± 8 | 10 ± 4 |
| 21WS | 4 ± 1 | 47 ± 6 | 10 ± 5 |
| 24WW | 11 ± 2 | 64 ± 15 | 9 ± 3 |
| 24WS | 8 ± 2 | 36 ± 5 | 4 ± 1 |
| 27WW | 4 ± 1 | 59 ± 13 | 5 ± 2 |
| 27WS | 4 ± 1 | 35 ± 6 | 2 ± 1 |

## The size of flowers decreased

The corolla surface, the petal length and the flower depth were reduced for stressed flowers. The morphology change reduced the accessibility to rewards for insects.

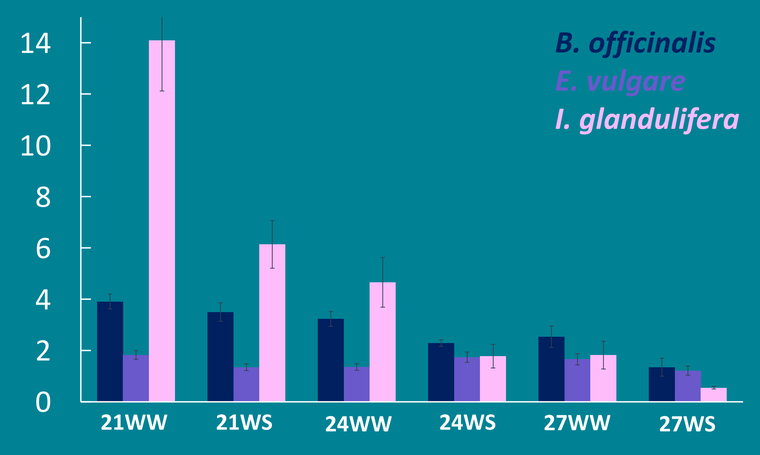
### Corolla surface ($cm^2$)

| *B. officinalis* | *E. vulgare* | *I. glandulifera* |
|---|---|---|
| 3.77 ± 0.45 | 1.95 ± 0.11 | 19.07 ± 0.99 |
| 3.67 ± 0.11 | 1.07 ± 0.11 | 12.41 ± 2.45 |
| 3.22 ± 0.08 | 1.77 ± 0.13 | 9.83 ± 1.39 |
| 2.69 ± 0.18 | 0.98 ± 0.09 | 12.56 ± 1.28 |
| 3.09 ± 0.42 | 1.53 ± 0.08 | 10.27 ± 0.66 |
| 2.23 ± 0.07 | 1.19 ± 0.15 | 6.77 ± 1.35 |

## The flower rewards decreased

Both stresses influenced this parameter. The nectar sugar content decreased mainly due to nectar volume reduction. The sugar concentration was less affected by stresses.

### Nectar sugar content (mg) /flower




| **Effects of temperature and water stress** | | | | | | |
|---|---|---|---|---|---|---|
| | **Temp *** **Water *** | Temp NS **Water *** | Temp NS Water NS | **Temp ***** **Water *** | Temp NS **Water *** | Temp NS Water NS |

Three weeks after stress induction, N=60 for *B. officinalis* and for *E. vulgare*, N=30 for I. *glandulifera.* Temp = effect of temperature rise ; Water = effect of water stress. * and *** indicate significative effect of Temp/Water at P<0.05 and P<0.001, respectively, according to analysis of variance (anova) test, NS indicates non-significative effect of Temp/Water.

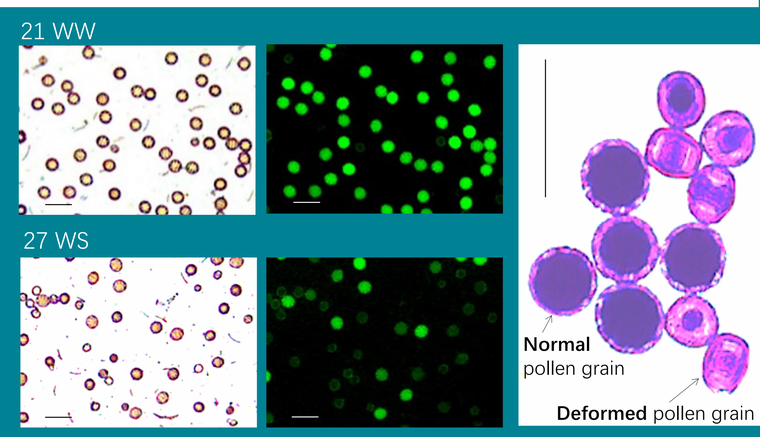
Total pollen quantity was not affected but pollen viability decreased from 79±4 % in 21WW to 25±9 % in 27WS for *B. officinalis*

### Flower modifications due to stress


*Borago officinalis*


*Echium vulgare*


*Impatiens glandulifera*




Pollen viability for *B. officinalis* (scale bar = 50 µm)

**Next step** : Which consequences for pollinators when floral signals are modifed ?