Impact of Urban Climate on Phenology and Fitness of Herbaceous Plant Species

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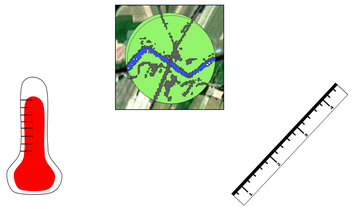
Introduction

- Global climate change, especially the increase in temperature, influences the vitality of plants and speeds up plant development.
- Urban climate, with warmer conditions (Urban Heat Island-Effect) represents a convenient setting to analyze climate change impacts on phenology and fitness (growth).
- The impervious surface area index (ISA-Index) and distance to the city center serve as indicators of urban land use. High impermeable built-up areas are responsible for a high ISA-Index in cities and contribute to an increased temperature.

Research Question

Do temperature mean (°C), ISA-Index (%) and distance to the city center (km) influence plant phenology and fitness?



Methods

- A direct gradient analysis was performed in the city of Bremen (Germany) with six herbaceous plant species: *Anthriscus sylvestris*, *Epilobium hirsutum*, *Filipendula ulmaria*, *Geum urbanum*, *Iris pseudacorus and Lythrum salicaria*.
- Plant size served as indirect fitness measure.

Fig.1: Phenological phases 0 (without bud) – 9 (fruit) of *E. hirsutum* (top left – bottom right).

- A phenological key was used to determine the generative plant development (Fig.1).
- 15 populations per species and 15 test plants per population were examined.

Results

- An indication for an Urban Heat Island-Effect in Bremen was revealed by four species (*L. salicaria*, *E. hirsutum*, *F. ulmaria* and *A. sylvestris*). For *L. salicaria*, the temperature increased significantly with increasing ISA-Index (Fig. 2).
- Overall, there was an impact of the measured variables on the phenology of all six species (Tab. 1) and on the fitness of *A. sylvestris*, *F. ulmaria* and *L. salicaria* (Tab. 2).
- A temperature increase of 1°C contributed to an advanced phenophase of *G. urbanum* (-11.4 days/ 1°C), *I. pseudacorus* (-3.2 days/ 1°C) and *L. salicaria* (-9.2 days/ 1°C). There was no consistent effect of temperature on fitness (Tab. 2).
- The ISA-Index influenced phenology and fitness almost exclusively positively, while distance mainly had a negative impact.

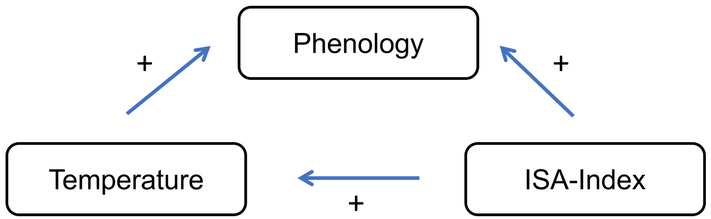


Fig. 2: Significant effects of the ISA-Index on temperature and of the ISA-Index and temperature on phenology of *L. salicaria*.

Tab. 1: Sensitivity values for phenology. They describe the change in the phenological phase per increase in temperature (+1°C), ISA-Index (+10 % ISA) and distance (+1 km) (Brackets represent marginally significant factors, expected results are visualized in blue).

Phenological Phase	+1° C	+10 % ISA	+1 km
A. sylvestris	- 1.65		
G. urbanum	+ 1.60		
I. pseudacorus	(+ 0.75)	+ 0.28	- 0.17
F. ulmaria			- 0.09
L. salicaria	+ 1.01	+ 0.24	+ 0.07
E. hirsutum			- 0.10

Tab. 2: Sensitivity values for fitness They describe the change in size (cm) per increase in temperature (+1°C), ISA-Index (+10 % ISA) and distance (+1 km) (Brackets represent marginally significant factors).

Fitness	+ 1° C	+ 10 % ISA	+ 1 km
A. sylvestris	+36.9		- 2.5
F. ulmaria	(- 9.3)		
L. salicaria	+20.3	(+ 4.1)	

Summary & Conclusion

- Across all six studied species, five showed expected phenology responses (Tab.1, visualized in blue), which involves a positive response to increasing temperature and increasing ISA-Index and a negative response to increasing distance.
- This highlights not only the direct accelerating impact of increasing temperature on phenology, but also an indirect positive effect of temperature in areas with a high extent of urbanization (high ISA-Index, low distance to the city center).
- Temperature-related spatial differences in phenology may reflect temporal changes in phenology as a consequence of climate change. This may be associated with mismatches of phenological phases between plants and pollinators.

References

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