Mechanisms in mutualisms: A chemically mediated thrips pollination strategy in common elder

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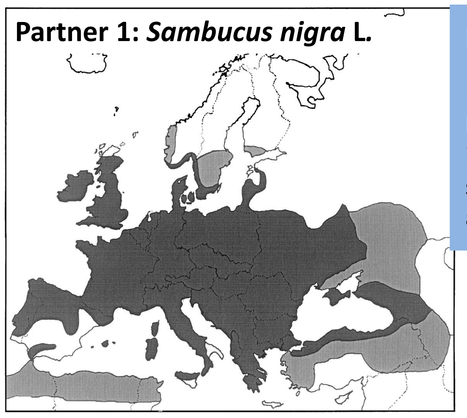
doi.org/10.1007/s00425-019-03176-5

Partner 1: *Sambucus nigra* L.



continuous distribution
Isolated populations[1]

Partner 2: *Thrips major* Uzel

'Widely distributed and very common throughout Britain, apart from the northern half of Scotland, and it is also recorded from across the island of Ireland. This species occurs throughout the Palaearctic as far south as Iran' [2]

Summary This study provides first evidence of a thrips species pollinating *Sambucus nigra* (Elderflower) and describes how interactions are driven by plant biochemical signalling and moderated by temporal changes in floral chemistry.

Introduction The concept of flower-feeding thrips as pollinating insects in temperate regions is rarely considered as thrips are more frequently regarded to be destructive florivores feeding on pollen and surrounding plant tissue. Combining laboratory and field-based studies we examined interactions between *S. nigra* and *T. major* within their native range to ascertain the role of thrips in the pollination of this species and to determine if floral chemicals mediated flower visits. If thrips provide a pollination service to *S. nigra*, then this will likely manifest in traits that attract the pollinating taxa at temporally critical points in floral development.

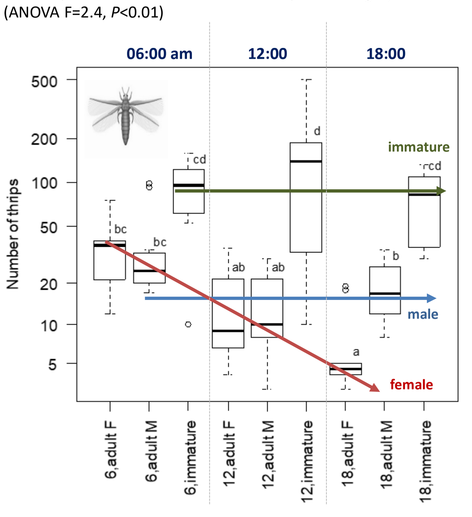
1. Floral development stages

Figure 1. Floral development in *S. nigra*; **DS0=closed bud**, DS1=<50% flowers in inflorescence open (not shown), **DS2= >90% flowers open (pre-anthesis), DS3=100% flowers open (at anthesis), DS4=senescence**, DS5= green fruit (not shown).

2. Flower development and floral volatile organic compound emissions

Floral volatile compound	Retention time (min)	Kovats retention index	Mean peak area DS0-DS1 (%)	Mean peak area DS2 - DS3 (%)
(E) Ocimene		1229	1921.3 ±1238.9	14291.3 ±14792.7
Linalool oxide		1416	464.3 ±287.3	19914.3 ±2728.8
Linalool		1523	454.8 ±454.8	112011.0 ±15904.8
Epoxy linalool		1710	608.5 ±359.9	54882.3 ±54882.3
Citronellol				

Fig 2a. Proportional abundance of component VOCs in total scent emissions collected over a 24 h from developing inflorescences of *S. nigra*. Differences were observed in abundance of each of the seven volatile compounds between flower development stages, DS2 to DS4 (ANOVA F=2.4, *P*<0.01)



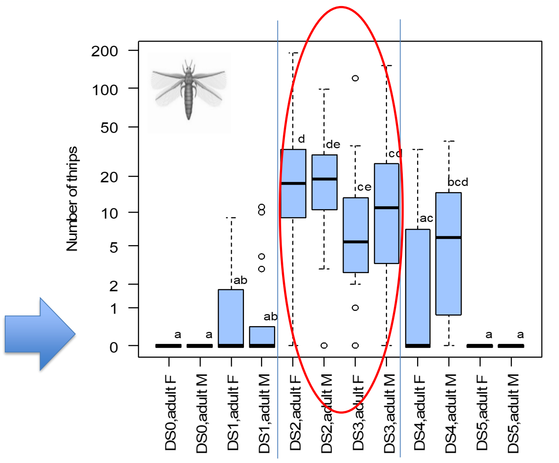


Figure 2b. Number of adult female and male thrips in inflorescences of *S. nigra* at six stages of floral development, sampled June and July 2016 (n=20). Significant difference between flower development stages (ANOVA, F=70.45, P<0.0001)

3. Diurnal activity of thrips in inflorescences and floral volatile emissions

Floral volatile compound	Retention time (min)	Kovats retention index	Peak area (% total volatile emission) 12:00 to 18:00	18:00 to 00:00	00:00 to 06:00	06:00 to 12:00
(E) Ocimene	6.091	1229	2734 (5)	7449 (5)	21404 (6)	5117 (4)
Linalool oxide	8.569	1416	5182 (9)	7202 (5)	15921 (6)	7268 (5)
Linalool	9.076	1523	33672 (58)	90866 (61)	**190292** (55)	81471 (58)
Epoxy linalool	12.029	1710	13874 (24)	37326 (25)	92056 (26)	40633 (26)
Citronellol	12.340	1739	2858 (5)	7263 (5)	16760 (5)	6232 (5)

Fig 3a. Proportional abundance of component VOCs in total scent emissions collected from an inflorescence of *S. nigra* (DS2) at four-time intervals, over 24 h

Fig 3b. Diurnal activity of thrips in inflorescences of *S. nigra*. Collections of single inflorescences repeated at 6 am (6:00), 12 pm (12:00) and 6 pm (18:00), showing different life stages of thrips foraging in flowers at specific times of the day. Significant differences between numbers of life stages and time of day (ANOVA, F=4.12, P<0.01)

4. Non-volatile defence compounds in floral tissue and thrips in inflorescences

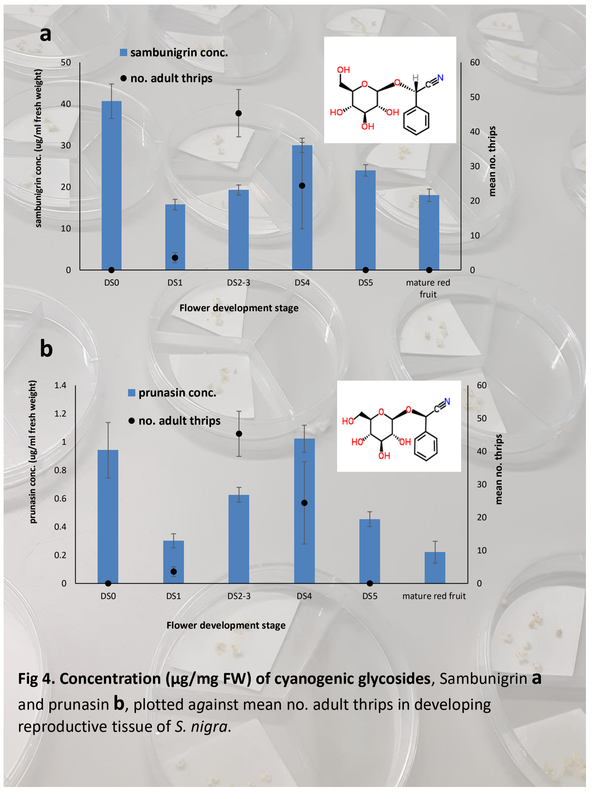


Fig 4. Concentration (µg/mg FW) of cyanogenic glycosides, Sambunigrin **a** and prunasin **b**, plotted against mean no. adult thrips in developing reproductive tissue of *S. nigra*.

Results

- Linalool was the major component of the inflorescence headspace with peak abundance coinciding with the highest number of adult thrips visiting flowers.
- Life cycle of *Thrips major* coincides with floral development. Thrips are present in highest numbers in young flowers, decreasing as flowers senesce.
- Floral volatile emissions peaked as flowers open, at night – crucially at a floral development stage receptive to pollen and when female *Thrips major* were foraging in inflorescences. Female thrips leave flowers during day – pollen transfer.
- Thrips were absent in buds and their numbers declined again in senescing flowers correlating with the concentration of cyanogenic glycosides, sambunigrin and prunasin recorded in the floral tissue.

mechanisms in
Compounds in floral tissue attract, store, defend
mutualisms

References

[1] Atkinson MD, Atkinson E (2002) Biological flora of the British Isles: *Sambucus nigra* L. J Ecol 90: 895-923

[2] Mound LA, Collins DW, Hastings A (2018) Thysanoptera Britannica et Hibernica - Thrips of the British Isles. Lucidcentral.org, Identic Pty Ltd, Queensland, Australia. https://keys.lucidcentral.org/keys/v3/british_thrips/