Do invaders come in peace?

Two invasive species as potential food resources for a generalist bumble bee

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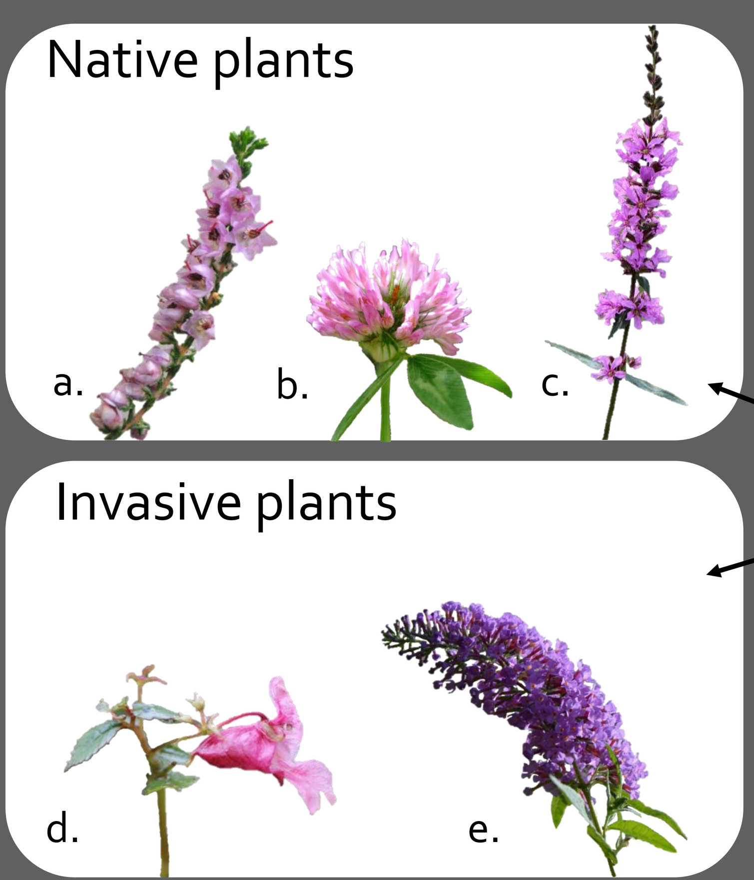
Introduction

Invasive plant species are frequently pinpointed as drivers of bee decline[(e.g. 1)]. However, their impact on bee population remains quite unclear and still controversial, as bee responses are highly variable among species (i.e., negative, positive or neutral). Changes in plant communities due to invaders could lead to predominance of new floral morphologies as well as differences in plant densities that pollinators have to deal with. Such modifications could then directly impact the energy balance of the foraging activity. Another key factor for the cost/benefit balance is probably the chemical composition of pollen which provides nutrients such as proteins.

In this work, we aimed (i) to compare the chemical composition of pollen from three native plant species, namely *Calluna vulgaris*, *Trifolium pretense* and *Lythrum salicaria*; as well as two invasive ones, namely *Impatiens glandulifera* and *Buddleia davidii*, (ii) to determine whether workers display the same pollen foraging pattern on these species regardless of their invasive behaviour, and (iii) to evaluate whether invasive species affect the nutritional intake of a European native generalist bumble bee species, *Bombus terrestris*. Our hypothesis is that the two invasive species display an easily accessible pollen resource for the buff-tailed bumble bee, with a similar nutritive composition to the three native ones.

Methodology



(i) Comparing the chemical composition (amino acid concentrations and profiles) of pollens (for floral and loads)

(ii) Comparing the foraging behaviour (e.g. visiting rate, foraging time) on each plant species

(iii) Comparing the foraging efficacy (i.e. pollen and amino acid intakes per hour (mg/h)) for each plant species.
We have then determined the weight of each pollen load brought back to the colony

Fig. 1: Studied plants species (a. *C. vulgaris*; b. *T. pratense*; c. *L. salicaria*; d. *I. glandulifera*; e. *B. davidii*) on which *B. terrestris* foraged on. Photo credit:T. Vermeulen, R. Johan, P. de Meirsman

Results and discussion

Table 1 **A**. The concentration (mg/g) of total (TAA) and essential amino acids (EAA) as well as the concentration of aspartate/glutamate (Asp and Glu) and proline for the pollens of the five host-plants (mean ± sd). Values with the same letter are not significantly different. **B.** The concentration of total and essential amino acids as well as the concentration of aspartate/glutamate and proline for the pollen loads coming from the five host-plants (mean ± sd). Values with the same letter are not significantly different.

Plant species	TAA content (mg/g)		EAA content (mg/g)		Asp and Glu content (mg/g)		Proline content (mg/g)	
Buddleia davidii (n = 3)	273.94 ± 19.81	b	135.53 ± 10.24	a	64.77 ± 3.83	ab	16.24 ± 1.04	c
Calluna vulgaris (n = 3)	290 ± 2.52	b	145.73 ± 1.06	a	62.04 ± 1	ab	22.9 ± 0.3	b
Impatiens glandulifera (n = 3)	252.85 ± 52.91	b	134.05 ± 28.56	a	54.12 ± 10.18	b	11.18 ± 2.9	c
Lythrum salicaria (n = 3)	315.23 ± 10.53	ab	150.8 ± 4.63	a	76.3 ± 3.07	a	27.65 ± 2.37	b
Trifolium pratense (n = 3)	403.39 ± 29.47	a	288.27 ± 20.6	a	58.72 ± 8.2	b	40.82 ± 3.17	a
Statistical results	$F_{4,10} = 7.55$, $P = 0.004$		H = 8.9, df = 4, $P = 0.063$		$F_{4,10} = 5.32$, $P = 0.015$		$F_{4,10} = 77.48$, $P = 0.001$	

A.

Plant species	TAA content (mg/g)		EAA content (mg/g)		Asp and Glu content (mg/g)		Proline content (mg/g)	
Buddleia davidii (n = 3)	151.72 ± 16.44	b	78.71 ± 8.2	a	37.81 ± 4.1	a	7.73 ± 1.18	d
Calluna vulgaris (n = 3)	193.33 ± 1.45	a	94.96 ± 0.34	a	39.87 ± 0.35	a	20.11 ± 0.79	b
Impatiens glandulifera (n = 3)	149.31 ± 6.71	b	76.61 ± 3.38	a	35.8 ± 1.25	a	6.24 ± 0.1	d
Lythrum salicaria (n = 2)	144.03 ± 5.4	b	70 ± 3.14	a	33.77 ± 0.51	a	13.94 ± 0.86	c
Trifolium pratense (n = 3)	184.5 ± 26.6	ab	84.63 ± 13.48	a	37.8 ± 4.56	a	28.97 ± 3.72	a
Statistical results	$F_{4,9} = 6.46$, $P = 0.01$		H = 6.8, df = 4, $P = 0.15$		H = 5.95 df = 4, $P = 0.2$		$F_{4,9} = 125.7$ $P < 0.001$	

B.

(i) Chemical suitability of *B. davidii* and *I. glandulifera*: The five plant species contained the full spectrum of EAA but floral pollen and pollen loads showed variable amino acid concentrations and compositions according to their botanical origin, as already highlighted in previous studies[(e.g. 2,3)]. However, our results revealed that pollen loads from the studied invasive plants had on average lower concentrations of **proline** (amino acid involved in the flight metabolism[(e.g. 4)]) compared to those from native species. By contrast, **histidine** (essential amino acid) was more abundant in pollen of *I. glandulifera*, than in pollen of native ones as already shown by Harmon-Threatt and Kremen[5]. Overall, despite these differences, *I. glandulifera* and *B. davidii* provide resources not consistently different in terms of amino acids from native plants, suggesting that generalist bumble bees may use them without change in their global pollen diet[3,5].

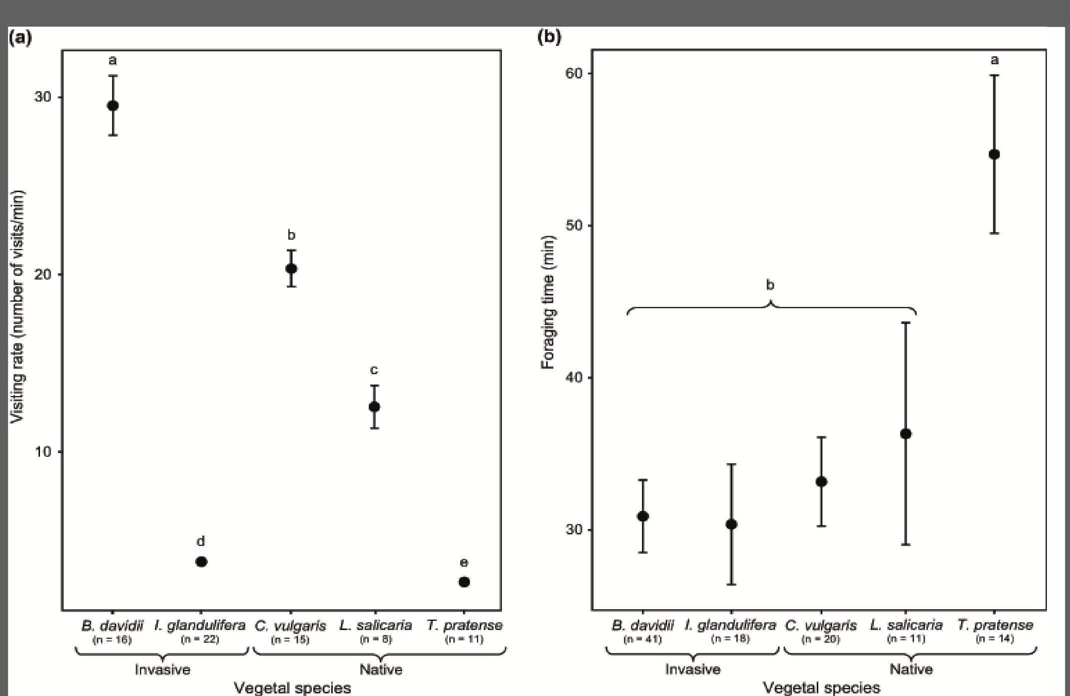


Fig. 2: Foraging behavior: Visiting rate (Fig 2a) and foraging time (Fig 2b) according to the plant species. Species with the same letter are not significantly different.

(ii) Foraging behaviour: Different pollen foraging behaviours (i.e. visting rate (Fig. 2a) and foraging time (Fig. 2b)) may be described for the five plant species: (i) a few foraging trips carrying small pollen loads (e.g. workers foraging on *C. vulgaris* and to a lesser extent on *I. glandulifera*), (ii) many foraging trips carrying small pollen loads (e.g., workers foraging on *B. davidii*), and (iii) a few foraging trips carrying large pollen loads (e.g. workers foraging on *T. pratense* and to lesser extent on *L. salicaria*). All these pollen foraging behaviours are likely related to the floral morphology and not to the plant type (invasive or not).

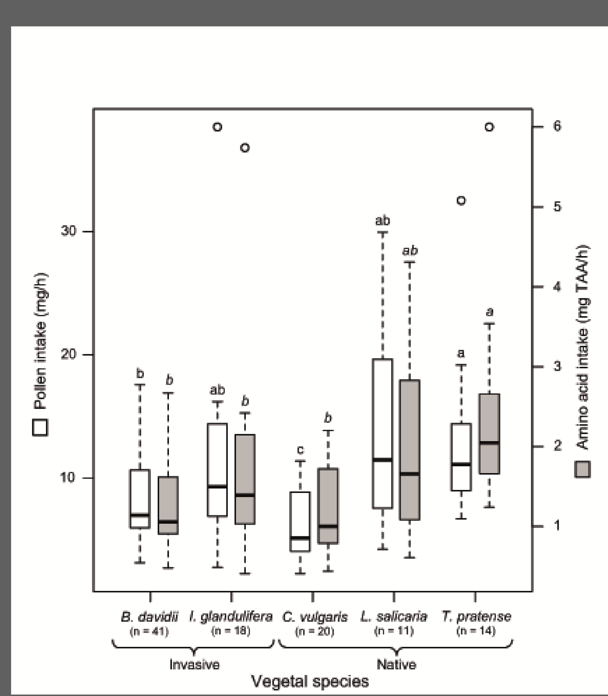


Fig. 3: Foraging efficacy: Expressed as pollen intake (i.e., mg/h, in white) and nutritive intake (i.e., TAA mg/h, in grey) according to the visited plant species foraged. Species with the same letter are not significantly different.

(iii) Foraging efficacy: Considering both pollen foraging behaviour and pollen chemical composition, foraging on *T. pratense* provided the highest nutritive intake (Fig. 3). Evidence is that the nutritional intake was related to both host-plant morphology and pollen quality rather than to the host-plant invasive behaviour. However, further studies are still needed to corroborate this finding, taking into account invasive plants with peculiar (i.e., unusual) flower morphologies and pollen composition.

Conclusion

The spread of invasive plant species directly impacts the plant community composition of invaded sites, leading to losses in plant diversity[(1,6)]. Such decrease in plant diversity would be detrimental to pollinator health by affecting the nutritional intake of bees[5,7]. Two situations can be distinguished. On the one hand, some generalist species (e.g. *B. pascuorum*, *B. terrestris*) are able to maintain their nutritional intake while incorporating new pollen resources in their diet, including invasive plant species[3,5,8]; on the other, this could impact a large array of oligolectic bees and species with a lower plasticity in their pollen diet that are intimately linked to native plants[1,3,8,9]. Further studies are needed on generalist species as well as specialists for a better understanding of the impact of invaders. Such understanding is clearly necessary to develop mitigation strategies for maintaining the bee diversity as well as the inherent ecosystem services.

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