Successful invasion of a floral market

An exotic Asian plant has moved in on Europe’s river-banks by bribing pollinators.

Invasive plants can displace native species through competition for nutrients, water, light and space. Here we show that they may also exert indirect pressure by competing for pollinators. We use the Asian plant Impatiens glandulifera as an example — this aggressive invader tempts bee pollinators away from native flowers with its rich nectar, which is more rewarding than that of any known native plant in central Europe. This causes a reduction of seed set in local plants in the vicinity and enables I. glandulifera to take over, reducing the fitness of native flora before competition for other resources even takes effect.

In just over a century since its introduction from the Himalayas, I. glandulifera (Fig. 1a) has conquered more than half of the river banks in the Czech Republic and is spreading at a comparable rate elsewhere in Europe and in North America. At over 2 metres high, it is the tallest annual in Europe, with extensive branching of the main stem ensuring monopoly of the aerial environment. It also tolerates a wide range of climates and soil types, which contributes to its success as a competitor. Each plant produces about 2,500 seeds, which fall to the ground at a density of 5,000–6,000 per square metre (ref. 2).

Pollination systems may be viewed as biological markets in which animals choose between ‘products’ (flower species) on the basis of their quality (sugar quantity in nectar, for example) and the plants compete for ‘customers’ (pollinators) (ref. 3). We tested whether competition for pollinators could be a mechanism by which I. glandulifera successfully excludes other plants. We first quantified the rewards they offer to pollinators. The nectar sugar concentration of I. glandulifera (48%) is well within the range of bumblebee-pollinated plants, but the rate of sugar production (0.47±0.12 mg per flower per hour; n=213) is substantially higher than in the other common bumblebee-visited species that we found associated with I. glandulifera along river-banks near Würzburg. These include Stachys palustris (0.04±0.02 mg per flower per hour; n=167), Lythrum salicaria (0.02±0.01 mg per flower per hour; n=85) and Epilobium hirsutum (0.01±0.02 mg per flower per hour; n=40).

The rate of sugar production by I. glandulifera exceeds that recorded for any other central European plant — of the nectar-rewarding plant species, none produces more than 0.3 mg per flower per hour and most generate less than 0.1 mg per flower per hour (ref. 3). I. glandulifera offers an even richer reward than some flowers pollinated by hummingbirds (up to 0.27 mg per flower per hour by Ipomopsis aggregata).

Stachys palustris occurs along river-banks in ‘pure’ patches, as well as in patches intermingled with I. glandulifera, a convenient arrangement for comparing the two species. Because of its extraordinarily rewarding nectar, visitation of I. glandulifera by bumblebees (mostly Bombus pascuorum) is frequent (2.5±1.5 visits per flower per 10-min interval) — roughly fourfold more often than to S. palustris (Fig. 1b).

We simulated invasion by I. glandulifera by moving ten large I. glandulifera plants in water buckets into previously pure S. palustris patches (both plant types bore at least 30 flowers each). Bees readily accepted the new plants and, although visitation (0.88±0.19 visits per flower per 10 min) was less frequent than in naturally occurring I. glandulifera patches, it was still greater than to S. palustris (Fig. 1b). We monitored the visitation frequency to S. palustris patches for 1–2 days before and 1–3 days after introducing I. glandulifera (excluding the first 3 h), by recording visitation to marked flowers in 7–50 short intervals (10 min per patch) according to a random schedule. We found that the number of visits to S. palustris was reduced by almost 50% when I. glandulifera was present (t-test, t=5.171, P=0.0006).

If the presence of I. glandulifera alters the visitation behaviour of pollinators to other plants, the fitness of these plants may also be affected. We therefore measured seed set in 102 inflorescences (with 2,567 flowers) from 15 pure patches of S. palustris, which were at least 500 m from the nearest I. glandulifera stand. We compared this seed set with that in 102 inflorescences (with 2,541 flowers) from 11 patches in which S. palustris grew intermingled with I. glandulifera. Seed set in the mixed patches was reduced by 25% relative to pure patches (Fig. 1c). A chi-squared contingency test on the frequency of flowers with 0, 1, 2, 3 or 4 seeds yielded a highly significant result (χ²=21; d.f.=4; P<0.0001).

To control for possible effects of competition for resources other than pollination, we repeated the experiment using pots of S. palustris plants and found that, again, seed set in plants placed in I. glandulifera patches (mean, 2.29; s.d., ±1.45) was significantly lower than in pure patches (mean, 3.2; s.d., ±1.07; χ²=16; d.f.=4; P=0.003).

Our results show that the presence of I. glandulifera has a strong negative effect on the fitness of native plants, simply because it attracts many more pollinators. As such ‘economic’ choices may be made by bees across large foraging ranges, competitive interactions between exotic and native plants may take place over much larger distances than previously thought. I. glandulifera and other exotic species may reduce the fitness of neighbouring plants even before competition for resources other than pollinators becomes an issue.

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