

**SPECIAL  
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Plant–Pollinator  
Interactions

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### Notes for Authors

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### Ecology and evolution of plant–pollinator interactions (Viewpoint)

Some of the most exciting advances in pollination biology have resulted from interdisciplinary research combining ecological and evolutionary perspectives. **Mitchell *et al.*** (pp. 1355–1363) highlight application of these approaches to two themes: (1) the link between pollinator behaviour and plant mating patterns, and (2) generalization and specialization in pollination systems. The authors conclude with several suggestions for future investigations that will further unite research in evolutionary and ecological pollination biology.



### Plant mating mediated by traplining pollinators

Rather than wandering randomly, some pollinators make repeated, sequential visits to sets of plants. **Ohashi and Thomson** (pp. 1365–1378) first review published work – computer simulations, laboratory experiments and field observations – on the consequences of such traplining for bumble-bees. New simulations then explore the effect of traplining on plant mating patterns and floral evolution.



### Pollinators influence among-flower variation in selfing

Adjacent flowers on *Mimulus ringens* floral displays often vary

markedly in selfing rate. Using paternity analysis, **Karron *et al.*** (pp. 1379–1383) experimentally demonstrate that this striking among-flower variation results from increased deposition of geitonogamous (among-flower, within-display) self pollen as bumble-bees probe consecutive flowers on each floral display.



### Seasonal variation in pollination success of alpine plants

Seed production of an alpine-snowbed plant, *Phyllodoce aleutica*, is strongly influenced by flowering time, which varies due to the effects of snowmelt regime. **Kameyama and Kudo** (pp. 1385–1394) find that the outcrossing rate of this species varies greatly (10–88 %) among populations, and reflects both the timing of pollinator availability during the season and the cryptic self-incompatibility of this species.



### Honey-bees limit outcrossing in Grevillea

Honey-bees have invaded Australian systems that evolved with vertebrate pollinators. **Whelan *et al.*** (pp. 1395–1401) explore whether differences in pollinators could explain variation in outcrossing among populations of *Grevillea macleayana*. Bird-exclosure reveals that honey-bees are effective in removing pollen from flowers, but birds are needed for high levels of outcross pollen deposition.



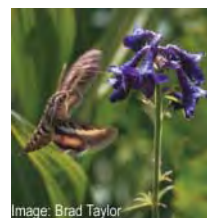
### New frontiers in competition for pollination (Review)

Plants that share pollinators may compete for pollination. **Mitchell *et al.*** (pp. 1403–1413) present a conceptual framework for studies of competition for pollination that involves both the quantity and quality of pollination services and considers both male and female sex functions of flowers. Using this framework, they explore how competition affects plant mating systems and multispecies' interactions. They also examine the effects of invasive species, climate change and pollinator declines on patterns of competition for pollination.



### Yeasts in floral nectar

A peculiarity of floral nectar that remains relatively unexplored is its role as a natural habitat for micro-organisms. A quantitative survey conducted by **Herrera *et al.*** (pp. 1415–1423) on 130 species of insect-pollinated plants from Spain and Mexico reveals that yeasts occur very frequently in floral nectar, where they sometimes reach densities of up to  $4 \times 10^5$  cells  $\text{mm}^{-3}$ . Incorporating nectar yeasts into the scenario of plant–pollinator interactions opens a number of intriguing avenues for research.



### Realized tolerance to nectar robbing

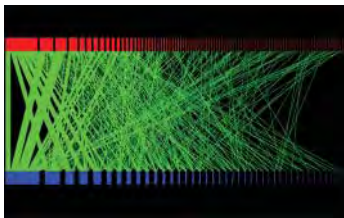
**Irwin** (pp. 1425–1433) uses an experimental common garden to find

that *Ipomopsis aggregata* exhibits variation in realized tolerance to nectar robbing and that increased flower production is associated with tolerance. By linking concepts and techniques from studies of plant–pollinator and plant–herbivore interactions, this work provides insight into the role of floral traits in pollinator attraction and plant defence.



#### Pollination biology of *Datura wrightii*

*Datura wrightii* is associated with the hawkmoth *Manduca sexta* at two stages: adults feed on nectar, then deposit their herbivorous offspring. **Bronstein *et al.* (pp. 1435–1443)** show that adult moths are highly effective pollinators of *Datura* even though much of their foraging activity is devoted to the bat-pollinated *Agave palmeri*. *Agave* thus has the potential to alter both the costs and benefits of this interaction.



#### Patterns and processes in mutualistic networks (Review)

Ecologists and evolutionary biologists are becoming increasingly interested in the study of networks of interacting plants and animal mutualists. **Vázquez *et al.* (pp. 1445–1457)** offer an overview of the mechanisms influencing the structure of these networks and show that substantial progress has been made in our understanding of the processes behind the patterns observed.



#### Nectar depth and proboscis length distributions

Plant–pollinator interaction webs exhibit consistent structural features, such as long-tailed distributions of generalization degrees and nestedness of interactions. The recognition of these shared features has led to a variety of explanations. By using the degree of size matching between nectar depth and proboscis length as a new network parameter, **Stang *et al.* (pp. 1459–1469)** show that beside size thresholds and species’ abundances, size distributions are important in understanding observed patterns of interaction.



#### Global test of pollination syndromes

‘Pollination syndromes’ are suites of phenotypic traits hypothesized to reflect convergent adaptations of flowers for pollination by specific types of animals. **Ollerton *et al.* (pp. 1471–1480)** test whether pollination syndromes successfully capture patterns of covariance of floral traits in communities surveyed on three continents. They conclude that syndromes do not successfully describe the diversity of floral phenotypes or predict the pollinators of most plant species. For example, although hummingbirds are the most frequent visitors to *Ipomopsis aggregata*, this species is also visited by *Bombus appositus*.



#### A generalized pollination system in the tropics

*Aphelandra acanthus* has an unusual mix of floral traits that corresponds to a pollination system generalized to bats and hummingbirds. **Muchhala *et al.* (pp. 1481–1487)** find that bats are more effective than hummingbirds in transferring conspecific pollen. However, bats also transfer large amounts of heterospecific pollen. Such interspecific pollen transfer probably decreases bat effectiveness and may select for generalized floral traits that attract both bats and hummingbirds.



#### Extreme floral variation and pollinator attraction

Flowers of *Echinopsis ancistrophora* vary dramatically among populations, in length, nectar production and timing of anthesis. **Schlumberger *et al.* (pp. 1489–1500)** find that these traits are associated with pollination by bees or hawkmoths, suggesting incipient differentiation at the population level. While hawkmoths only visit the longest flowers with rich nectar supplies, bees are more flexible, accounting for pollination not only in short, but also in intermediate flowers.



#### Fly pollination in *Ceropegia*

Fly pollination is widespread within the flowering plants but is relatively poorly researched compared with pollination

systems involving larger, more charismatic taxa such as bees and birds. **Ollerton *et al.* (pp. 1501–1514)** study the pollinator diversity of *Ceropegia*, which temporarily traps the flies that visit its flowers, in relation to the phylogeny and the biogeography of this asclepiad genus.



### Ecology and evolution of wind pollination (Review)

**Friedman and Barrett (pp. 1515–1527)** provide a comprehensive review of the ecology and evolution of pollination and mating in wind-pollinated plants. They review the literature and provide their own new experimental results on pollen limitation, pollen capture and pollen-transfer efficiencies. They discuss the effects of floral and inflorescence architecture for pollination and mating, and suggest that in many wind-pollinated hermaphroditic plants with unisexual flowers geitonogamous selfing is likely to provide reproductive assurance.



### How do flowers achieve adaptive accuracy?

Adaptive accuracy is a conceptual approach that explores the causes of individual and population phenotypic departure from adaptive optima. For flowers to achieve high fitness, they must have precise and accurate pollen placement on pollinators and precise and accurate stigma contact with pollinators, relative to the position of pollen placement. **Armbruster *et al.* (pp. 1529–1545)** show that floral integration and fusion of floral parts can improve floral precision, but that selection for herkogamy (outcrossing) often operates in conflict with pollination accuracy,

leading to departure of the population mean from the pollination optimum.



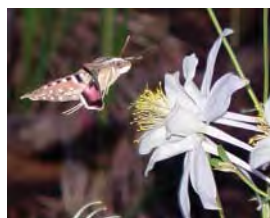
### Testing adaptiveness of anther position (Review)

Anther position within flowers may affect pollen removal and subsequent male seed siring success. **Conner *et al.* (pp. 1547–1556)** show that this is true for anther exertion (the degree to which anthers protrude from the corolla tube) in wild radish. Whether the four-high and two-low anther arrangement common to most mustards is also adaptive is less clear.



### Phenotypic manipulations and selection of floral associations (Viewpoint)

A basic theme in pollination ecology is that pollinators select for suites of floral traits. **Campbell (pp. 1557–1566)** argues for using phenotypic manipulations to evaluate the separate and combined effects of traits. Methods for studying multivariate selection are critically reviewed, and the experimental approach is illustrated with western USA and New Zealand alpine plants.



### Pollinators and floral traits in Rocky Mountain columbine

**Brunet (pp. 1567–1578)** observes wide variation in pollinator abundance and composition over time and space at sites in the western USA, but one species of

bumble-bee or hawkmoth predominates in each population each year. Floral characteristics vary widely among populations; however, whiter flowers are associated with the annual presence of hawkmoths and spur length is influenced by the presence of a specific hawkmoth species.



### How much does agriculture depend on pollinators?

Productivity of many crops benefits from the presence of pollinating insects, so a decline in pollinator abundance should compromise global agricultural production. **Aizen *et al.* (pp. 1579–1588)** consider variation among individual crops in their degree of pollinator dependency and estimate that the disappearance of pollinators would have only minor effects on total agriculture production and diversity. However, they predict that a pollinator shortage would substantially increase demand for agricultural land, particularly in the developing world, which could contribute significantly to global environmental change.



### Modelling pollination services Lonsdorf *et al.* (pp. 1589–1600)

describe and test the first quantitative model that predicts pollinator abundance on a landscape. On two of three test sites, the model explained up to 80 % of variance among farms for pollinator abundance. The approach provides a foundation to evaluate and develop land-use plans that promote pollinator conservation and service delivery.