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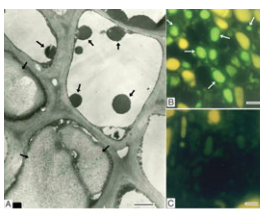
John Bryant takes a closer look at some of this month's Original Articles

What a drag — fading flowers fulfil fertility function

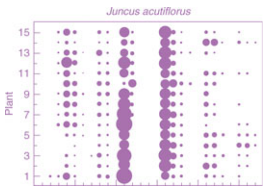
'There is no Plan B' we hear from committed political, military or business leaders. However, more cautious strategists, recognizing that even the best-laid plans may go wrong*, will formulate an alternative. This happens in the plant world too, where natural selection has sometimes led to development of a 'back-up' strategy. This is well illustrated by the work of **Qu *et al*. (Beijing and Haifa, pp. 1155–1164)** on pollination in *Incarvillea sinensis*, an annual member of the family Bignoniaceae. In out-breeding mode, *I. sinensis* is pollinated by bees, but as the authors have shown, if out-breeding fails, there is a 'Plan B', self-pollination, which depends on corolla abscission. Corolla senescence/abscission is not triggered by fertilization, as occurs in many species, but in these short-lived flowers occurs late in anthesis whether or not fertilization has occurred. Field observations indicated that abscission is wind assisted and that the movement of the corolla drags with it the anthers (which are inserted at the base of the corolla). As they pass the stigma, they brush against the stigmatic lobes (if the stigma is still receptive) causing pollen to be deposited on the stigmatic surface. Thus, a stigma that had not received non-self pollen via bees would now receive instead self-pollen. How important is this for the reproductive success of the plant? Firstly, as shown by the authors, self-fertilization is as effective as non-self in leading to seed set: the species is completely self-fertile. Secondly, as would be expected, growth of plants in an insect-proof cage did not reduce seed set because of the effectiveness of selfing. Thirdly, however, if the insect-proof cages were also wind proof, corolla abscission was reduced very markedly while seed set was only approx. 40 % of the value for plants that had undergone wind-assisted corolla abscission. This is indeed a fascinating and previously undescribed mechanism of delayed self-pollination, ensuring reproductive success when pollinators are scarce.

* or, as the Scottish poet, Robert Burns (1749–1796) put it: *The best laid schemes o' mice an' men, Gang aft a-gley, An' lea'e us nought but grief an' pain, For promised joy.*



Evergreen exception proved in protein storage story

Mention of plant storage proteins generally leads us to think about the more obvious examples, namely those in seeds. However, storage proteins are also laid down in vegetative organs in many plants. In addition to their storage function, many of these vegetative storage proteins (VSPs) have other roles; these include enzyme activities that may facilitate breakdown of other storage materials and defence, often mediated by protease inhibition. In some species, VSPs are deposited in preparation for a metabolically costly event such as flowering or seed set. In many deciduous trees, proteins are deposited as a seasonal nitrogen store; they are much rarer in evergreen trees, in many of which VSPs have never been detected. However, the work of **Tian *et al*. (Hainan, Haikou and Xi'an, China, pp. 1199–1208)** shows that amongst evergreen trees, lychee (*Litchi chinensis*) is an exception. Classic protein storage cells with protein-packed central vacuoles are present in roots, and in the trunk, branches and twigs. The protein is mobilized during the development of young shoots and during fruiting, pointing clearly to its storage function. Extraction and initial characterization of the protein showed that it is a single 22-kDa polypeptide. More detailed analysis revealed several very similar iso-forms encoded by a small gene family; homologous storage proteins occurring in fruits and seeds. Messenger RNA encoding one of the VSP isoforms was used for synthesis of cDNA that was then expressed to produce the 'recombinant' protein *in vitro*. Comparison of the protein sequence with others in the databases revealed a strong homology to other plant proteins that inhibit the proteases trypsin and chymotrypsin. This inhibitory activity was tested *in vitro* with the recombinant *L. chinensis* VSP. The VSP does indeed inhibit these enzymes and, like VSPs from herbaceous plants, but not like the majority of those from deciduous trees, may thus also have a role in defence.



All together now — doing it in synchrony

I am writing this on a train journey between Southampton and Exeter and we have passed many fields of maize (corn) waiting to be harvested. That harvest, of course, has depended on wind pollination earlier in the year. This is generally not a limiting factor; in large stands of a single variety, pollen has no trouble in ‘finding’ a receptive stigma. However, in natural ecosystems it is a different story. Plant numbers and plant density are much lower and consequently the likelihood of successful pollen transfer is reduced. Some remarkable strategies have evolved to maximize reproductive success, one spectacular example of which is discussed by **Michalski and Durka (Halle, Germany, pp. 1271–1285)**. They have studied flowering patterns in populations of several *Juncus* species growing in the Halle area. In different species of *Juncus* the flowering period ranges from 7 to 42 d, but individual flowers are short lived with anthesis taking place over 1 d or less. In this very careful investigation, between nine and 24 individual flower spikes (one selected per plant) were tagged in each population. For all species except *J. atratus* (which was pot grown), populations were of wild plants, comprising several hundred to several thousand individuals and covering between 200 and 630 000 m^2. Flowering times were observed for all the tagged spikes. In all species, there was a clear tendency for all flowers on one spike to open together; in some species this synchrony was very marked. Even more remarkable, synchrony was also seen at population level so that pulses of flower opening were interspersed with days when no flowers opened. The actual pattern varied between species. *Juncus effusus*, for example, exhibited one major flowering episode while other species exhibited several. Although *Juncus* species are self-fertile, this synchronous flowering strategy clearly increases out-breeding by ensuring that wind-blown pollen has a greater chance of reaching another open flower.

Aspen attracts amicable arthropods

My enemy’s enemy is my friend, so an old saying goes. In nature this strategy is exemplified by the attraction to plants of predatory or parasitic arthropods, including spiders, ants, wasps and flies, that target herbivores, as discussed by **Wooley *et al.* (University of Wisconsin, USA, pp. 1337–1346)** in relation to the development of extra-floral nectaries (EFNs) in *Populus tremuloides* (aspen). In aspen, EFNs develop on the leaves and attract flies and wasps that attack major herbivores. EFN production varies between genotypes and the variability is heritable. Young plants, in which leaves are a more valuable resource, produce more EFNs than older trees: there is a clear negative ‘gradient’ of EFN density from 1-year-old to 10-year-old trees. In a given tree, the leaves in the upper canopy develop more EFNs than those in the lower canopy. In evolutionary terms this may be because the upper canopy leaves are more photosynthetically efficient and therefore more worth protecting. Further, the production of EFNs is inducible. Young trees, initially 1 year old, were extensively defoliated over 2 years by exposure to tent caterpillars and/or cutting off 75 % of each leaf with scissors. This resulted in the formation, on average, of 23 % more EFNs in the third year (the range was 0–100 % in different genotypes and the capacity for induction was heritable). The authors determined the concentrations of normal defence chemicals, such as tannins and phenolic glycosides; there was no correlation, either positive or negative, between the concentration of these compounds and EFN density and thus no evidence of trade-off between EFN production and other defences. Neither was there a correlation between EFN density and the number of visiting predaceous or parasitic arthropods. However, it is possible firstly that EFNs affect the length of a visit and secondly that other cues also affect arthropod behaviour. Overall, therefore, the data are consistent with Optimal Defence Theory.

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