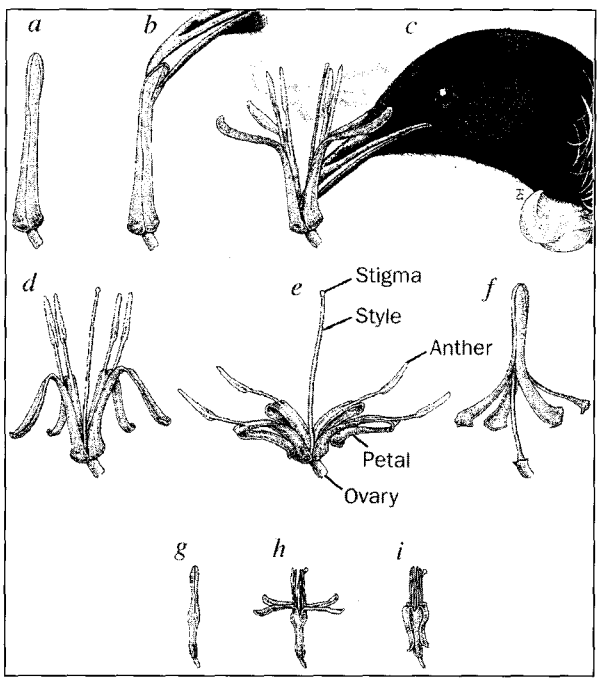
Explosive New Zealand mistletoe

SIR — Many flowers of the mistletoe *Peraxilla tetrapetala* (Loranthaceae) in New Zealand open from the bottom (*f* in the figure) rather than the top (*d*); Kuijt[1] called this an "unsolved mystery . . . we cannot even guess at the meaning of this bizarre performance." Here we report that flower buds of *P. tetrapetala* and *P. colensoi* open from the top only when twisted by a bird, a form of 'explosive' flower opening common in Africa but previously unknown in Australasia. Kuijt's "bizarre performance" is simply the consequence of flowers not being visited by birds. However, pollination in *Peraxilla* is possible without birds: unvisited flowers sometimes self-pollinate when the petals undergo abscission from the bottom.

The closely related *Alepis flavida* may show how explosive opening evolved. Its flowers open unaided, but birds twist buds to try and open them early. Another close relative, *Trilepidea adamsii*, is believed extinct, but historical paintings and herbarium sheets show an even more specialized explosive mechanism than in *Peraxilla*.

We discovered explosive flower opening in both endemic New Zealand *Peraxilla* species when we noted that flower buds bagged for hand pollination almost never opened (3/394 for *P. tetrapetala*, 1/82 for *P. colensoi*). The petals remained fused at the top, while eventually undergoing abscission from their base (*f* in the figure). Field observations of unbagged flowers revealed that they were opened by two native honeyeaters (Meliphagidae): tuis (*Prosthemadera novaeseelandiae*; *c* in the figure) and bellbirds (*Anthornis melanura*).

Both pollinators twisted only ripe buds; neither bird visited flowers that had already opened. Nectar production schedules discourage repeat visits, as *Peraxilla* buds already contain 70–98% of all the nectar they will ever produce. Exclusion experiments showed that the dependence of *Peraxilla* species on birds is not total, as 22% of unopened flowers set seed.



Explosive flower opening in the New Zealand mistletoe *Peraxilla colensoi* (*a–f*) and its possible precursor in *Alepis flavida* (*g–i*). *P. colensoi*: *a*, Unopened bud, mean length 47 mm. *b*, Bird (a tui) grasps the top of a ripe bud with its beak and twists. *c*, After 0.55 ± 0.10 s (mean ± 95% confidence interval, from 23 video recordings), the flower explodes open, flinging pollen from the already-dehisced anthers, and the bird drinks nectar from the side or above, pollinating the flower. *d*, Four hours after opening, petals have folded back further. Birds ignore open flowers, which produce little nectar after the ripe-bud stage. *e*, Three days after opening, petals fold back through 180°. *f*, Without a twist from a bird, the top of the flower never opens, but 4–8 days after bud ripening the petals undergo abscission from the base and pull the anthers over the top of the stigma, aiding self-pollination. *Alepis flavida*: this species does not have explosive flowers, and flowers open unaided. However, impatient birds sometimes twist flowers to try and open them early. *g*, Unopened bud, mean length 20 mm. *h*, Open flower on day of opening. *i*, Petals fold back within 2 days of opening. Drawings by T. Galloway.

In *A. flavida*, bagged flowers opened normally without the assistance of birds. However, we saw a bellbird twist *A. flavida* buds in an unsuccessful attempt to hasten their opening; this suggests how explosive opening could have evolved. Birds benefit by being able to forage more efficiently, because buds have not had their nectar harvested by any other bird (or insect)[2]: tamper-proof twist-top fast food for birds. The mistletoe may benefit through more faithful pollinator attention.

These discoveries in *Peraxilla* led us to reconsider the extinct *Trilepidea adamsii*, once congeneric with *Peraxilla* and *Alepis*. Study of pollination in extinct species is difficult, but paintings and herbarium sheets show previously overlooked features diagnostic of very complex explosive flowers. In the African *Tapinanthus*[3], ripe flower buds carry slits (fenestrae), which are probed by a bird's beak, causing the flower to unzip down that side. The stigma swings outwards towards the bird's head. The painting of *Trilepidea* by Osborne[4] shows flowers exactly matching this pattern, as do herbarium sheets (for example, 4 of 7 flowers on sheet AK103910). *Trilepidea* almost certainly had more complex explosive flowers than *Peraxilla*. Such specialization may have rendered *Trilepidea* more sensitive to reduced bird densities due to introduced mammalian predators, contributing to its rapid and puzzling[5] decline.

Explosive flower opening is well known in other mistletoes[6], including many of the 230 species in Africa[3], and a few species in India[7], Java, New Guinea and South America[1,6]. However, this is the first report from Australasia. The New Zealand flora generally displays few specialized pollination mechanisms[8]. We have shown that the two endemic *Peraxilla* mistletoes, and probably also *Trilepidea*, show very specialized ornithophilous pollination. This has interesting biogeographical implications, as the New Zealand Loranthaceae are generally considered primitive[9].

Our study also has implications for conservation. First, if outbreeding benefits *Peraxilla*, bird populations must be maintained, or cross-pollination becomes impossible. Current bird populations are insufficient in some areas to open more than a minority of *Peraxilla* flowers. Second, learning by the birds may be important. In the North Island, *Peraxilla* populations have been reduced markedly by Australian brushtail possums (*Trichosurus vulpecula*)[10]. In 1993–94, banding of trees to exclude possums allowed more extensive flowering, but the flowers were largely ignored by bellbirds (S. Dopson, personal communication), which may no longer know how to open them. Finally, posthumous recognition of explosive flowers in *Trilepidea* both sheds light on its extinction and increases our sadness at the fact.

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Scientific Correspondence

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