

The unique mouse-pollination in an orchid species

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The Chinese orchid, *Cymbidium serratum*, is pollinated by wild mountain mouse, *Rattus fulvescens*. The flowers use both odor and colour as attractants, and provide labellum as food reward for the pollinators. The mice pollinate the flowers during their endeavour to eat the labellums.

Charles Darwin was not exaggerating when he renounced that the various contrivances and adaptation of orchids vastly transcend those which the most fertile imagination of the world's most imaginative man could dream up with unlimited time at his disposal. Although the very large Orchid Family, with approximately 35,000 species, is renowned for its enormous diversity of pollination mechanisms, their pollinators are fairly monotonous - mainly insects and rarely birds. Here we describe the unique mouse pollination in an Orchidaceae species, *Cymbidium serratum*. This is the first record of mammal pollinator in Orchidaceae.

Cymbidium serratum is a terrestrial orchid found in the mountainous area of central and South China. Our studying location is Han Zhong area, Shaanxi province of Central China. The plant grows on humus-rich woody slopes in scattered clumps (Density) and its altitudinal rang confined to 500-1000m in studying area. The flowering period is from the end of February to the end of March, lasting for about a

month. 1-12 terminal flowers open in the same time on one individual. Scapes are 18.3 ± 6.2 cm ($n = 20$) in length. Sepals and lateral petals are green, but labellum is white and dark-red spotted. Because the flowers are facing slightly downward, the labellum are invisible to observers from above (Fig. 1a), but conspicuous from lower (Fig. 1b). Although they are described as unscented by earlier researchers^{1,2}, we found that they produce an odor smelled like fermented fodder to human nose. The smelling is weak in the day but stronger in the night. The tip of the column curves and covers stigma in 72 hours after successfully pollinated. Artificial experiment showed that both self-pollinating and cross-pollinating fruited well, but cannot set fruit when bagged, indicating that spontaneous self-pollinating is absent in the species.

We studied 6 natural populations of *C. serratum* for 5 continuous years and found that wild mountain mouse (*Rattus fulvescens*) is the only pollinator of the plant. The mouse is middle size (body length about 13 cm, tail length about 17 cm) and widely distributed in mountainous area in central and south China. They like woodlands, cultivated areas, and forests. The sense of smell is highly developed, and these rodents can detect the exact location of buried seeds without having to dig at random in a general area. The diet of the Wood Mouse consists of roots, grains, seeds, berries, nuts, grasses, fruits and insects³. They are nocturnal or crepuscular. They are active from nightfall to dayspring. The mouse approaches a flowering clump attracted by the smell, ultimately gets closely enough to be guided visually to eat the labellum of the flower standing on hind legs. During their visiting, the upper side of the nose stick to vicidium, then drag out the pollinium. The anther cap may function to prevent geitonogamy in one plant⁴. After finished with one flower, it usually turns to another one until all labellum on the plant are eaten up (Fig 1c; Fig1d; Fig 1e). The anther cap falls off either immediately of during their moving around on the ground. The pollinium may have the chance to adhere to the stigma of next flower when the mouse visits another plant. A

wild mountain mouse could move around in an area of 50-80m in diameter and possibly visit 10-20 clumps of *C. serratum* one night.

Unlike insect pollinated ones, the flowers of *C. serratum* are neither bright coloured nor aromatic. They adapt to mouse pollination in several ways. The flowers are basically dull green in colour. The bright coloured succulent labellum is favoured by wild mountain mouse. According to our experience, the labellum tastes slightly sweet, but the other flower parts including the lateral petals and the sepals tastes slightly bitter to human. We consider this could explain why the mouse is merely interested in labellum and leave the other parts intact. The plant flowers in early spring when the mice are active and other food resources are scarce. Since the body lengths of the mice are similar to the height of the flowers (about 12.7 ± 6 cm ($n = 20$) above ground), the mice can easily get the flowers. The odor production is synchronized with the activity of the mouse. The distance between column and lip petal is about 9 ± 1.5 mm ($n = 20$), similar to the height of the upper jaw of the mouse (about 12 mm). When foraging on the flower, the upper side of their snout can easily contact with the pollinium.

The pollination mechanism in *C. serratum* is very unique and different from that in other known rodent pollinated plants, which provide nectar as reward to those rodent pollinators. Rodent pollinating plants tend to have robust flowers with dull coloration, abundant pollen, copious amounts of nectar, exerted styles and stamens, and special structures called mammal guards^{5,6,7}. Since *C. serratum* provides pollinators with labellum instead of nectar as food reward, its flower is relatively slender and nectarless. Unlike the exerted styles and stamens in other rodent pollinated flowers, the stigmas and polliniums in *C. serratum* positioned in a way that they can be contacted with the body of the animals only when the pollinators feed on the labellum in certain posture. Although the plant doesn't have mammal guard, it successfully prevents the destruction

by mouse, probably by its special distribution of certain chemical contents in different organs.

Of many varied interactions between plants and animals, one of the most unexpected is pollination of flowers by rodents. The phenomenon was first recorded in Protea shrubs (Proteaceae) in the 1970s⁸, and until now, was thought to be confined to shrubs belonging to three dicotyledon families: Proteaceae, Loasaceae, and Melastomataceae, and one monocotyledon family, Hyacinthaceae⁵. Our finding adds to the diversity of both pollinating mechanisms in Orchidaceae and rodent pollinating plant groups. Closely related species may own different pollination mechanisms. The closest relative, or the sibling species, of *C. serratum*, *C. georingii*¹, is strongly fragrant and a typical bee pollinating species that owns food-deceptive pollination mechanism⁹. The unique pollination mechanism of *C. serratum* may evolve independently in the family.

1. Chen S.-C. *Floral of China* (Science Press, Beijing, 1999).
2. Liu, Z.-J., Chen, S.-C. & Ru, Z.-Z. *The Genus Cymbidium in China* (Science Press, Beijing, 2006)
3. Nowak, R. M. *Walker's Mammals of the World* 5th edn Vol II (Johns Hopkins University Press, Baltimore 1991).
4. Cheng J., Liu S.-Y., He R., Wei X.-L. & Luo Y.-B. *Biodiv. Sci.* **15**, 608-617 (2007)
5. Steven, D. J., Anton, P. & Jeremy, M. *Am. J. Bot.* **88**, 1768-1773(2001).
6. Carthew, S. M. & Goldingay, R. L. *Tre. Eco. Evol.* **12**, 104-108(1997).
7. Andrea, A. C. & Alicia, N. S. *Pl. Sys. Evol.* **221**, 113-128(1998).
8. Wiens, D. & Rourke, J. P. *Nature* **276**, 71-73(1978).
9. Yu, X.-H., Luo, Y.-B. & Dong, M. *J. Sys. Evo.* **46**, 163-174 (2008).

Acknowledgements The research work was funded by Doctoral Research Fund of Shaanxi University of Technology (SLGQD0512).

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Figure 1 Mouse pollination in *Cymbidium serratum*. a, A flowering clump observed from above, with flowers dull green and insignificant. b, A flowering clumps observed at ground level, with labellum bright colored and conspicuous. c, A flower visited by wild mountain mouse, note that the pollinarium has been removed, the labellum has been eaten, and the other floral parts are intact. Lower arrow, the position where labellum once attached. Upper arrow, the position where pollinium once located. d, A wild mountain mouse visiting a flower. e, A wild mountain mouse with pollinarium stuck on its snout after visiting the flowers of *C. serratum*. Arrow, pollinium.

