

# The pollination of *Paphiopedilum hirsutissimum*

SHI JUN, LUO YIBO, CHENG JIN, SHANGGUAN FAZHI  
and DENG ZHENHAI report on the pollination and  
reproduction of *Paphiopedilum hirsutissimum* var. *esquirolei*  
in Yachang Orchid Nature Reserve, in Guangxi, China

**I**N THE EARLY 19th century, when *Paphiopedilum* species were introduced to Europe and bloomed in greenhouses, orchid enthusiasts were astounded by their beautiful flowers. Now, *Paphiopedilum* species, or slipper orchids, are grown

in botanic gardens and private greenhouses all around the world. Millions of offspring have been produced through hand-pollination in cultivation, but until now, little has been known about their reproduction in the wild (Atwood 1985; Bänziger

1994, 1996, 2002; Shi *et al.* 2007a).

Like other orchids, *Paphiopedilum* species have suffered from over-collection and habitat loss. Moreover, changes in climate and environment may influence the number and activities of pollinators. As many

**1** A female hoverfly, *Allobaccha apicalis*, struggles to escape from the flower trap of *Paphiopedilum hirsutissimum* var. *esquirolei*

**2** The hoverfly eventually exits the flower through the rear escape aperture, complete with a mass of yellow pollen stuck to its thorax

**3** *Allobaccha apicalis* prepares to take off from the dorsal sepal of *Paphiopedilum hirsutissimum* var. *esquirolei* taking the pollen mass with it



orchids have specific pollinators, any reduction in pollinators could seriously affect their reproductive success. If there are few pollinators, fruit set will be lower, seedlings will be fewer, and eventually the beautiful plants will disappear. So studying the reproduction of wild orchids is important in the conservation of orchid species.

#### How we conducted our research

*Paphiopedilum hirsutissimum* var. *esquirolei*, a colonial lithophyte growing on sheer rock-faces and cliffs, is a widespread species, occurring from northeast India to southern China and Indo-China (Cribb 1998). As the commonest species of *Paphiopedilum* in China, *P. hirsutissimum* var. *esquirolei* was found in SW Guizhou, SW and NW Guangxi and SE Yunnan (Cribb *et al.* 1999). We studied pollination in the largest population of *P. hirsutissimum*

in China, in Yachang Orchid Nature Reserve, Guangxi province (Shi *et al.* 2007b). A total of 240 hours were spent observing pollination from April to June, 2006 and 2007. These observations were made between 9am

## The fly is trapped in the pouch for between 60 seconds and half an hour

and 5pm. Flower visitors were photographed using a Nikon D70 (Japan) with a Nikkor macro lens (105mm).

In our study site, the flowering period of *P. hirsutissimum* var. *esquirolei* started towards the end of April and continued for seven to eight weeks.

Flowering plants develop an inflorescence with a single flower with purple-red petals, yellowish and brown sepals and lips. The staminode is subquadrate with two white spots on its surface. Only a few other orchids were in flower at the same time, including *Dendrobium fimbriatum* and *Cheirostylis chinensis*.

#### The pollination mechanism

During our observations, only a few insects visited the flowers of *P. hirsutissimum* var. *esquirolei* and among these visitors, only female hoverflies (*Allobaccha apicalis*) were found to remove pollen from the anthers. We saw one *A. apicalis* approach orchid flowers eight times, it entered the labellum twice and removed pollen twice.

The hoverflies usually hovered around the flowers before they landed. It was only when they landed



Sequence by Shi Jun



on the staminode that they fell into the pouch through the broad entrance. The fly would be trapped in the pouch for between 60 seconds to more than half an hour (1,800 seconds), until it crawled out through one of the rear apertures under each anther located on either side of the staminode. It made contact with the dehiscent anther as it crawled out of a rear exit and the anther deposited portions of its pollen-mass on the dorsum of the insect's thorax in irregular, amorphous lumps. After escaping from the trap, a few hoverflies would rest on the dorsal sepal, but most flew away immediately. There were no starch bodies, nectar, liquid oil secretions, wax plates or resin secretions in or on any floral organs of *P. hirsutissimum*, so the poor pollinator could not benefit from the visitation. The hoverflies were deceived into pollinating the flowers of *P. hirsutissimum* var. *esquirolei* and got nothing in return.

### Deception of the pollinators

As far as we know, no flowers in the genus *Paphiopedilum* offer rewards for pollinator-service and their inflated labellum functions as a one-way trap (Atwood 1985; Bänziger 1994, 1996, 2002; Shi *et al.* 2007a). Two separate modes of pollination-by-deceit have been reported in this genus – food deception and brood-site deception. Species such as *P. rothschildianum* and



*P. callosum* that imitate brood sites have many small, black, often hairy, sculptures on their petals or labellum which may mimic an aphid colony. These dummy aphids could attract female hoverflies to lay their eggs on floral organs. In contrast, the flowers of food deceptive species, such as *P. bellatulum*, *P. charlesworthii* and *P. villosum*, lack dummy aphid structures but present a yellow, non-secretory, often papillose and shiny staminode that may represent mimicry of pollen grains, dehiscent anthers, nectar droplets or the honeydew secreted by aphids.

There is nothing on the flowers of *P. hirsutissimum* var. *esquirolei*, such as is found on food-deceptive or brood-site deceptive *Paphiopedilum* species. We are pleased to report, however, that we did find a few hoverfly eggs on the *P. hirsutissimum* flowers. We suggest that *P. hirsutissimum* var. *esquirolei* might employ a special brood-site deception, which is slightly different from that of *P. rothschildianum* and *P. callosum*. The purple-red petals of *P. hirsutissimum* look like the young leaves of *Rapanea neriifolia* trees. These leaves are usually infested by aphids, which are the food of larvae of many hoverflies, and we have found that female hoverflies lay eggs beside the aphids on these leaves. Therefore, we suggest that the petals of *P. hirsutissimum* lure the hoverflies by their resemblance to the young leaves of *R. neriifolia* (and other trees), the brood-sites of hoverflies. However, further studies are needed to prove this hypothesis. Another question will be addressed, namely how does the staminode of *P. hirsutissimum* attract the hoverflies?

### Breeding system, natural fruit set and conservation

Both hand self-pollination and cross-pollination lead to 100 percent fruit set. The flowers of bagged but unmanipulated controls set no fruit. This indicates that *P. hirsutissimum*

is self-compatible but pollinators are required to transfer orchid pollen to the stigma.

Although hand-pollination led to 100 percent fruit set, natural fruit set was very low, only 7 percent in 2006 and 4 percent in 2007. This showed that the reproduction of *Paphiopedilum hirsutissimum* was strongly pollinator-limited. A similar phenomenon has also been found in *P. villosum* (8 percent) and *P. charlesworthii* (0.67 percent) (Bänziger 1994, 1996, 2002).

Most species of *Paphiopedilum* are pollinated by hoverflies (Atwood 1985; Bänziger 1994, 1996, 2002; Shi *et al.* 2007). Obviously, the reduction of hoverflies will influence the pollination and reproduction of *Paphiopedilum* species. Many investigations showed that the number of hoverflies could be seriously affected by habitat destruction, a reduction of food-supplements and the use of pesticides in agriculture (Sommaggio 1999). Besides protecting the *Paphiopedilum* from over-collecting and habitat loss, we should also protect the hoverflies, which, as their pollinators, are crucial to the survival of the *Paphiopedilum*. ■

**SHI JUN** and **LUO YIBO** research orchid pollination, evolution and conservation at the State Key Laboratory of Systematic and Evolutionary Botany, at the Chinese Academy of Sciences, Beijing. Email: sj027001@hotmail.com, Luoyb@ibcas.ac.cn,

**CHENG JIN** works at the College of Biological Sciences and Biotechnology at Beijing Forestry University. Email: chengjin9912@163.com

**SHANGGUAN FAZHI** studies orchid conservation at Guizhou University, Guiyang. Email: bba01042@yahoo.com.cn

**DENG ZHENHAI** is an administrator at Yachang Orchid Nature Reserve, Guangxi. Email: 68368598@163.com.

### ACKNOWLEDGEMENTS

The authors would like to thank Luo Dun, Liu Shiyong, Ni Shidong, Xin Rongshi, Chen Yunmeng, Wang Gongxin, Xie Xiaoqing and Zhang Lianhua of Yachang administration for their assistance during our study in the Yachang Nature Reserve. Financial support is gratefully acknowledged for Luo Yibo from the State Forestry Administration, PR China

### REFERENCES

- Atwood, JT** (1985) Pollination of *Paphiopedilum rothschildianum*: Brood-site imitation. *National Geographic Research* 1: 247–254
- Bänziger, H** (1994) Studies on the natural pollination of three species of wild lady-slipper orchids (*Paphiopedilum*) in Southeast Asia. In *Proceedings of the 14th World Orchid Conference* (Pridgeon, A, ed.), Edinburgh: HMSO, 201–202
- Bänziger, H** (1996) The mesmerizing wart: the pollination strategy of epiphytic lady slipper orchid *Paphiopedilum villosum* (Lindl.) Stein (Orchidaceae). *Bot. J. Linn. Soc.* 121: 59–90
- Bänziger, H** (2002) Smart alecks and dumb flies: natural pollination of some wild lady slipper orchids (*Paphiopedilum* spp., Orchidaceae). In *Proceedings of the 16th World Orchid Conference* (J Clark, WM Elliott, G Tingley, J Biro eds.), Vancouver Orchid Society, 165–169
- Cribb PJ** (1998) The genus *Paphiopedilum*. Natural History Publications (Borneo) and the Royal Botanic Gardens, Kew
- Cribb, PJ, Luo, YB & Siu, G** (1999) *Paphiopedilum hirsutissimum* var. *esquirolei* in Southern China. *Orch. Rev.* 107: 217–219
- Shi, J, Cheng, J, Luo, D, Shangguan, FZ & Luo, YB** (2007a) Pollination syndromes predict brood-site deceptive pollination by female hoverflies in *Paphiopedilum dianthum* (Orchidaceae). *Acta Phytotax. Sin.* 45: 551–560
- Shi, J, Cheng, J, Luo, D, Liu, SY, Tan, HS & Luo, YB** (2007b) An orchid paradise: The Yachang Orchid Nature Reserve, in Guangxi, China. *Orch. Rev.* 115: 188–195
- Sommaggio, D** (1999) *Syrphidae*: can they be used as environmental bioindicators? *Agriculture, Ecosystems and Environment* 74: 343–356