Pollination Ecology of *Dendrobium setifolium*, *Neuwiedia borneensis*, and *Lecanorchis multiflora* (Orchidaceae) in Sarawak

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ABSTRACT We studied pollination biology of three orchids, *Dendrobium setifolium*, *Neuwiedia borneensis* and *Lecanorchis multiflora*, during 1993-1994 in Sarawak. *Dendrobium setifolium*, a canopy epiphyte, was pollinated by one species of stingless bee, *Trigona melanocephala*. This may be the first report on stingless-bee pollination of *Dendrobium*. A primitive orchid, *Neuwiedia borneensis*, was pollinated by three species of stingless bees which visited flowers for pollen. Autogamy was observed in *Lecanorchis multiflora*.

Key Words: *Dendrobium* / *Lecanorchis* / *Neuwiedia* / pollination / Sarawak / *Trigona*

The Orchidaceae consists of 17,000 - 30,000 species, and is one of the largest families of flowering plants (Dressler, 1981, 1993). On Borneo Island, Malaysia, more than 1400 orchid species have been recently listed (Wood & Cribb, 1994) and this group may be one of the richest plant groups in Borneo. One major factor thought to be responsible for this diversity of orchids is an adaptive radiation in relation to pollinators (van der Pijl & Dodson, 1969). Thus, the study of pollination ecology of orchids in Borneo offers a basis to understand the diversity of orchids, and to test the hypothesis on the genesis and maintenance of biodiversity in the tropics. We have been carrying out studies on the pollination biology of orchids in Borneo since the summer of 1993. At this time we report our preliminary observations on three species of orchids, *Dendrobium setifolium*, *Neuwiedia borneensis*, and *Lecanorchis multiflora*.

This study has been carried out as part of the Canopy Biology Program in Sarawak (Inoue & Hamid, 1994). Two tree towers of 35 m tall were built, and access to canopy flowers can be made safely and easily. It would be impossible to study the pollination of canopy flowers such as *Dendrobium setifolium* without such facilities. Thus, the present report may be the first account of orchid pollination biology in high canopies of tropical rainforests.

In addition, there seems to be no report on the pollination biology of *Neuwiedia*. *Neuwiedia* is considered to be one of the most primitive orchids, with three fertile stamens and without column and pollinia structure, and is taxonomically treated as belonging to the subfamily Apostasioideae or to a separate family, Apostasiaceae. *Neuwiedia* is generally considered to be an important group to link the advanced orchids with other monocotyledonous ancestors. Thus, the pollination biology of *Neuwiedia borneensis* may offer useful information on the evolution of orchids.

Reports on pollination of mycotrophic orchids such as *Lecanorchis* are scarce. At our research site, we had opportunities to observe *Lecanorchis multiflora* and made some

Table 2. Visitors of *Dendrobium setifolium* at Lambir.

Visitor	Visitation date	No. of insects observed	No. of insects collected	Pollinia attached
<i>Trigona</i> (<i>Tetragonula</i>) <i>melanocephala</i>	93/8/3	1	0	–
	94/1/16	ca. 5	2	yes
<i>Braunsapis</i> sp. (Anthophoridae)	93/12/29	ca. 2	0	–
	94/1/17	ca. 3	1	no

Table 3. Visitors of *Neuwiedia borneensis* at Lambir.

Visitor	Visitation date	No. of insects that visited	No. of insects collected	Pollen grain attachment
<i>Trigona</i> (<i>Tetragonula</i>) <i>melanocephala</i>	93/8/6	ca.10	2	yes
	93/8/7	ca. 5	1	yes
	93/8/8	ca. 5	0	---
<i>Trigona</i> (<i>Tetragonula</i>) <i>minangkabau</i>	93/8/6	ca. 5	0	yes
<i>Trigona</i> (<i>Tetragonula</i>) <i>laeviceps</i>	93/8/8	ca. 5	0	yes

several flower visitors were observed in January of 1994 when flowering plants were relatively abundant (nearly 20). Table 2 lists the visitors to *D. setifolium* flowers. Pollinia of *D. setifolium* were found attached to the corbicula of the hind legs of two individuals of a stingless bee (*Trigona melanocephala*) collected at the flowers of *D. setifolium* (Fig. 2). This stingless bee species was concluded to be a pollinator of *D. setifolium*. One anthophorid bee (*Braunsapis* sp.) also visited the flowers of *D. setifolium*; however, the collected bee had no pollinia attached to its body, and could not be concluded to be a pollinator. The stingless bees seemed to visit flowers of *D. setifolium* to collect nectar. As the flowers are not resupinate, the bees landed on the column foot; consequently, the pollinia became attached to the leg of the bees as they exited from the flowers.

Reports of *Trigona* pollination of orchids are a few (cf. Pijl & Dodson, 1969; Dressler, 1993), and this may be the first report of *Trigona* pollination of *Dendrobium*.

Pollination of *Neuwiedia borneensis*

Neuwiedia borneensis seemed to have annual life cycle in flowering and fruiting, although observation was limited. Flowers and matured fruits of *Neuwiedia borneensis* were observed in July to August and developed green fruits were observed in December; hence, *N. borneensis* seemed to flower in August and to mature in August of the next year.

Three stingless bee species visited flowers of *N. borneensis* (Table 3). Flowers of *N. borneensis* did not secrete nectar, and the stingless bees foraged for pollen grains from fresh flowers. The stingless bees visited the flowers from early morning (7:00 AM) to late morning (11:00 AM), when available pollen-grains were depleted. Stingless bees seized one of the three stamens with their legs and collected pollen grains using their mandibles (Fig. 3). Pollen grains were gathered and mounted on their corbicula (Fig. 4). Each stingless bee sequentially visited flowers within a plant. The frequent visits of bees and high fruit set (approximately 100 %) indicated that these bees were efficient pollinators. Judging from the visitation frequencies, *Trigona melanocephala* was the principal pollinator of *N. borneensis* among the three species observed. *T. melanocephala* is a stingless bee which collects nectar and pollen mainly from small flowers in the understory (Nagamitsu & Inoue, 1994). It is interesting that *T. melanocephala* was also a pollinator of the epiphytic canopy orchid, *Dendrobium setifolium*.

Vogel (1981) suggested that the subfamily Apostasioideae including *Neuwiedia* was pollinated by bees with buzzing; however, buzz- pollination was not observed in *N. borneensis*, although the attraction of bees with pollen was consistent with Vogel. The phylogenetic position of Apostasioideae will influence the determination as to whether pollen as a floral attractant is a primitive or derived condition.

Pollination of *Lecanorchis multiflora*

At Lambir, *Lecanorchis multiflora* seemed to flower throughout the year as a population, although individual plants seemed to have different life cycles of flowering and fruiting. The inflorescence of *L. multiflora* is an indeterminate raceme (as with most other orchids), and the flowers opened basipetally, that is, from the bottom to the top. Each flower remained open for approximately three days. Of the five flowers recorded from bud to fading, four flowers opened only slightly, without the petals spreading, and only a part of the hairs of the lip extended outside throughout the flowering period (Fig. 5). However, even the remaining flower did not open fully. The fifth flower opened fully, with the petals spreading, for several hours on the first flowering day, but did not open fully on the following days, returning to the semi-opened condition of the other flowers. The perianth of all the flowers dropped off on the fourth day, but the pedicel and ovary remained on the stems. Following this, the next higher bud in the inflorescence developed and flowered within one week. Based on this sequence of flowering, one large inflorescence with 20 or more flowers was roughly estimated to have continued flowering for at least half a year. The remaining ovaries continued to develop and matured into young fruits, and most of infructescences indicated fruit set of nearly 100 %. During our observation period, no insects visited the plants, and self-pollination was observed at a flower sampled on the third day, when a part of the pollinia was observed to have come in contact with the stigma (Fig. 6). This indicates that typical mode of pollination in this species is autogamy.

The same mode of self-pollination is reported from the Japanese *Lecanorchis kiusiana* (Chuma, 1980; Tuyama, 1982), and seems to be a common feature in *Lecanorchis*. It is noteworthy that not all of the flowers fully opened. Tuyama (1982) also noted that most of the Japanese *Lecanorchis* flowers were found in semi-opened condition and that fully opened flowers were scarce. Although there were no observations on Japanese *Lecanorchis* through flowering duration, it is possible that Japanese *Lecanorchis* flowers do not open, and hence set seeds via self-pollination.

The flowers secreted fluids at the base of bracts which dried to a white powder and attracted ants (Fig. 5). At this point, the function of this secretion in the process of pollination is unknown; however, one possibility may be ant-protection against herbivores. We cut one flower at the third-day stage, leaving the pedicel and ovary on the stem. The pedicel and ovary were found to be dropped from the stem next morning, suggesting that flowers injured by herbivores are aborted.

ACKNOWLEDGMENTS We thank Abang A. Hamid of the Forest Department of Sarawak for providing facilities for this research. We also thank Jeff Hapeman for English corrections. This work was partly supported by Japan Ministry of Education, Science and Culture for International Scientific Research #06041013.

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Received April 9, 1995

Accepted September 10, 1995

井上 健, 加藤真, 井上民二 マレーシア・サラワク州における *Dendrobium setifolium*, *Neuwiedia borneensis*, *Lecanorchis multiflora* (ラン科) のポリネーション

1993-4年にマレーシア・サラワク州において *Dendrobium setifolium*, *Neuwiedia borneensis*, *Lecanorchis multiflora* の3種のランのポリネーションについて観察した。*D. setifolium* は林冠木の40メートル以上の枝に着生し、ハリナシバチの一種により送粉されていた。これはセッコク属におけるハリナシバチによる花粉媒介の最初の報告であろう。*N. borneensis* も3種類のハリナシバチにより送粉されていた。*N. borneensis* は花蜜は分泌せず、ハリナシバチは花粉を収集していた。これも *Neuwiedia* の送粉の最初の報告であろう。*Neuwiedia* は原始的なランとして知られるが、この報告はランの進化を考える上で有益な情報と思われる。ムヨウラン属の *L. multiflora* は日常的に自家送粉を行うことが観察された。自家送粉はこの属の他の種でも報告されており、自家送粉はこの属で広く行われているものと思われる。