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THE STATUS OF *GASTRODIA JAVANICA* (BL.) LINDL. IN SINGAPORE

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INTRODUCTION

Gastrodia is a small genus with an estimated 17–31 species (Seidenfaden & Wood, 1992). Its members range from Madagascar, eastern Siberia and Japan, through much of Southeast Asia, New Guinea, Australia, and New Zealand (Wood, 1990). In Southeast Asia, *Gastrodia* species are usually found in damp primary and secondary forests where a thick layer of humus is available. The genus *Gastrodia* was initially proposed by Robert Brown in 1810, and almost all orchid systematists have since used this name, except for Blume who proposed the genus *Epiphanes* for the now named *Gastrodia javanica* (Comber, 2001; Fig. 1). *Gastrodia* species are saprophytic orchids with an elongated underground tuber, erect stems which bear one- to many-flowered unbranched racemes (Wood, 1990). The flowers of *Gastrodia* have their petals and sepals connate for most of the length, forming a broad tube, with only five, short, free lobes round the rim; the lip is much shorter than the sepals and is normally entire; the column is comparatively long, with a short foot; the stigma is near the base and has two pollinia (Comber, 2001; Wood, 1990).

Although described as "saprophytic" by many authors, Arditti (1993) refers to *Gastrodia* species as being epiparasitic, which is probably a more accurate nutritional description of these plants. In general, orchid mycorrhizae have two different histological expressions; ptyophagy and tolypophagy (Zettler et al., 2003). The majority of orchid mycorrhizal interactions between the phytobiont and mycobiont is tolypophagy. In this sort of interaction, the intracellular hyphae forms characteristic coils called pletons before lysis occurs. The hyphal cytoplasm remains separated from the cytoplasm of the phytobiont by an interface consisting of the hyphal plasmalemma, hyphal cell wall, interfacial matrix, and phytobiont plasmalemma serving as the location of nutrient exchange (Rasmussen, 1995). In chlorophyll-deficient orchids such as *Gastrodia*, the orchids are dependent on their mycobionts as the only source of nutrition during their entire life cycle (Zettler et al., 2003). In these orchids, the phytobiont and mycobiont interaction is termed ptyophagy, where the intracellular hyphae enter the cortical cells of the root. The hyphal tips lyse, leaking their contents into the interface between the phytobiont plasmalemma and the mycobiont cell walls. The released fungal material then forms spherical bodies called ptyosomes which are then digested by the phytobiont.

Fig. 1. *Gastrodia javanica* growing at the MacRitchie Reservoir forest floor. (Photograph by: Alvin Francis Lok Siew Loon).

Burgeff (1959) described in detail ptyophagy between holomycotrophic orchids such as *Gastrodia* with a homobasidiomycete (*Armillaria mellea*) as the mycobiont. Later research by Xu & Guo (2000) also reported holomycotrophic *Gastrodia* species, utilising a fungus (*Armillaria* species), that in turn parasitizes and destroys live trees. A similar relationship was also observed between the holomycotrophic orchid *Galeola* and *Armillaria* (Terashita & Chuman, 1987). Whatever the case, ptyophagy remains a rare phenomenon in orchid mycorrhizae in comparison with tolypophagy, and seems to be limited to holomycotrophic orchids with non-*Rhizoctonia* mycobionts.

PAST AND PRESENT RECORDS

Gastrodia javanica is only one of five epiparasitic orchid species in Singapore (Table 1.). Four were considered nationally extinct but later rediscovered, while *Didymoplexis pallens* Griff. was considered vulnerable, but later had its status upgraded to nationally critically endangered. The reason why four species were thought to be extinct but later rediscovered, is probably because these orchids being epiparasitic or "saprophytic", they spend most of their life cycle underground, only emerging when flowering, to reveal their very short lived inflorescence, so sightings are a matter of luck.

Table 1. List of epiparasitic orchids found in Singapore with conservation status category data from the Singapore Red Data Book, 1st Edition (Ng & Wee, 1994), and 2nd Edition (Davison et al., 2008).

Species	Family	1st Edition Status	2nd Edition Status
Aphyllorchis pallida Blume	Orchidaceae	Nationally Extinct	Nationally Extinct
Didymoplexis pallens Griff.	Orchidaceae	Nationally Vulnerable	Nationally Critically Endangered
Galeola nudifolia Lour.	Orchidaceae	Nationally Extinct	Nationally Critically Endangered
Gastrodia javanica (Blume) Lindl.	Orchidaceae	Nationally Extinct	Nationally Critically Endangered
Stereosandra javanica Blume	Orchidaceae	Nationally Extinct	Nationally Extinct

Table 2. Previous Singapore collections of *Gastrodia javanica* (Bl.) Lindl. deposited in the Herbarium, Singapore Botanic Gardens (SING).

S/No.	Bar Code No.	Collector	Collector's No.	Collection Date	Locality
1.	0047367	Ridley, H.N.	s.n.	29 Oct.1889	Seletar
2.	0047366	Ridley, H.N.	s.n.	Feb.1890	Bukit Timah
3.	0010819	Mat	s.n.	Oct.1891	Bukit Mandai
4.	0056501	Ridley, H.N.	s.n.	1893	–
5.	0047365	Ridley, H.N.	s.n.	13 Oct.1894	–
6.	0010818	Sinclair, J.	39485	7 Feb.1953	MacRitchie Reservoir

The epiparasitic *Gastrodia javanica* was first collected in Singapore by H. N. Ridley on 29 Oct.1889 at Seletar, then in Feb.1890 at Bukit Timah, and again on 13 Oct.1894 (Table 2). He later described this taxon as *Gastrodia malayana* in 1907, but was later found to be synonymous with *Gastrodia javanica*. Keng et al. (1998) later described *Gastrodia javanica* as being strictly restricted to Nee Soon Swamp Forest. For years this species was not collected and presumed nationally extinct as indicated in the first edition of the Red Data Book. Later, it was rediscovered in Nee Soon Swamp Forest in front of the Seletar Driving Range, adjacent to Upper Seletar Reservoir Park during an National Parks Board (NParks) survey conducted between 1992–1994 (Ali bin Ibrahim, pers. comm.), and had its conservation status category downgraded to nationally critically endangered (Tan et al., 2008).

On 13 Oct.2009, *Gastrodia javanica* was again encountered at a remote corner of MacRitchie Reservoir close to the bridge foundations leading to the former *Syonan Jinja*, the Imperial Japanese Army Shinto Shrine (Fig. 1). The vegetation in the area was predominantly secondary forest dominated by *Elaeocarpus*, *Calophyllum*, and *Garcinia* species, with a thin layer of leaf litter above thick humus. Three inflorescences were collected by AFSLL and WFA along a walking trail used by Singapore Armed Forces personnel, about 5 m or so from the reservoir's edge. The specimens were collected, preserved and deposited in the Herbarium, Raffles Museum of Biodiversity Research (SINU accession no. 2007018331). It is also interesting to note that most of the collections made of *Gastrodia javanica* in Singapore, occurred in October and in February, suggesting that the flowering period of this species may coincide with the rainy season here.

Three dull purplish-brown inflorescences were observed. They were 15–25 cm tall, with short sheaths widely spaced along their lengths. The underground rhizome was not observed, as care was taken not to disturb these delicate plants.

All three inflorescences collected had a succession of unopened flower buds in different stages of development, 1–2 fully opened flowers and a few older flowers that had been pollinated, forming fruits (Figs. 2–4). No pollinators were observed on the inflorescences, but the flowers were very lightly and pleasantly scented. The flowers were short-peduncled, around 2 cm long and about 1.8 cm wide and were predominantly brownish-yellow with purplish-brown stripes at the top of the flowers, becoming gradually light pale yellow at the base. The adaxial surfaces of the dorsal and lateral sepals show a slightly warty surface along the purplish brown stripes, becoming slightly more pronounced at the tips giving the flowers a dull brown appearance from above (Fig. 4). The abaxial surfaces of the dorsal and lateral sepals in contrast to the adaxial ones are predominantly off-white, become gradually darker yellow at the lateral sepals, giving the flowers their whitish yellow appearance from front and bottom (Fig. 2). The dorsal and lateral sepals are almost entirely fused with only about 3–4 mm free at the tips. The bright lemon yellow lip is slightly tri-lobed, and elongated diamond- shaped.

CONCLUSIONS

Gastrodia javanica may be easily overlooked because this interesting orchid spends much of its life cycle underground, so possibly giving the impression that they are rarer than they really are. Its existence relies on the interaction with its mycobiont decomposing the leaf litter, thus, forest health is an important factor to the survival of this species. Additionally, unlike autotrophic orchids, these epiparasitic orchids cannot be cultured using routine tissue culture methods, making *ex situ* conservation impossible at the moment. Hence, the commitment to conservation of the remaining forest fragments in Singapore from development and disturbances and the prevention of alien plant species from invading them are of utmost importance in protecting this rare and beautiful orchid species.

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Fig. 2. Close up of the flower, front view and flower buds. Flower = 1.8 cm across. (Photograph by: Alvin Francis Lok Siew Loon).

Fig. 3. Side view of flower, another flower and unopened buds. Flower = 2 .0 cm long. (Photograph by: Alvin Francis Lok Siew Loon).

Fig. 4. The characteristically brownish yellow appearance of the flower from above and showing the slightly warty surface of the upper sepal and lateral petals. (Photograph by: Alvin Francis Lok Siew Loon).

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