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THE STATUS AND DISTRIBUTION IN SINGAPORE OF *DIPTERIS CONJUGATA* REINW. (DIPTERIDACEAE)

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INTRODUCTION

Dipteris conjugata (Fig. 1) is currently the only member in the family Dipteridaceae extant in Singapore. This species was previously placed in the Polypodiaceae. It is considered critically endangered in Singapore (Tan et al., 2008). This species is typically a montane plant found from 300–1,700 m altitude in Peninsular Malaysia (Holttum, 1965; Wee, 1984; Piggott, 1988). Interestingly in Singapore, this species grows at sea level, and has led some people to speculate that the populations here are a relic of a time when Singapore was much cooler than present (Wee, 1984). However, this species could instead have a wide altitudinal range or ecological amplitude. An example is *Fagraea auriculata*, another species which also occurs on cliff faces at sea level or epiphytic on trees in Singapore and can be found as high as 1,600 m in Cameron Highlands, Peninsular Malaysia (Leenhouts, 1962), thus demonstrating that some plants display a wider altitudinal tolerance and ecological amplitude than other species.

The *Dipteris conjugata* plant spreads via long, creeping rhizomes, allowing it to cover considerable area. The rhizomes are often covered with black hairs that become very coarse in the older parts. The stipes are 1.3–2.0 m long, arising at regular intervals along the rhizome. The fronds are divided into two dichotomous lobes, which further divide into nine or more unequal lobes (Fig. 2). Fronds are variably-sized, reaching up to 40–50 by 25–35 cm. Younger fronds are somewhat less dichotomously divided and possess more rounded lobes (Fig. 3). Each frond has an acuminate tip with coarsely serrated margins. Veins on the fronds are also dichotomously-branched with 2–4 main veins entering each of the lobes (Fig. 2). Very small, exindusiate sori are also found within the perimeters of the areoles (Fig. 4).

Fig. 1. *Dipteris conjugata* plants growing on a cliff face in the Tengeh Reservoir area, Singapore. (Photograph by: Alvin Francis Lok Siew Loon).

Fig. 2. Dichotomously-branched leaves and veins showing many sori. (Photograph by: Alvin Francis Lok Siew Loon).

Fig. 3. Fronds of young leaves are more rounded and less dichotomously branched. (Photograph by: Alvin Francis Lok Siew Loon).

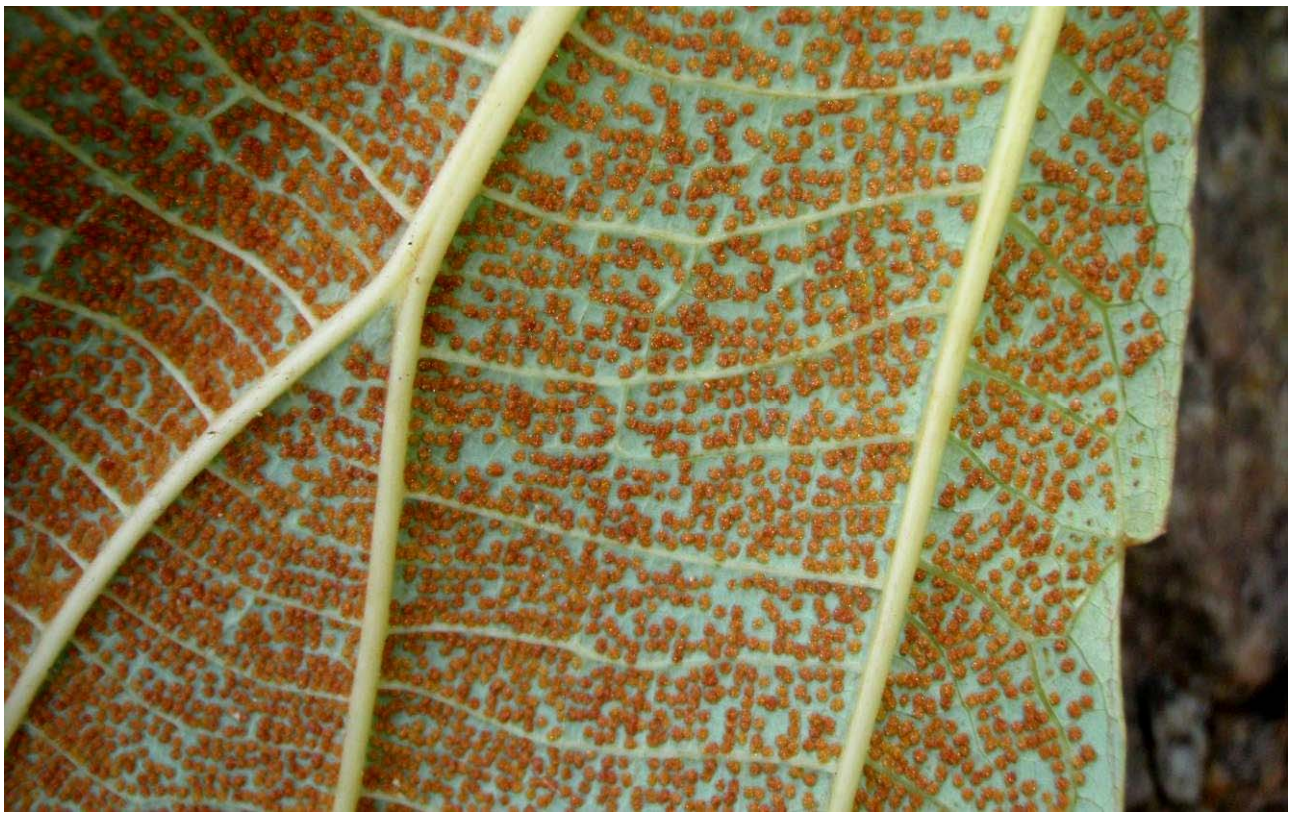

Fig. 4. The exindusiate sori on the frond's underside. (Photograph by: Alvin Francis Lok Siew Loon).

Table 1. Previous collections of *Dipteris conjugata* Reinw. deposited in the Herbarium, Singapore Botanic Gardens (SING; with bar code no.) and Herbarium, Raffles Museum of Biodiversity Research, National University of Singapore (SINU; with accession no.).

S/No.	Accession/Bar Code No.	Collector	Collector's No.	Date	Locality
1.	31564	H. N. Ridley	1693	7 Jan.1890	Woodlands
2.	31565	H. N. Ridley	4227	1892	Pulau Tekong
3.	31563	H. N. Ridley	s.n.	Undated	Woodlands
4.	31561	J. Sinclair	39527	28 Mar.1953	Sungei Hantu
5.	31562	J. Sinclair	39545	11 Apr.1953	Pulau Sarimbun
6.	31560	Ali bin Ibrahim	56	14 Apr.1988	Labrador Park
7.	53129	Ali bin Ibrahim	4	24 Mar.2004	Western Catchment Area
8.	2007017128	Jumali bin Kafrawi	s.n.	12 Apr.1967	Labrador
9.	1999 P 0530	H. B. Gilliland	5051	4 Apr.1956	Labrador
10.	1999 P 0531	Wee Yeow Chin	s.n.	28 Jun.1961	Tanjong Gul
11.	1999 P 0532	Wee Yeow Chin	s.n.	Jul.1961	Tanjong Gul
12.	1999 P 0533	Wee Yeow Chin	s.n.	28 Jun.1961	Tanjong Gul

PAST AND PRESENT RECORDS

Dipteris conjugata, locally called bua chek, has historically been recorded in Singapore from only seven localities (Table 1) (Fig. 5), mainly from coastal cliffs, growing with *Dicranopteris linearis* and *Blechnum orientale* (Johnson, 1977). Out of these seven localities, the populations of only three localities are still currently extant. However, owing to the unstable nature of the habitat of this species, populations can be wiped out instantly through landslides. The most accessible population of *Dipteris conjugata* in Singapore till 2006 was that at Labrador Nature Reserve. It was very plentiful in the 1960s (Lim et al., 1994) then waned significantly over subsequent decades until this population was wiped out in a major landslide after a period of bad weather and no regrowth has yet been observed. The population at the Woodlands locality, with specimens originally collected by Ridley on 7 Jan.1890, has long since been expunged. The Sungei Hantu population, with specimens collected by James Sinclair in 1953, has also been extirpated owing to the construction of the Sarimbun Reservoir, which entailed the widening of Sungei Karang, Sungei Hantu, and Sungei Sarimbun and finally the construction of a dyke by 1981 (Public Utilities Board, 1985), while the Tanjong Gul population was lost when the area was cleared and reclaimed for the construction of the Tuas Naval Base.

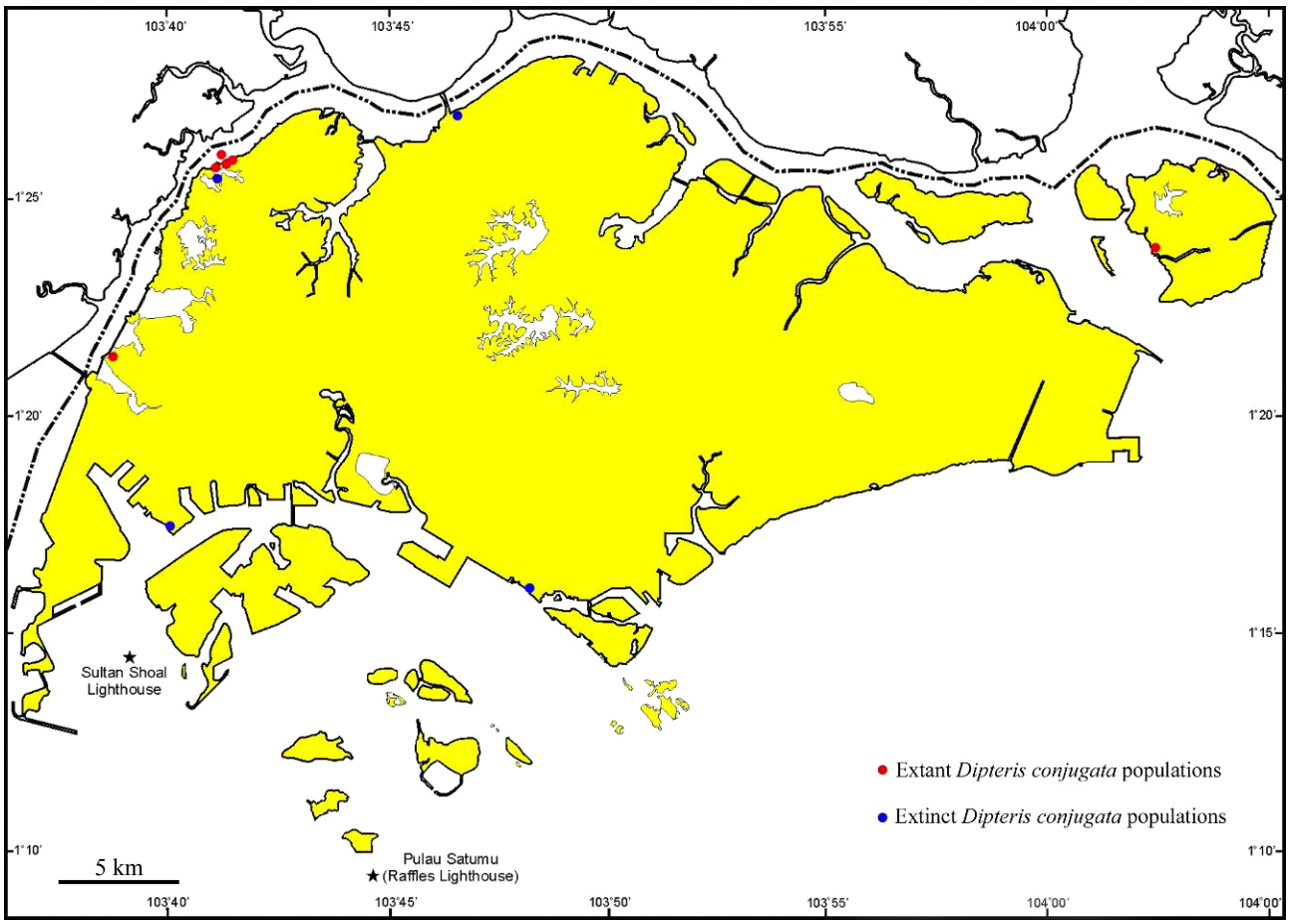

Fig. 5. Distribution of *Dipteris conjugata* in Singapore.

The remaining extant populations of *Dipteris conjugata* all occur within the Singapore Armed Forces (SAF) training areas in the Western Catchment Area and Pulau Tekong. In the Western Catchment area, *Dipteris conjugata* exists in two distinct populations which are more than 10 km apart. At the southern end of the Western Catchment Area, *Dipteris conjugata* is found growing along a dirt track around Tengeh Reservoir (Wee et al., 2008; unpublished data) on steep earth embankments (Fig. 7), while at the northen end of this area, *Dipteris conjugata* is found along the extensive coastal cliffs adjacent to the Sarimbun Reservoir and Tanjong Chenting (Wee et al., 2008) (Fig. 8), as well as on cliffs of Pulau Sarimbun (Wee et al., 2008; our observations) (Fig. 9). The habitat conditions of the populations at Tengeh Reservoir are not as exposed as that of the Sarimbun Reservoir populations, and might diminish in the near future as the simpoh air (*Dillenia suffruticosa*) plants on the slopes overgrow and shade out these ferns. The Pulau Tekong population is found growing on a seaward facing cliff at the old Basic Military Training (BMT) Camp 2 site with *Dicranopteris linearis* and an unidentified vandaceous orchid. This cliff face has suffered several landslides over the years, and it is not certain if the population is still surviving.

In Singapore, generally two main types of cliffs exist (Lu et al., 2005). The first type is the granitic cliff, mostly found at Pulau Ubin and Changi. The second type is the sedimentary rock cliff where *Dipteris conjugata* occurs, and are only found in the northwestern coast line in the Western Catchment Area, the Southern Islands and Labrador Nature Reserve as well as the southern tip of Pulau Tekong. Cliffs are also uncommon in Singapore, and as a result of such a restricted habitat for the growth of *Dipteris conjugata*, this species has become extremely rare with populations dwindling over the years, making it critically endangered in Singapore (Tan et al., 2008).

CONCLUSIONS

Because this species prefers growing on active cliff environments (i.e., cliffs subjected to coastal processes), their habitats are extremely unstable, but provide the sufficient amount of light that these plants require and would otherwise be shaded out by other beach vegetation on more stable slopes (Tan et al., 2007). Furthermore, such cliffs are also uncommon in Singapore. It is therefore expected that populations of *Dipteris conjugata* around Singapore would be relatively transient, with new populations popping up at different localities while other populations dwindle and get shaded out. It is therefore important that active conservation of this species, through habitat protection be carried out by

Fig. 6. *Dipteris conjugata* at the Labrador cliff face in the 1960s. (Photograph by: Wee Yeow Chin.)

Fig. 7. Plants on an earth embankment, beside a dirt track at Tengeh Reservoir. (Photograph by: Alvin Francis Lok Siew Loon).

Fig. 8. Plants along the coastal cliffs adjacent to Sarimbun Reservoir. (Photograph by: Ang Kai Yang).

Fig. 9. *Dipteris conjugata* (arrowed) growing on exposed cliffs on Pulau Sarimbun. (Photograph by: Hugh Tan Tiang Wah).

the authorities to ensure that the Singapore genotype of this species is not lost. Though *Dipteris conjugata* was known to be quite a common fern in different localities around Singapore about 65 to 33 years ago, it has now been classified as critically endangered in Singapore (Tan et al., 2008). Presently, all extant populations are protected within military areas. However, overhanging vegetation needs to be regularly pruned so that they will not overgrow the *Dipteris conjugata* stands and shade them out (Wee et al., 2008).

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