State of Nature Conservation in Malaysia 2025, 59–65
doi: 10.62613/sonc2025.v1flc06

CHAPTER 6

Thismia (Thismiaceae) of Malaysia and its conservation

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Abstract: The mycoheterotrophic genus *Thismia* Griff. (Thismiaceae), commonly known as fairy lanterns, comprises some of the most enigmatic flowering plants in tropical forests. Malaysia is recognised as a global centre of diversity for the genus, harbouring a remarkable assemblage of species across Peninsular Malaysia, Sabah, and Sarawak. These plants are fully mycoheterotrophic and depend on specialised fungal associations within undisturbed forest ecosystems, making them highly sensitive to habitat disturbance. This study updates the diversity of the genus in Malaysia by compiling a species list and conservation data from historical literatures, herbarium records, and recent discoveries. Currently, approximately 45 species are known from Malaysia, the majority occurring in Peninsular Malaysia. Many species are highly localised endemics restricted to single forest reserve or mountain area. A checklist of Malaysian *Thismia* species, their geographic occurrence, conservation assessments based on available IUCN evaluations, and patterns of regional endemism are presented. A discovery timeline from 1878 to 2025 highlights the dramatic increase in species discovery during the last decade. The results show that Malaysian forests support exceptional diversity of mycoheterotrophic plants and represent one of the most important centres of *Thismia* diversity globally. Continued botanical exploration, integrative taxonomic research, and targeted conservation strategies are urgently needed to safeguard this unique component of Malaysia's forest biodiversity.

INTRODUCTION

The genus *Thismia* Griff. (Thismiaceae) is one of the most unusual and morphologically distinctive groups of flowering plants in tropical forests. Species of *Thismia* are small, achlorophyllous herbs that lack functional chlorophyll and therefore do not perform photosynthesis (Garrett *et al.* 2023). Instead, they are fully mycoheterotrophic, obtaining carbon and nutrients through highly specialised symbiotic associations with soil fungi, which are themselves connected to photosynthetic plants via mycorrhizal networks (Garrett *et al*. 2023; Ogura-Tsujita *et al*. 2021). Members of the genus are typically diminutive herbs, often only a few centimetres tall, with reduced, scale-like leaves (Siti-Munirah and Nikong 2023) and delicate stems emerging from root systems. As they spend most of their life cycle underground and emerge only briefly during flowering, *Thismia* species are difficult to detect (Mar and Saunders 2015). Their ephemeral above-ground appearance, combined with their preference for shaded microhabitats beneath dense leaf litter, has contributed to the perception that they are among the rarest and most cryptic flowering plants in the tropics. The genus *Thismia* has a pantropical distribution; the native range of this genus spans tropical and subtropical Asia, northern and eastern Australia, the North Island of New Zealand, north-central U.S.A., and the tropical Americas from Costa Rica to southern Brazil (POWO 2026). However, most species are concentrated in Southeast Asia and the Malesian floristic region, especially the Malay Peninsula and Borneo,. Currently, more than 120 species have been described worldwide (Siti-Munirah *et al.* 2025), although this number continues to increase as new species are discovered.

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Malaysia occupies a unique biogeographical position within Southeast Asia, encompassing both the Sundaic flora of Peninsular Malaysia and the diverse ecosystems of Borneo. Over the past two decades, Malaysia has emerged as one of the most important centres of Thismia diversity globally. Numerous new species have been discovered in Peninsular Malaysia, particularly within protected areas in Terengganu (Siti-Munirah and Mohamad Alias 2025) and in Borneo, especially Sarawak (Dančák *et al*. 2025). Despite the increasing number of discoveries, knowledge of Thismia diversity in Malaysia remains incomplete. This paper aims to provide a baseline assessment of diversity, geographic distribution, and conservation status.

MATERIALS AND METHODS

Information on Malaysian *Thismia* species was compiled through a review of published taxonomic literatures, herbarium records, and conservation databases. Primary data sources included original species descriptions, taxonomic revisions, and recent publications describing newly discovered species. Herbarium data from the Forest Research Institute Malaysia (Herbarium Kepong, KEP) and other regional herbaria were consulted to verify their occurrences. For this study, species were categorised into three principal regions: Peninsular Malaysia, Sabah, and Sarawak. Conservation status was recorded according to IUCN categories as previously documented: Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Least Concern (LC), and Not Evaluated (NE). Endemism status was also determined based on the available data.

RESULTS

Based on the compilation, Malaysia currently hosts approximately 45 recognised species of *Thismia* (Table 1, Figure 1). Peninsular Malaysia is the primary centre of diversity, with more than half of the known Malaysian species. Sarawak is the second most diverse region, while Sabah supports a smaller but distinctive assemblage of species associated with montane habitats.

A quantitative analysis of conservation statuses (Figure 2) reveal a precarious future for Malaysia's fairy lanterns. Over 60% of the country's *Thismia* species fall into threatened categories (Critically Endangered – CR, Endangered – EN, and Vulnerable – VU). Notably, 40% of species are classified as CR. This high proportion results directly from their extreme endemism; many species are known from only a few dozen individuals in a single, localised microhabitat. For these taxa, the loss of even a few square metres of forest floor can cause immediate extinction.

Figure 2 highlights a significant gap in current knowledge, with 31.11% of species remains Not Evaluated (NE). This information gap is particularly concerning, as most newly discovered species in the modern discovery phase (2000 – 2025) are likely to be rare or threatened by default due to their cryptic nature and small known distribution ranges. As these NE species undergo formal assessment, it is highly probable that the percentage of threatened taxa will increase, shifting the chart further towards the "Critically Endangered" and "Endangered" categories. With only 2.22% of species classified as Least Concern (LC), *Thismia* is one of the most threatened plant genera in Malaysia. This data underscores the urgency of shifting conservation efforts from general forest protection to safeguarding specific "micro-hotspots" where these fragile populations persist.

Table 1. List of *Thismia* taxa recorded in Malaysia, with conservation status and endemism. (Besi *et al.* 2024; Dančák *et al.* 2020, 2025; Jonker 1948; Siti-Munirah 2018; Siti-Munirah *et al.* 2022, 2024, 2025; Siti-Munirah and Mohamad Alias 2025; Siti-Munirah and Ling 2025).

No.	Species	Peninsular Malaysia	Sabah	Sarawak	Conservation Status	Endemic
1	*T. alba*	√	–	–	NE	–
2	*T. acuminata*	–	–	√	CR	***
3	*T. aliasii*	√	–	–	CR	* +
4	*T. arachnites*	√	–	–	NE	–
5	*T. aseroe*	√	–	√	NE	–
6	*T. belumensis*	√	–	–	CR	*
7	*T. bifida*	–	–	√	NE	***+
8	*T. brunneomita*	–	√	√	EN	–
9	*T. brunneomitroides*	√	–	–	NE	–
10	*T. bryndonii*	–	√	–	NE	** +
11	*T. chrysops*	√	–	–	NE	* +
12	*T. clavigera*	√	–	√	NE	–
13	*T. clavigeroides*	√	–	–	NE	–
14	*T. crocea*	√	–	–	NE	+
15	*T. cornuta*	–	–	√	EN	***
16	*T. coronata*	–	–	√	CR	***
17	*T. dasyantha*	–	–	√	CR	***
18	*T. domei*	√	–	–	CR	*
19	*T. episcopalis*	–	–	√	NE	***+
20	*T. fumida*	√	–	–	NE	–
21	*T. goodii*	–	√	√	CR	–
22	*T. grandiflora*	√	–	–	NE	* +
23	*T. hexagona* var. *grandiflora*	–	–	√	NE	**
24	*T. javanica*	√	–	–	CR	–
25	*T. kelabitiana*	–	–	√	CR	***
26	*T. kelantanensis*	√	–	–	VU	* +
27	*T. kenyirensis*	√	–	–	LC	* +
28	*T. kinabaluensis*	–	√	–	NE	**
29	*T. laevis*	–	–	√	CR	***
30	*T. latiffiana*	√	–	–	CR	* +
31	*T. limkokthayi*	√	–	–	CR	* +
32	*T. malayana*	√	–	–	VU	*
33	*T. minutissima*	–	–	√	VU	***
34	*T. neptunis*	–	–	√	EN	***
35	*T. nigra*	–	–	√	EN	***
36	*T. ophiuris*	–	–	√	NE	***
37	*T. ornata*	√	–	√	VU	–
38	*T. perlisensis*	√	–	–	DD	–
39	*T. pallida*	–	√	√	CR	–
40	*T. racemosa*	√	–	–	NE	* +
41	*T. selangorensis*	√	–	–	CR	* +
42	*T. sitimeriamiae*	√	–	–	CR	* +
43	*T. terengganuensis*	√	–	–	CR	* +
44	*T. velaris*	–	–	√	CR	***
45	*T. viridistriata*	–	–	√	EN	***

Note:
Conservation Status: CR = Critically Endangered, EN = Endangered, VU = Vulnerable, LC = Least Concern, DD = Data Deficient, NE = Not Evaluated. Endemism Key: * = Endemic to Peninsular Malaysia; ** = Endemic to Sabah; *** = Endemic to Sarawak; +Highly localised endemic (known only from type locality).



Figure 1. Some species of *Thismia* from Malaysia. **A.** *Thismia alba*, **B.** *T. domei*, **C.** *T. kelantanensis*, **D.** *T. latiffiana*, **E.** *T. malayana*, and **F.** *T. perlisensis* (All photos by Siti-Munirah Mat Yunoh).

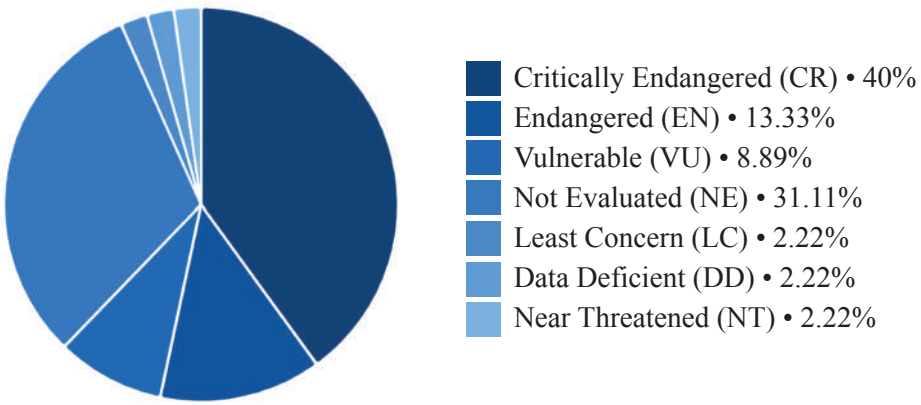

Figure 2. Conservation status of *Thismia* species in Malaysia based on IUCN Red List categories (Table 1). The data highlights that 40% of known species are Critically Endangered (CR), reflecting high habitat sensitivity and narrow endemism.

DISCUSSION

The high diversity of *Thismia* in Malaysia reflects the ecological complexity and environmental stability of Malaysian forests. These species however are threatened by habitat vulnerability. Most are known from extremely small populations and restricted geographic ranges. Even minor disturbances, such as hiking trails or selective logging, can disrupt the soil fungal networks essential for their survival. Protected areas such as Taman Negeri Kenyir thus serve as crucial refugia. The results of this synthesis confirm that Malaysia is one of the most significant global centres of diversity for the genus. With 45 recognised species, Malaysia hosts nearly 40% of the world's known species. This concentration is a result of the country's unique position within the Sundaland biogeographic region. The high species richness is driven by the long-term climatic stability of the region's rainforests, which has allowed the persistence of complex subterranean fungal networks. Unlike photosynthetic plants that compete for light, *Thismia* species occupy a specialised niche on the forest floor, relying on a stable and moist microclimate that only an intact primary forest canopy can provide. The striking level of endemism, with many species such as *T. sitimeriamiae* and *T. latiffiana* known only from a single forest reserve, suggests a pattern of localised evolutionary radiation. In states such as Terengganu, the complex topography of mountain ranges and undisturbed habitat acts as a series of forest islands. These isolated habitats facilitate speciation through geographic isolation. Furthermore, the morphological diversity of floral structures, ranging from the mitriform domes of *T. kelantanensis* to the elongated tentacles of *T. aliasii*, indicates a high degree of pollinator specialisation. Most *Thismia* species are believed to be pollinated by fungus gnats. The evolution of diverse floral traps suggests that *Thismia* has undergone rapid diversification to exploit specific local insect populations, further driving the high rates of endemism observed across Peninsular Malaysia and Borneo.

The history of *Thismia* discovery in Malaysia spans more than a century. The early discovery phase (1878 – 1930) documented pioneering taxa. After a long period of limited discovery (1930 – 2000), the modern discovery phase (2000 – 2025) has seen a dramatic resurgence. Many currently recognised taxa were discovered after 2015, particularly in Peninsular Malaysia. The modern discovery phase (2000 – 2025), highlighted in the results section, reveals a critical bias in botanical history. For decades, *Thismia* species were considered "rare" primarily because they were overlooked. Their ephemeral life cycle, with the plant remaining underground for most of the year and producing a flower for only a few days, means that traditional botanical surveys often miss them. The recent surge in discoveries is less an indication of a sudden population boom and more a reflection of improved citizen science and targeted botany of the forest floor. This suggests that many more species likely exist in the remote interior of Peninsular Malaysia, Sarawak, and Sabah, where survey intensity has historically been lower.

The most pressing concern raised by this study is the conservation status of these plants. As *Thismia* species are fully mycoheterotrophic, they are considered ultimate indicators of forest health. They require not only trees, but also a specific, undisturbed relationship between trees and soil fungi. Several factors contribute to their vulnerability. Soil compaction, even from small-scale disturbances such as the widening of hiking trails in popular locations like Genting Highlands or Taman Negeri Kenyir, can crush the delicate, shallow rhizomes of *Thismia* and destroy the mycelial mats they depend on. Microclimate sensitivity is another factor: selective logging and thinning of the canopy increase the temperature and decrease the humidity of the forest floor. *Thismia* species, which lack a protective cuticle and are prone to desiccation, cannot survive these changes. Finally, there is the "Critically Endangered" paradox: under IUCN criteria, many Malaysian *Thismia* are classified as CR because they occupy an Area of Occupancy (AOO) of less than 10 km^2. This makes them extremely susceptible to stochastic events; a single landslide or new road construction could effectively wipe out an entire species.

To safeguard the *Thismia* of Malaysia, conservation must extend beyond protecting trees and focus on microhabitats. We recommend that the Forestry Departments establish "Micro-Conservation Zones" within larger Forest Reserves. In areas where *Thismia* hotspots are identified, human foot traffic should be strictly diverted and the removal of leaf litter prohibited. Furthermore, Thismia should serve as a flagship species for hidden biodiversity to increase public awareness of the importance of soil health and fungal conservation in tropical ecosystems.

CONCLUSION

The study of *Thismia* in Malaysia highlights the hidden richness of tropical forest ecosystems. With 45 species and high endemism, the country plays a central role in global conservation of mycoheterotrophic plants. Protecting the habitats that sustain these species is essential not only for *Thismia* but also for the overall health of forest biodiversity. The comprehensive synthesis presented in the paper underscores the country's status as a global epicentre for mycoheterotrophic biodiversity. With 45 recognised species, many described only in the last decade, it is clear that we are in the midst of a golden age of discovery for the genus Thismia. The high degree of regional endemism identified in this study highlights the unique evolutionary history of the Sundaic and Bornean floras, where local ecological niches have fostered a remarkable radiation of floral forms and specialised pollination syndromes.

However, the findings of this research also provide a sobering assessment of the survival prospects for these enigmatic plants. The overwhelming majority of Malaysian *Thismia* species are currently classified as Critically Endangered (CR), Endangered (EN), or Not Evaluated (NE) due to their extreme rarity and cryptic life cycles. As these plants are inextricably linked to the health of subterranean fungal networks, their presence serves as a living barometer for the ecological integrity of Malaysia's primary forests. The loss of a single forest patch in a hotspot such as Terengganu or Sarawak does not merely represent the loss of individual plants, it signifies the collapse of complex, millions of years old symbiotic relationships that are largely invisible to the naked eye.

Looking ahead, the study of Malaysian *Thismia* requires a shift from opportunistic discovery to systematic, integrative research. Future efforts should prioritise the use of molecular phylogenetics to resolve the evolutionary relationships between the Peninsular and Bornean lineages. In addition, ecological studies focusing on the specific fungal partners of *Thismia* are essential. If the specific fungi these plants rely on can be identified, their occurrence can be better predicted and forest management practices can be tailored to protect the mycorrhizal networks that sustain them. Ultimately, conserving *Thismia* in Malaysia requires a shift in national conservation paradigms. Protecting the charismatic megaflora of the canopy, such as the dipterocarps, is necessary but insufficient if the delicate, ephemeral flora of the forest floor is neglected. We recommend that *Thismia* species be formally recognised as flagship organisms for hidden biodiversity. By integrating *Thismia* hotspots into the management plans of the Central Forest Spine and the Heart of Borneo, Malaysia can lead the way in holistic tropical conservation. This paper serves as both a baseline and a challenge to the scientific community. While we have documented 45 species, the vast, unexplored interior of Sabah and Sarawak likely holds many more fairy lanterns yet to be discovered, even in Peninsular Malaysia. With sustained botanical exploration, strengthened legal protection for microhabitats, and a commitment to understanding the below-ground world, Malaysia can ensure that these extraordinary plants continue to thrive in the shadows of its majestic rainforests for generations to come.

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