BIOTROPIA ISSN: 0215-6334 | e-ISSN: 1907-770X
The Southeast Asian Journal of Tropical Biology
Vol. 31 No. 2, 2024: 169 - 180
DOI: 10.11598/btb.2024.31.2.1874

Research Article

CONSERVATION STATUS OF TREE SPECIES OF THE FRESHWATER SWAMP FOREST, PERAK TENGAH, MALAYSIA

Liliwirianis Nawi[1]*, Mohd Nazip Suratman[2], Farida Zuraina Mohd Yusof[3], Abdul Latiff Mohamad[4]

[1]Faculty of Applied Sciences, Universiti Teknologi MARA Pahang, Bandar Tun Abdul Razak Jengka 26400, Malaysia. [2]Institute for Biodiversity and Sustainable Development, Universiti Teknologi MARA (UiTM), Shah Alam 40450, Malaysia. [3]Faculty of Applied Sciences, Universiti Teknologi MARA (UiTM), Shah Alam 40450, Malaysia. [4]Department of Biological Science and Biotechnology, Universiti Kebangsaan Malaysia, Bangi 43600, Malaysia.

ARTICLE HIGLIGHTS

- Approximately 3,364 tree individuals with a diameter at breast height (dbh) of 10.0 cm and above were assessed in the Perak Tengah freshwater swamp forest.
- The study has recognised 58 species identified are new to Perak.
- 72 tree species are listed as endemic, and 194 species are listed in the Red List of Threatened Species by The International Union for Conservation of Nature (IUCN).
- This study mphasize the need to preserve ecology and mitigate threats.

Article Information

Received 25 January 2023
Revised 23 March 2024
Accepted 22 May 2024

***Corresponding author, e-mail:**
liliwirianis@uitm.edu.my

ABSTRACT

The forests of Peninsular Malaysia have long been recognized as a significant home of endemic species. The purpose of this study was to assess the endemism and conservation status of tree species present in the Perak Tengah freshwater swamp forest. A total of 150 plots (20 m × 20 m) were established in the study area using a random sampling design. Approximately 3,364 tree individuals with diameter at breast height (dbh) of 10.0 cm and above were enumerated in all plots. In the study area, 58 species identified are new to Perak, 72 tree species are listed as endemic, and 194 species are listed in the Red List of Threatened Species by IUCN. Thus, it is crucial to preserve the ecology and lessen the impact of threats in the Perak Tengah freshwater swamp forest, which is home to numerous endemic and endangered species.

Keywords:
endangered, endemic, freshwater swamp forest, malaysia, perak, threatened

INTRODUCTION

Malaysia has lost a substantial amount of forest due to cash-crop plantations (oil palm, rubber, and acacia, including fallow lands) and urban expansion (Huang & Oey 2019). For the past 29 years, nearly 16% (189,423 ha) of Perak's forest cover has disappeared due to anthropogenic activities (Kanniah & Siong 2017; Jaafar *et al.* 2020). According to the Fifth National Report of the Convention on Biological Diversity (2020), over 80% of the larger genera are endemic. Most endemic species are vulnerable to extinction because they are only restricted to one area with a specific microclimate.

Malaysia is estimated to possess 15,000 species of flora, with 8,300 species found in Peninsular Malaysia. There are currently at least 9,030 vascular plant taxa in Peninsular Malaysia, made up of 1,651 genera and 248 families, with at least 149 new taxa identified since 2005 (Yong *et al.* 2021). Malaysia has also recorded approximately 2,500 species of endemic vascular plants (Saw & Chung 2015).

Rare species are becoming the most significant concern for conservationists due to the risk of extinction. Species can be considered rare when they have small population sizes, restricted geographical ranges, or narrow habitat tolerances. When combined, these characteristics define several forms of rarity and different levels of extinction risk (Kruckeberg & Rabinowitz 1985).

Rare species have greater sensitivity to both natural- and human-induced disturbances, such as overexploitation, habitat loss, and global environmental changes (Davies *et al.* 2004). Meanwhile, from the ecological aspect, endemism refers to the occurrence of any taxonomic entity (species, genus, or family) within a restricted and entirely defined area. Endemism is essential to ecologists, biogeographers, and evolutionary biologists in general. Endemics can be old (palaeoendemics) or new (neoendemics). Endemic species are an important target of global conservation efforts. As for species richness, a smaller amount of total area will need to be conserved if endemism patterns among taxa are correlated. Generally, the number of taxa endemic to a particular area increases with size and geographic isolation (Anderson 1994).

Extinction will result in ecological loss and disturbance to the equilibrium of the forest. A better understanding of the rarity types and their differences needs to be considered for better conservation planning and strategies. Thus, the establishment of the International Union for Conservation of Nature (IUCN) aims to influence, encourage, and assist societies to conserve diversity and to ensure that any use of natural resources is equitable and ecologically sustainable.

The study aimed to assess the endemism and conservation status of species found in the Perak Tengah freshwater swamp forest. Due to the ecology and drainage, freshwater swamp forests are particularly vulnerable to outside influences. Although endemic species are not necessarily rare or threatened by extinction, species typically become rare before going extinct (Kruckeberg & Rabinowitz 1985; Dobson *et al.* 1995). Endemic species, especially those with narrow distributions, as in this freshwater swamp forest, are particularly vulnerable to extinction resulting from habitat disturbance and other threats (Kiew *et al.* 2017; Kiew & Rahman 2021).

MATERIALS AND METHODS

Study Area

The study area was located at the freshwater swamp forest remnant located in the District of Perak Tengah, Bandar Sri Iskandar. The area of Perak Tengah District is about 12,205 ha and comprises 11 subdistricts. The study areas were located at the Universiti Teknologi MARA (UiTM) Perak Sri Iskandar Forest (4°21'31.1" N; 100°57'12.7" E), Universiti Teknologi Petronas (UTP) Tronoh Forest (4°22'49.9" N; 100°57'44.8" E), and the Parit Forest Reserve, Parit (4°24'13.9" N; 100°56'03.7" E), as shown in Figure 1. The forest is surrounded by secondary forests with urban development leaving isolated freshwater swamp forest areas. Freshwater swamp forest is a unique habitat that occurs in permanently flooded soil. The forest comprises stilt roots, knee roots, and plank-like sinuous buttresses, which are common features of tree species found in freshwater swamp forests. The mean monthly temperatures for the study area ranged from 26.5 °C to 28.7 °C with an annual rainfall of 245.6 cm.

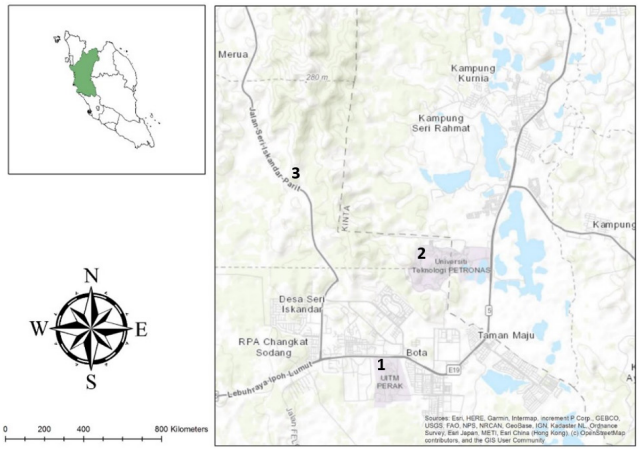

Figure 1 Map of study area at Perak Tengah, Perak
Notes: (1) UiTM Perak, Sri Iskandar Forest; (2) UTP, Tronoh Forest; and (3) Parit Forest Reserve, Parit.

Data Collection

The study plots were established using random sampling from May 2011 to April 2015. A total of 150 plots of 20 × 20 m each were established in the study area, totalling 6 ha. All trees with a diameter breast height (DBH) of 10 cm or greater were measured using a diameter tape. Leaves and fruit specimens from the trees with DBH of more than 10 cm were collected, recorded, and kept in the Universiti Kebangsaan Malaysia (UKM) Herbarium. Woody climbers and creepers were excluded from the study. The trees were identified to the species level using the existing specimens in the UKM Herbarium, existing taxonomic keys (Whitmore 1972; 1973), and the assistance of an experienced botanist from UKM and the Pahang Forestry Department. The nomenclature of the species was determined according to Turner (1995) and the International Plant Name Index (IPNI). Meanwhile, specimens that could not be matched with herbarium specimens were only identified up to the genus or family level.

Species New Records, Endemic and Conservation Status

New records and endemic species were listed and referred to according to Turner (1995) and Chua *et al*. (2010). Conservation status was determined based on the IUCN Red List of Threatened Species version 2020.1 (IUCN Red List of Threatened Species, 2020) and Yong *et al*. (2021). In addition, the Dipterocarpaceae family was also compared using the Malaysian Plant Red List (Saw *et al*. 2010).

RESULTS AND DISCUSSION

New Records of Species

About 58 of 624 tree species (9.3%) in the freshwater swamp forest in Perak Tengah were listed as new species to Perak State based on Turner (1995) (Table 1). The new records in Perak State may be due to insufficient sample collection from the past. The freshwater swamp forest also faces threats from deforestation and urban expansion, leading to habitat reduction (Saw 2010). On top of that, in Peninsular Malaysia, habitat degradation and loss pose the biggest challenge to plant populations. The primary causes of habitat loss include changes in land use for agricultural, residential, and commercial development (Yong *et al*. 2021). The discovery of these 58 species during these two decades may offer signs of hope for Malaysia's local biodiversity. It also shows that the knowledge about these tree species is still far from satisfactory and complete.

Interestingly, some of the species listed in Table 1 were only found in one state. For example, *Castanopsis foxworthyi* and *Helicia maxwelliana* were found only in Terengganu. However, the species was also found in the study area, i.e., the freshwater swamp forest. On top of that, theoretically, *C. foxworthyi* also occupies lowland peat-swamp, heath forest, and upper montane forest, while *H. maxwelliana* is found in the montane forest at 1,200 m. Nishimura *et al*. (2008) revealed that some species from the Fagaceae family showed a random distribution pattern. Moreover, *Palaquium confertum*, *Syzygium polyanthum* var. *polyanthum*, *S. polyanthum* var. *sessile*, and *Trigonostemon polyanthus* were only found in Johore, *Croton kelantanicus* was found in Kelantan, and *Syzygium claviflorum* var. *riparium* which were documented in Pahang can also be found in the freshwater swamp forest of Perak Tengah.

Endemic Species of Peninsular Malaysia

An endemic species usually grows and is found in a specific area and has restricted distribution. A total of 72 tree species from 56 families encountered in the Perak Tengah freshwater swamp forest were listed as endemic based on Turner (1995) and Chua *et al*. (2010) (Table 2). From the list presented in Table 2, 12 of them are recorded as new in Perak.

A previous study in Perak Tengah revealed that Vatica flavida was left with a small number of individuals (249 individuals) due to the loss of large tracts of freshwater swamp forests followed by forest fragmentation. Shorea hemsleyana ssp. hemsleyana and Hopea apiculata were also threatened since their populations have decreased and their habitat has been degraded. It can be concluded that the most significant impact on the habitat has been from activities related to the development and human activities that lead to the depletion of their habitat (Liliwirianis 2021).

Table 1 List of new tree species to Perak State at Perak Tengah Freshwater Swamp Forest, Perak

No.	Species	Known distribution
1	*Actinodaphne pruinosa*	Kd, Pn, Sl, Ns, Ml, Sp
2	*Alseodaphne bancana*	Sl, Jh, Sp.
3	*Alstonia scholaris*	Kd, Kl, Tg, Ph, Sl, Ml, Jh.
4	*Anacolosa frutescens*	Kd, Ph, Sl, Ns, Ml, Jh, Sp.
5	*Aporosa frutescens*	Kd, Pn, Kl, Ph, Jh, Sp.
6	*Aporosa microstachya*	Kd, Tg
7	*Ardisia korthalsiana*	Tg, Ph, Ml, Jh.
8	*Artocarpus kemando*	Tg, Ph, Sl, Jh, Sp.
9	*Calophyllum ferrugineum* var. *ferrugineum*	Jh, Sp.
10	*Calophyllum rubiginosum*	Sl, Ns, Ml, Jh, Sp.
11	*Calophyllum soulattri*	Ps, Kd, Pn, Kl, Ph, Ns, Ml, Jh.
12	*Canarium megalanthum*	Kd, Ph, Ns, Jh.
13	*Canthium cochinchinense*	P. Langkawi, Tg.
14	*Castanopsis foxworthyi*	Tg.
15	*Chrysophyllum roxburghii*	Kd, Ph, Sl,, Ns, Ml, Jh, Sp.
16	*Croton kelantanicus*	Kl
17	*Cryptocarya ferrea*	Kd, Kl, Tg, Ph, Sl.
18	*Cryptocarya zollingeriana*	Kl, Sl.
19	*Dillenia reticulata* var. *reticulata*	Ml
20	*Diospyros ismailii*	Kd, Tg, Ph, Sl, Ns, Jh;
21	*Diospyros montana*	P. Langkawi.
22	*Diospyros undulata*	Ps, Kd, P. Langkawi.
23	*Durio carinatus*	Ph, Jh.
24	*Elaeocarpus nitidus* var. *velutinus*	Kl, Ph, Jh;
25	*Helicia maxwelliana*	Tg.
26	*Horsfieldia penangiana*	Pn, Ph, Sl.
27	*Hydnocarpus kunstleri* var. *tomentosa*	Tg, Pk, Ph, Sl, Jh;
28	*Knema latericia* ssp. *ridleyi*	Tg, Jh, Sp.
29	*Litsea erectinervia*	Tg, Ph, Sl, Ml, Sp.
30	*Litsea magnifica*	Pn, Kl, Ph, Ml, Jh
31	*Lophopetalum pallidum*	Kd, Pn, Sl, Ns, Ml, Jh.
32	*Madhuca decipiens*	Jh, Sp.
33	*Madhuca selangorica*	Ph, Sl, Ns;
34	*Neo-uvaria acuminatissima*	Pn, Ph, Sl.
35	*Neo-uvaria foetida*	Tg, Ns, Ml.
36	*Nephelium cuspidatum* var. *cuspidatum*	Tg, Sl, Ns, Jh
37	*Nephelium cuspidatum* var. *eriopetalum*	Kl, Ph, Sl, Ns, Jh.
38	*Palaquium confertum*	Jh.
39	*Palaquium leiocarpum*	Kl, Tg.
40	*Palaquium macrocarpum*	Sl, Jh.
41	*Palaquium obovatum*	Kd, Pn, Kl, Tg, Ph, Sl, Ns, Ml, Jh, Sp.
42	*Parishia maingayi*	Tg, Pk, Ph, Sl, Jh, Sp.
43	*Pimelodendron macrocarpum*	Sl, Ml, Jh.
44	*Polyalthia cinnamomea*	Ps, Kd, Pn, Kl, Tg, Ph, Sl, Ns, Ml, Jh.
45	*Pternandra galeata*	Ph, Jh.
46	*Rennellia microcephala*	Kd, Kl, Tg, Ph;
47	*Santiria rubiginosa* var. *nana*	Sl.
48	*Schoutenia accrescens* ssp. *borneensis*	Ulu Endau, Jh.
49	*Sterculia rubiginosa* var. *setistipula*	Sl.
50	*Syzygium anisosepalum*	Kd, Ph, Sl, Ns, Ml;
51	*Syzygium attenuatum* ssp. *attenuatum* var. *attenuatum*	Kd, Pn, Ph, Sl, Ml, Jh, Sp.
52	*Syzygium claviflorum* var. *riparium*	Ph
53	*Syzygium polyanthum* var. *polyanthum*	Jh
54	*Syzygium polyanthum* var. *sessile*	Jh
55	*Syzygium scortechinii* var. *scortechinii*	Tg, Ph, Sl, Ns, Jh;
56	*Toona sureni*	Ps, P. Langkawi, Kd, Pn, Kl, Ph, Sl, Jh.
57	*Trigonostemon polyanthus*	Jh.
58	*Urophyllum corymbosum*	Ps, Ph, Sl, Ns, Jh, Sp.

Notes: Kd = Kedah; Pn = Penang; Sl = Selangor; NS = Negeri Sembilan; Ml = Melaka; Sp. = Singapore; Jh = Johore; Tg = Terengganu; Kl = Kelantan; Ps = Perlis; Ph = Pahang.

Table 2 List of tree species found at Perak Tengah Freshwater Swamp Forest that are endemic to Peninsular Malaysia

No.	Endemic species	Total individuals found	Distribution
1	*Actinodaphne pruinosa**	3	Kd, Pn, Sl, Ns, Ml, Sp
2	*Alangium ridleyi*	1	Kd, Pn, Tg, Pk, Ph, Sl, Ns, Ml
3	*Alphonsea kingii*	2	Pk
4	*Alphonsea maingayi*	1	Pk, Sl, Ns, Ml, Jh, Sp
5	*Aporosa selangorica*	1	Kd, Pk, Ph, Sl
6	*Baccaurea griffithii*	16	Throughout
7	*Baccaurea polyneura*	2	Pk, Ml;
8	*Beilschmiedia insignis*	1	Kl, Pk, Ph, Sl
9	*Beilschmiedia pahangensis*	1	Kl, Pk, Ph
10	*Calophyllum subsessile*	2	Pk
11	*Calophyllum ferrugineum* var. *oblongifolium*	4	Kl, Tg, Pk, Ph, Sl, Ns, Ml, Jh
12	*Calophyllum wallichianum* var. *wallichianum*	6	Kd, Pn, Kl, Pk, Ns
13	*Canarium pseudosumatranum*	1	Ps, Kd, Pk, Ph, Sl, Ns
14	*Casearia clarkei* var. *clarkei*	5	Pn, Pk, Sl, Ml, Sp

No.	Endemic species	Total individuals found	Distribution
15	*Cinnamomum mollissimum*	2	Pn, Kl, Tg, Pk, Ph, Sl, Ns, Ml, Jh
16	*Croton erythrostachys*	1	Tg, Pk, Ph, Sl, Ns, Ml, Jh
17	*Croton kelantanicus**	1	Sg Ketil, Kl
18	*Cyathocalyx pruniferus*	4	Kl, Tg, Pk, Ph, Sl, Ml, Jh
19	*Dacryodes kingii*	1	Throughout
20	*Dacryodes puberula*	1	Pk, Ph, Ns, Ml
21	*Dillenia reticulata* var. *reticulata**	8	Ml
22	*Diospyros argentea*	3	Sp, Tg, Ml, Pk, Sl, Ph, Ns, Jh,
23	*Diospyros ismailii**	2	Kd, Tg, Ph, Sl, Ns, Jh
24	*Diospyros scortechinii*	1	Kl, Tg, Pk, Ph, Ns
25	*Diospyros singaporensis*	7	Kd, Pk, Ph, Sl, Ns, Ml, Jh
26	*Elaeocarpus nitidus* var. *velutinus**	1	Kl, Ph, Jh
27	*Elaeocarpus nitidus* var. *wrayi*	1	Tg, Pk, Ph
28	*Enicosanthum fuscum*	6	Pk, Ph
29	*Enicosanthum macranthum*	3	Pk
30	*Garcinia uniflora*	1	Pk, Ph
31	*Gentingia subsessilis*	1	Pk, Ph, Sl
32	*Gluta curtisii*	1	Kd, Kl, Pn, Pk, Ph, Sl, Jh
33	*Hydnocarpus filipes*	1	Tg, Pk, Ph, Sl
34	*Hydnocarpus kunstleri* var. *tomentosa*	1	Tg, Pk, Ph, Sl, Jh;
35	*Knema oblongifolia*	1	Tg, Pk, Ph, Sl
36	*Lithocarpus curtisii*	4	Pn, Kl, Tg, Pk, Ph, Sl
37	*Litsea curtisii*	1	Kd, Pn, Pk, Sl, Jh
38	*Litsea wrayi*	1	Kd, Pk, Sl, Ns
39	*Madhuca selangorica**	1	Ph, Sl, Ns
40	*Mallotus griffithianus*	2	Throughout
41	*Mallotus penangensis*	1	Throughout
42	*Melanochyla nitida*	1	Pn, Pk;
43	*Mesua lepidota* var. *parviflora*	1	Tg, Pk, Sl, Ml, Jh
44	*Mesua nuda*	1	Kd, Pn, Kl, Tg, Pk, Ph, Sl, Ns, Ml, Jh
45	*Nephelium costatum*	58	Pk, Ph, Ns, Ml, Kd, Kl, Jh
46	*Nephelium hamulatum*	9	Kd, Kl, Tg, Pk, Ph, Sl, Ns, Ml, Jh
47	*Palaquium maingayi*	2	Kd, Kl, Pk, Ph, Sl, Ns, Ml, Jh
48	*Palaquium oxleyanum*	1	Pk, Ph, Sl, Sp
49	*Payena maingayi*	7	Kd, Pn, Tg, Pk, Ph, Sl, Ns, Ml, Jh, Sp
50	*Pellacalyx saccardianus*	12	Widespread
51	*Pentace perakensis*	1	Pk
52	*Popowia fusca*	1	Pk, Ph, Sp
53	*Prunus malayana*	6	Tg, Ph, Pk
54	*Psydrax maingayi*	5	Tg, Ph, Pk, Sl, Ns, Ml, Jh
55	*Ptychopyxis caput-medusae*	17	Kl, Tg, Pk, Ph, Sl, Ns, Ml, Sp
56	*Rennellia microcephala**	1	Kd, Kl, Tg, Ph
57	*Santiria ridleyi*	5	Gg Keladang, Pk
58	*Sarcotheca laxa* var. *laxa*	52	Ps, Kd, Kl, Tg, Pk
59	*Sarcotheca monophylla*	9	Pk, Ph, Sl, Ml
60	*Sauropus suberosus*	1	Pk, Ph
61	*Shorea singkawang* ssp. *singkawang*	1	Tg, Ph, Pk
62	*Streblus perakensis*	3	Pk, Ph
63	*Syzygium anisosepalum**	3	Kd, Ph, Sl, Ns, Ml
64	*Syzygium castaneum*	2	Pk, Jh
65	*Syzygium claviflorum* var. *riparium**	1	Sg Tahan, Ph
66	*Syzygium perakense*	3	Pk, Sl
67	*Syzygium polyanthum* var. *polyanthum**	1	Sg Kayu, Jh
68	*Syzygium polyanthum* var. *sessile**	2	Jh
69	*Syzygium scortechinii* var. *scortechinii**	1	Tg, Ph, Sl, Ns, Jh
70	*Vatica flavida*	6	Pk
71	*Vatica pallida*	1	Pn, Pk

Notes: Pk = Perak; Ml = Melaka; Kl = Kelantan; Ph = Pahang; Sl= Selangor; NS = Negeri Sembilan; Pn = Penang; Sp.= Singapore; Jh = Johore; Tg = Terengganu. *New record in Perak.

Since species have a necessary minimum population size and distribution for optimum survival, extremely small residual populations of rare and endemic taxa may all be extinct. This is exacerbated by edge effects, which may include invasion and species composition alteration by more common species prevalent just outside this forest. Most studies identifying hotspots do not use the same criteria proposed at the global scale (Major 1988), and endemicity is often the only criterion used (Huang *et al.* 2012; Kraf *et al.* 2010). This is because endemic species are often explored better in a particular area than the complete flora or the threats. Furthermore, since narrowly endemic species are often endangered, endemic taxa are an important category for conservation (Laffan *et al.* 2013)both within their region and at continental scales. We do this using the plant family Myrtaceae in relation to the globally important Greater Blue Mountains World

Heritage Area (GBMWHA). Additionally, since their numbers and distribution are well-known and because they sustain virtually all animal life, plants have been employed as indicators of species endemism.

IUCN Conservation Status

A total of 2,830 plant species in Malaysia are listed in the IUCN Red List of Threatened Species version 2020.1 (The IUCN Red List of Threatened Species, 2020). Only one species is listed in the extinct (EX) category, one species is listed as extinct in the wild (EW), 166 species are listed as critically endangered (CR), 248 species are categorized as endangered (EN), 579 species are included in the vulnerable category (VU), 194 species are classified as near threatened (NT), 102 species are categorized as lower risk/conservation dependent (LR/CD), 98 species are considered in the status of data deficient (DD), and 1,440 species are classified as the least concern (LC; The IUCN Red List of Threatened Species, 2020). Species categorized as CR, EN, and VU are collectively referred to as threatened.

All the species found in the study plots were compared with the IUCN Red List, with 194 of 624 tree species in the Perak Tengah freshwater swamp forest were found in the Red List of Threatened Species (Table 3). The study area comprises 7% of the listed plants in the IUCN for Malaysia. The Dipterocarpaceae family leads the number of threatened species with 22 species (46.8%), and the family comprises six species listed as CR.

Table 3 The IUCN conservation status of tree species in Perak Tengah freshwater swamp forest

No.	Family	Species	IUCN status
1	Anacardiaceae	*Gluta curtisii*	Lower risk/ least concern
2	Anacardiaceae	*Mangifera foetida*	Lower risk/ least concern
3	Anacardiaceae	*Mangifera magnifica*	Lower risk/ least concern
4	Anacardiaceae	*Melanochyla nitida*	Lower risk/ least concern
5	Anacardiaceae	*Pentaspadon motleyi*	Data Deficient
6	Anisophylleaceae	*Anisophyllea apetala*	Vulnerable
7	Annonaceae	*Alphonsea kingii*	Critically endangered
8	Annonaceae	*Alphonsea maingayi*	Lower risk/ least concern
9	Annonaceae	*Cyathocalyx pruniferus*	Lower risk/ least concern
10	Annonaceae	*Enicosanthum fuscum*	Near Threatened
11	Annonaceae	*Enicosanthum macranthum*	Vulnerable
12	Annonaceae	*Popowia fusca*	Lower risk/ least concern
13	Apocynaceae	*Alstonia scholaris*	Lower risk/ least concern
14	Apocynaceae	*Dyera costulata*	Lower risk/ least concern
15	Apocynaceae	*Hunteria zeylanica*	Lower risk/ least concern
16	Aquifoliaceae	*Ilex cymosa*	Lower risk/ least concern
17	Burseraceae	*Canarium hirsutum*	Lower risk/ least concern
18	Burseraceae	*Canarium littorale*	Lower risk/ least concern
19	Burseraceae	*Canarium pseudodecumanum*	Vulnerable
20	Burseraceae	*Canarium pseudosumatranum*	Lower risk: conservation dependent
21	Burseraceae	*Dacryodes incurvata*	Lower risk/ least concern
22	Burseraceae	*Dacryodes kingii*	Lower risk: conservation dependent
23	Burseraceae	*Dacryodes puberula*	Vulnerable
24	Burseraceae	*Dacryodes rostrata*	Lower risk/ least concern
25	Burseraceae	*Santiria apiculata* var. *apiculata*	Lower risk/ least concern
26	Burseraceae	*Santiria griffithii*	Lower risk/ least concern
27	Burseraceae	*Santiria laevigata*	Lower risk/ least concern
28	Burseraceae	*Santiria rubiginosa* var. *nana*	Vulnerable
29	Burseraceae	*Santiria rubiginosa* var. *rubiginosa*	Vulnerable
30	Celastraceae	*Bhesa paniculata*	Lower risk/ least concern

No.	Family	Species	IUCN status
31	Celastraceae	*Bhesa robusta*	Lower risk/ least concern
32	Celastraceae	*Lophopetalum javanicum*	Lower risk/ least concern
33	Chloranthaceae	*Licania splendens*	Lower risk/ least concern
34	Chrysobalanaceae	*Parinari costata* ssp. *polyneura*	Lower risk/ least concern
35	Ctenolophonaceae	*Ctenolophon parvifolius*	Vulnerable
36	Dilleniaceae	*Dillenia reticulata* var. *psilocarpella*	Lower risk/ least concern
37	Dilleniaceae	*Dillenia reticulata* var. *reticulata*	Lower risk/ least concern
38	Dipterocarpaceae	*Anisoptera costata*	Endangered
39	Dipterocarpaceae	*Dipterocarpus crinitus*	Vulnerable
40	Dipterocarpaceae	*Dipterocarpus kerrii*	Endangered
41	Dipterocarpaceae	*Dipterocarpus kunstleri*	Critically endangered
42	Dipterocarpaceae	*Dipterocarpus semivestitus*	Critically endangered
43	Dipterocarpaceae	*Hopea apiculata*	Endangered
44	Dipterocarpaceae	*Neobalanocarpus heimii*	Endangered
45	Dipterocarpaceae	*Shorea curtisii* ssp. *curtisii*	Lower risk/ least concern
46	Dipterocarpaceae	*Shorea guiso*	Vulnerable
47	Dipterocarpaceae	*Shorea hemsleyana* ssp. *hemsleyana*	Vulnerable
48	Dipterocarpaceae	*Shorea hopeifolia*	Critically endangered
49	Dipterocarpaceae	*Shorea leprosula*	Near Threatened
50	Dipterocarpaceae	*Shorea macrantha*	Critically endangered
51	Dipterocarpaceae	*Shorea macroptera*	Lower risk/ least concern
52	Dipterocarpaceae	*Shorea materialis*	Critically endangered
53	Dipterocarpaceae	*Shorea multiflora*	Lower risk/ least concern
54	Dipterocarpaceae	*Shorea ovalis* ssp. *ovalis*	Endangered
55	Dipterocarpaceae	*Shorea parvifolia* ssp. *parvifolia*	Endangered
56	Dipterocarpaceae	*Shorea pauciflora*	Endangered
57	Dipterocarpaceae	*Shorea platycarpa*	Critically endangered
58	Dipterocarpaceae	*Shorea singkawang* ssp. *singkawang*	Vulnerable
59	Dipterocarpaceae	*Vatica flavida*	Critically endangered
60	Dipterocarpaceae	*Vatica pallida*	Endangered
61	Dipterocarpaceae	*Vatica pauciflora*	Vulnerable
62	Dipterocarpaceae	*Vatica stapfiana*	Vulnerable
63	Dipterocarpaceae	*Vatica umbonata*	Lower risk/ least concern
64	Dipterocarpaceae	*Vatica venulosa*	Critically endangered
65	Ebenaceae	*Diospyros apiculata*	Lower risk/ least concern
66	Ebenaceae	*Diospyros areolata*	Lower risk/ least concern
67	Ebenaceae	*Diospyros argentea*	Lower risk/ least concern
68	Ebenaceae	*Diospyros ismailii*	Lower risk/ least concern
69	Ebenaceae	*Diospyros scortechinii*	Lower risk/ least concern
70	Ebenaceae	*Diospyros singaporensis*	Lower risk/ least concern
71	Elaeocarpaceae	*Elaeocarpus petiolatus*	Lower risk/ least concern
72	Euphorbiaceae	*Baccaurea ramiflora*	Lower risk/ least concern
73	Euphorbiaceae	*Breynia vitis-idaea*	Lower risk/ least concern
74	Euphorbiaceae	*Claoxylon longifolium*	Lower risk/ least concern
75	Euphorbiaceae	*Croton kelantanicus*	Vulnerable
76	Euphorbiaceae	*Endospermum diadenum*	Lower risk/ least concern
77	Euphorbiaceae	*Mallotus penangensis*	Lower risk/ least concern
78	Euphorbiaceae	*Sapium baccatum*	Lower risk/ least concern
79	Fagaceae	*Lithocarpus curtisii*	Vulnerable

No.	Family	Species	IUCN status
80	Flacourtiaceae	*Hydnocarpus filipes*	Vulnerable
81	Flacourtiaceae	*Ryparosa javanica*	Lower risk/ least concern
82	Gnetaceae	*Gnetum gnemon* var. *gnemon*	Lower risk/ least concern
83	Guttiferae	*Calophyllum soulattri*	Lower risk/ least concern
84	Guttiferae	*Cratoxylum arborescens* var. *arborescens*	Lower risk/ least concern
85	Guttiferae	*Cratoxylum formosum*	Lower risk/ least concern
86	Guttiferae	*Cratoxylum maingayi*	Lower risk/ least concern
87	Guttiferae	*Garcinia scortechinii*	Lower risk/ least concern
88	Guttifereae	*Cratoxylum cochinchinense*	Lower risk/ least concern
89	Guttifereae	*Garcinia uniflora*	Lower risk/ least concern
90	Guttifereae	*Mesua nuda*	Lower risk/ least concern
91	Irvingiaceae	*Irvingia malayana*	Lower risk/ least concern
92	Lauraceae	*Actinodaphne pruinosa*	Lower risk/ least concern
93	Lauraceae	*Alseodaphne insignis*	Lower risk/ least concern
94	Lauraceae	*Beilschmiedia insignis*	Lower risk/ least concern
95	Lauraceae	*Beilschmiedia kunstleri*	Lower risk/ least concern
96	Lauraceae	*Beilschmiedia madang*	Lower risk/ least concern
97	Lauraceae	*Beilschmiedia pahangensis*	Lower risk/ least concern
98	Lauraceae	*Beilschmiedia wallichiana*	Vulnerable
99	Lauraceae	*Cinnamomum iners*	Lower risk/ least concern
100	Lauraceae	*Cinnamomum mollissimum*	Lower risk/ least concern
101	Lauraceae	*Cinnamomum porrectum*	Lower risk/ least concern
102	Lauraceae	*Cryptocarya ferrea*	Lower risk/ least concern
103	Lauraceae	*Litsea castanea*	Lower risk/ least concern
104	Lauraceae	*Litsea curtisii*	Endangered
105	Lauraceae	*Litsea elliptica*	Lower risk/ least concern
106	Lauraceae	*Litsea erectinervia*	Lower risk/ least concern
107	Lauraceae	*Litsea grandis*	Lower risk/ least concern
108	Lauraceae	*Litsea myristicifolia*	Lower risk/ least concern
109	Lauraceae	*Litsea sessiliflora*	Lower risk/ least concern
110	Lauraceae	*Litsea wrayi*	Lower risk/ least concern
111	Lauraceae	*Nothaphoebe panduriformis*	Lower risk/ least concern
112	Leguminosae	*Acacia mangium*	Lower risk/ least concern
113	Leguminosae	*Cynometra malaccensis*	Near threatened
114	Leguminosae	*Koompassia malaccensis*	Lower risk/ conservation dependent
115	Leguminosae	*Pongamia pinnata*	Lower risk/ least concern
116	Leguminosae	*Sindora coriacea*	Lower risk/ least concern
117	Meliaceae	*Aglaia elliptica*	Lower risk/ least concern
118	Meliaceae	*Aglaia argentea*	Lower risk/ least concern
119	Meliaceae	*Aglaia crassinervia*	Near Threatened
120	Meliaceae	*Aglaia odoratissima*	Lower risk/ least concern
121	Meliaceae	*Aglaia rubiginosa*	Near Threatened
122	Meliaceae	*Aglaia squamulosa*	Near Threatened
123	Meliaceae	*Sandoricum koetjape*	Vulnerable
124	Moraceae	*Antiaris toxicaria*	Lower risk/ least concern
125	Moraceae	*Artocarpus elasticus*	Lower risk/ least concern
126	Moraceae	*Ficus fistulosa* var. *fistulosa*	Lower risk/ least concern
127	Moraceae	*Ficus vasculosa*	Lower risk/ least concern
128	Myristicaceae	*Horsfieldia crassifolia*	Near Threatened

No.	Family	Species	IUCN status
129	Myristicaceae	*Horsfieldia irya*	Lower risk/ least concern
130	Myristicaceae	*Horsfieldia penangiana*	Vulnerable
131	Myristicaceae	*Horsfieldia superba*	Near Threatened
132	Myristicaceae	*Horsfieldia tomentosa*	Near Threatened
133	Myristicaceae	*Knema conferta*	Lower risk/ least concern
134	Myristicaceae	*Knema curtisii* var. *paludosa*	Vulnerable
135	Myristicaceae	*Knema furfuracea*	Lower risk/ least concern
136	Myristicaceae	*Knema glauca*	Vulnerable
137	Myristicaceae	*Knema kunstleri*	Near Threatened
138	Myristicaceae	*Knema latericia* ssp. *ridleyi*	Lower risk/ least concern
139	Myristicaceae	*Knema laurina* var. *heteropilis*	Lower risk/ least concern
140	Myristicaceae	*Knema laurina* var. *laurina*	Lower risk/ least concern
141	Myristicaceae	*Knema oblongifolia*	Lower risk: conservation dependent
142	Myristicaceae	*Knema scortechinii*	Lower risk/ least concern
143	Myristicaceae	*Knema stenophylla*	Lower risk/ least concern
144	Myristicaceae	*Myristica iners*	Lower risk/ least concern
145	Myrsinaceae	*Ardisia korthalsiana*	Lower risk/ least concern
146	Myrtaceae	*Melaleuca cajuputi*	Lower risk/ least concern
147	Myrtaceae	*Rhodamnia cinerea*	Lower risk/ least concern
148	Myrtaceae	*Syzygium claviflorum* var. *claviflorum*	Lower risk/ least concern
149	Myrtaceae	*Syzygium claviflorum* var. *riparium*	Lower risk/ least concern
150	Myrtaceae	*Syzygium nervosum*	Lower risk/ least concern
151	Olacaceae	*Anacolosa frutescens*	Lower risk/ least concern
152	Olacaceae	*Ochanostachys amentacea*	Data deficient
153	Opiliaceae	*Champereia manillana*	Lower risk/ least concern
154	Oxalidaceae	*Sarcotheca laxa* var. *laxa*	Vulnerable
155	Oxalidaceae	*Sarcotheca monophylla*	Near Threatened
156	Proteaceae	*Helicia attenuata*	Lower risk/ least concern
157	Proteaceae	*Helicia petiolaris* var. *petiolaris*	Lower risk/ least concern
158	Rhizophoraceae	*Pellacalyx saccardianus*	Lower risk/ least concern
159	Rosaceae	*Prunus arborea* var. *arborea*	Lower risk/ least concern
160	Rosaceae	*Prunus malayana*	Lower risk/ least concern
161	Rosaceae	*Prunus polystachya*	Lower risk/ least concern
162	Rutaceae	*Acronychia pedunculata*	Lower risk/ least concern
163	Sapindaceae	*Arytera littoralis*	Lower risk/ least concern
164	Sapindaceae	*Glenniea penangensis*	Vulnerable
165	Sapindaceae	*Lepisanthes tetraphylla*	Lower risk/ least concern
166	Sapindaceae	*Nephelium costatum*	Vulnerable
167	Sapindaceae	*Nephelium hamulatum*	Vulnerable
168	Sapindaceae	*Nephelium lappaceum* var. *lappaceum*	Lower risk/ least concern
169	Sapindaceae	*Nephelium lappaceum* var. *pallens*	Lower risk/ least concern
170	Sapindaceae	*Pometia pinnata*	Lower risk/ least concern
171	Sapotaceae	*Chrysophyllum roxburghii*	Lower risk/ least concern
172	Sapotaceae	*Madhuca korthalsii*	Near Threatened
173	Sapotaceae	*Madhuca motleyana*	Near Threatened
174	Sapotaceae	*Madhuca selangorica*	Lower risk: conservation dependent
175	Sapotaceae	*Madhuca utilis*	Endangered
176	Sapotaceae	*Palaquium gutta*	Near Threatened
177	Sapotaceae	*Palaquium herveyi*	Near Threatened

No.	Family	Species	IUCN status
178	Sapotaceae	*Palaquium leiocarpum*	Near Threatened
179	Sapotaceae	*Palaquium maingayi*	Vulnerable
180	Sapotaceae	*Palaquium obovatum*	Lower risk/ least concern
181	Sapotaceae	*Payena lucida*	Near Threatened
182	Sapotaceae	*Payena maingayi*	Lower risk/ least concern
183	Sapotaceae	*Pouteria malaccensis*	Near Threatened
184	Sterculiaceae	*Sterculia parviflora*	Lower risk/ least concern
185	Thymelaeaceae	*Aquilaria malaccensis*	Vulnerable
186	Thymelaeaceae	*Gonystylus affinis*	Vulnerable
187	Tiliaceae	*Microcos laurifolia*	Lower risk: conservation dependent
188	Tiliaceae	*Microcos tomentosa*	Lower risk/ least concern
189	Tiliaceae	*Pentace curtisii*	Near Threatened
190	Tiliaceae	*Pentace perakensis*	Vulnerable
191	Tiliaceae	*Pentace triptera*	Lower risk/ least concern
192	Ulmaceae	*Gironniera subaequalis*	Lower risk/ least concern
193	Verbenaceae	*Callicarpa longifolia*	Lower risk/ least concern
194	Verbenaceae	*Vitex pinnata*	Lower risk/ least concern

A total of 92 taxa of Peninsular Malaysia Dipterocarps are listed under the threatened category of the IUCN Red List (Saw *et al.* 2010). There are four species of Burseraceae; three species of Myristicaceae, Sapindaceae, and Sapotaceae; two species of Thymelaeaceae and Lauraceae; and one species of Anisophylleaceae, Annonaceae, Euphorbiaceae, Fagaceae, Flacourtiaceae Meliaceae, Oxalidaceae, and Tiliaceae. Thus, the threatened species of Dipterocarps found in the Perak Tengah freshwater swamp forest contributed to 23.9% of threatened Peninsular Malaysia Dipterocarp species.

Liliwirianis (2021) reported that some Dipterocarp species residing in Perak Tengah comprise CR species. Unfortunately, the population size, to some extent, is extremely small, comprising less than 53 individuals, as befallen *D. semivestitus*. The tree number had decreased from the report by Saw (2010) over ten years. Saw (2010) reported that the freshwater swamp forest of the Lumut District, Perak, containing some of the rarest trees (*D. semivestitus* and *V. flavida*), is now confined to remnant areas. In the case of *D. semivestitus*, the species exists only as a remnant population in a 55-ha freshwater swamp forest at Universiti Teknologi MARA, Perak. To date, it is the only population that has been discovered in Peninsular Malaysia. An extensive survey of this area found only 53 individual trees. The species, which was once considered extinct, has been found in Perak, Malaysia.

Endangered tree conservation is of utmost priority, as endangered species compete for limited suitable habitats with human development. Saw *et al*. (2010) reported that 92 taxa (56.1%) of Dipterocarpaceae were at some level of threat in Malaysia. In addition, Saw and Yen (2000) urged changes in land use patterns and rising demands on forest resources, and Malaysia's attention to the sustainable use of forest resources now involves consideration of the entire problem of protection of all biodiversity.

The IUCN Red List Categories and Criteria were developed using five criteria: population reduction, geographic range in the form of extent of occurrence or area of occupancy, small population size and decline, very small or restricted population, and quantitative analysis. Yong *et al.* (2021) confirmed that Perak is the second state with the highest number of threatened taxa, with 166 taxa. In addition, Chua *et al.* (2010) affirmed that Perak is the second highest state that comprises several threatened taxa (53 taxa) of Dipterocarps and perhaps is the most vulnerable as it has the greatest number of CR taxa (10), i.e., *Dipterocarpus coriaceus*, *D. semivestitus, Hopea auriculata, Hopea bilitonensis, Parashorea globosa*, *S. hemsleyana* ssp.

hemsleyana, *Shorea lamellata, Shorea lumutensis, Shorea teysmanniana,* and *V. flavida*. Our study showed that the freshwater swamp forest of the Perak Tengah study area consisted of some of the species: *D. semivestitus, S. hemsleyana* ssp. *Hemsleyana*, and *V. flavida*.

CONCLUSION

For a large field of research in freshwater swamp forests in Perak Tengah, the amount of endangered, new records, and vulnerable species is high. The results indicated that six species were documented as new for Perak, endemic and listed in the IUCN. The species were *V. pallida, C. kelantanicus, Madhuca selangorica, Actinodahphne pruinosa, Dillenia reticulata* var. *reticulata, Diospyros ismailii*, and *S. claviflorum* var. *riparium*. The species are also highly specialized since they are only confined to their special habitats. Thus, these unique groups would be at risk if the freshwater swamp forest and its adjacent regions are disturbed. Conservation of native and rare species could demand active protection, restoration, and high uniqueness of species-rich habitats and areas since the listed threatened species are currently not protected in the network of Totally Protected Areas (TPA) despite some of the study areas being monitored by the Forest Research Institute of Malaysia (FRIM). The Perak Tengah freshwater swamp forest has unique areas that house many endemic and endangered species needing of protection, and it is important to protect the environment and mitigate the threats.

ACKNOWLEDGMENTS

This work was supported by the research grants through the Fundamental Research Grant Scheme (FRGS) 600-RMI/FRGS 5/3 (41/2014) and UiTM's Research Intensive Faculty (RIF) Grant (600-RMI/DANA 5/3/RIF (404/2012)).

REFERENCES

Anderson S. 1994. Area and endemism. The quarterly review of biology 69(4):451-71.

Chua LSL, Suhaida M, Hamidah M, Saw LG. 2010. Malaysia Plant Redlist: Peninsular Malaysian Dipterocarpaceae. Research Pamphlet. No. 129. Kepong (MY): Forest Research Institute Malaysia.

Davies KF, Margules CR, Lawrence JF. 2004. A synergistic effect puts rare, specialized species at greater risk of extinction. Ecology 85(1):265-71.

Dobson FS, Yu J, Smith AT. 1995. The importance of evaluating rarity. Conservation Biology 9(6):1648-51.

Fifth National Report to the Convention on Biological Diversity. 2020. Government of Malaysia Ministry of Natural Resources and Environment Fifth National Report to the Convention on Biological Diversity. www.nre.gov.my

Huang J, Chen B, Liu C, Lai J, Zhang J, Ma K. 2012. Identifying hotspots of endemic woody seed plant diversity in China. Diversity and Distributions 18:673-88. DOI:10.1111/j.1472-4642.2011.00845.x

Huang S, Oey L. 2019. Malay Archipelago forest loss to cash crops and urban expansion contributes to weaken the Asian summer monsoon: An atmospheric modeling study. J Clim 32(11):3189-3205. DOI:10.1175/JCLI-D-18-0467.1

International Plant Names Index [Internet]. 2020. Available from: https://www.ipni.org/

Jaafar WSWM, Maulud KNA, Kamarulzaman AMM, Raihan A, Sah SM, Ahmad A, Saad SNM, Azmi ATM, Syukri NKAJ, Khan WR. 2020. The Influence of Deforestation on Land Surface Temperature: A Case Study of Perak and Kedah, Malaysia. Forests 11(6):670. doi.org/10.3390/f11060670

Kanniah KD, Siong HC. 2017. Urban forest cover change and sustainability of Malaysian cities. Chem Eng Trans 56:673-8.

Kessler M. 2002. The elevational gradient of Andean plant endemism: Varying influences of taxon-specific traits and topography at different taxonomic levels. J Biogeogr 29(9):1159-65. DOI: 10.1046/j.1365-2699.2002.00773.x

Kiew R, Rafidah AR, Ong PT, Ummul Nazrah AR. 2017 Limestone treasures: Rare plants in Peninsular Malaysia-where they are, where they grow and how to conserve them. Malaysian Naturalist 71:32-41.

Kiew R, Rahman RA. 2021. Plant diversity assessment of karst limestone, a case study of Malaysia's Batu Caves. Nat Conserv 44:21-49.

Kraf NJB, Baldwin BG, Ackerly DD. 2010. Range size, taxon age and hotspots of neo endemism in the California flora. Divers Distrib 16:403-13.

Kruckeberg AR, Rabinowitz D. 1985. Biological aspects of endemism in higher plants. Ann Rev Ecol Syst 16(1):447-79.

Laffan SW, Ramp D, Roger E. 2013. Using endemism to assess representation of protected areas-the family Myrtaceae in the Greater Blue Mountains World Heritage Area. J Biogeogr 40(3):570-8. DOI:10.1111/jbi.12001

Liliwirianis N. 2021. Ecological Characteristics of Freshwater Swamp Forest, Perak Tengah, Malaysia [Thesis]. Bangi (MY): Universiti Kebangsaan Malaysia. Retrieved from Universiti Kebangsaan Malaysia.

Liliwirianis N, Suratman MN, Tahir SZM. 2013. Conservation of the critically endangered tree species Dipterocarpus semivestitus in Malaysia. In BEIAC 2013. IEEE Business Engineering and Industrial Applications Colloquium. p.225-8. DOI:10.1109/BEIAC.2013.6560121

Major J. 1988. Endemism: A botanical perspective. In Myers AA, Giller PS (Editors). Analytical Biogeography: An Integrated Approach to the Study of Animal and Plant Distributions. London (UK): Chapman & Hall. p. 117-46.

Ng FSP, Low CM, Sanah MAN. 1990. Endemic trees of the Malay Peninsular. Research Pamphlet No. 106. Forest Research Institute Malaysia.

Nishimura S, Yoneda T, Fujii S, Mukhtar E, Kanzaki M. 2008. Spatial patterns and habitat associations of Fagaceae in a hill dipterocarp forest in Ulu Gadut, West Sumatra. J Trop Ecol 24(5):535-50.

Primack RB. 2002. Essentials of Conservation Biology. Sunderland (US): Sinauer Association.

Saw LG. 2010. Vegetation of Peninsular Malaysia. In Kiew R, Chung RCK, Saw LG, Soepardmo E, Boyce PC (Editors). Flora of Peninsular Malaysia 2(1):21-45.

Saw LG. 2010. Vegetation of Peninsular Malaysia. Seed Plant 1:1-41.

Saw LG, Chung RCK. 2015. The Flora of Malaysia Projects. Rodriguesia 66(4):947-60.

Saw LG, Yen SY. 2000. Conservation of Dipterocarpaceae in Peninsular Malaysia. J Trop For Sci 12(3):593-615.

Turner IM. 1995. A Catalogue of the Vascular Plants of Malaya. Vol. 1. National Parks Board Singapore Botanic Garden.

Walker BH. 1987. A general model of savanna structure and function. IUBS Monogr Ser. 1-12.

Whitmore TC. 1972. Tree Flora of Malaya. Kuala Lumpur (MY): Longman Malaysia Sdn. Berhad.

Whitmore TC. 1973. Tree Flora of Malaya. Vol. 2. Kuala Lumpur (MY):Longman Malaysia Sdn. Berhad.

Yong WS, Chua LS, Lau KH, Siti Nur Fatinah K, Cheah YH, Yao TL, Rafidah AR, Lim CL, Syahida Emiza S, Ummul Nazrah AR, Nor Ezzawanis AT. 2021. Malaysia Red List: Plants of Peninsular Malaysia Part 1. Aslita, Kuala Lumpur.