

## LEE L. (VITACEAE) OF SINGAPORE

Alvin Francis S. L. Lok, W. F. Ang, B. Y. Q. Ng, S. M. Suen, C. K. Yeo and Hugh T. W. Tan \*

Department of Biological Sciences, National University of Singapore

14 Science Drive 4, Singapore 117543, Republic of Singapore

(\*Corresponding author: [dbsttw@nus.edu.sg](mailto:dbsttw@nus.edu.sg))

### INTRODUCTION

This paper seeks to document the distribution and status of native *Leea* species in Singapore. *Leea* L. is a relatively small genus comprising around 34 species (Ridsdale, 1974; 1976; Wen, 2007). It is found entirely in the Old World Tropics, ranging from tropical Africa to Asia and Polynesia (Ridley, 1922). Malesia is the centre of diversity for this genus with 25 endemics (Ridsdale, 1974; 1976). Malesian species are usually found below an altitude of 1,000 m, with some species extending their altitudinal range to 1,700 m, as in the case of *Leea indica* (Fig. 1). The general observed trend is that *Leea* species with widespread distribution are usually found in secondary and riverine forests, while those with limited distribution are found in the understorey of primary forests or along forest streams. Pollination of the scentless flowers of *Leea* is believed to be carried out by short-tongued bees, and syrphids (Ridsdale, 1976), although their flowers have been observed to be visited frequently by ants (Fig. 2), bees, wasps (Fig. 3), as well as a variety of butterflies including *Eurema hecabe contubernalis*, *Eurema simulatrix tecmessa*, and *Iambrix salsala salsala* (Fig. 4) (pers. obs). Fruit and seed dispersal of *Leea* species are not well-documented, but are believed to be performed by birds (pers. obs), as in the case of *Leea indica*, whose plants are normally visited by bulbuls that are attracted to its reddish-black berries (Fig. 5).

*Leea* was originally assigned to the family Ampelideae (Ridley, 1922), but was transferred to the Leeaceae (Ridsdale, 1974; 1976), and then more recently to the Vitaceae (Stevens, 2001; APG, 2003). *Leea* species are generally trees, shrubs, or creeping or erect herbs. They may be armed with prickles (e.g., *Leea angulata*) or unarmed (e.g., *Leea indica*), with simple, 1-foliate, 3-foliate, or 1–4-pinnate leaves. The lamina margins of the pinnae are serrate, dentate, or crenate. The base of the petiole is expanded to form a stipular structure on both margins that surrounds the stem apex. The stipules are narrowly sheathing and persistent or large, obovate, and caducous. The inflorescence is usually a



Fig. 1. *Leea indica* seen here bearing inflorescence and infructescence. (Photograph by: Alvin Francis Lok Siew Loon).





Fig. 2. *Leea indica* flowers visited by a wasp (*Rhynchium haemorrhoidale*). (Photograph by: Alvin Francis Lok Siew Loon).



Fig. 3. *Leea rubra* flowers visited by an ant (*Camponotus* species). (Photograph by: Alvin Francis Lok Siew Loon).





Fig. 4. *Leea indica* flowers visited by *Iambrix salsala salsala*. (Photograph by: Alvin Francis Lok Siew Loon).

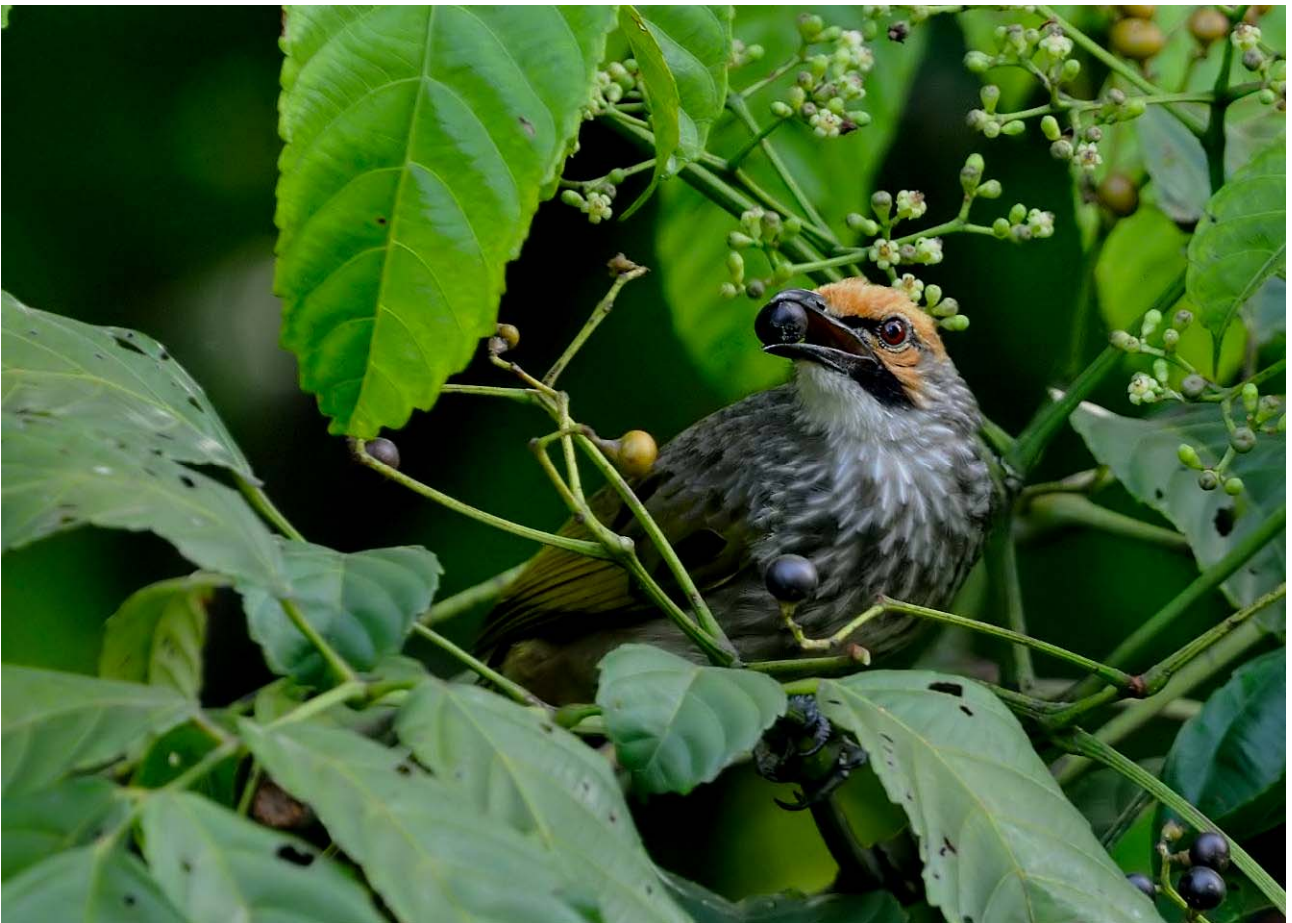


Fig. 5. The straw-headed bulbul (*Pycnonotus zeylanicus*) eating *Leea indica* fruits. (Photograph by: Chan Wei Luen).

terminal pedunculate cyme, opposite to the leaf. Flowers are bisexual, pedicellate, with a campanulate calyx, a 4–5-lobed, valvate corolla whose lobes are connate at the apical keel in the bud, becoming reflexed at anthesis. Each flower has 4–5 stamens, which are filamentous, syngenesious, and adnate to the basal part of the disc, extending over the sinuses of the disc and having introse anthers. The disc is 4–5-lobed. The ovaries are 3-carpellate, 3–6-loculate, with 1–2 ovules per locule depending if the septa are fused. The styles are short and entire, and the stigma is capitate and glabrous.

### PAST AND PRESENT RECORDS

From Singapore herbarium records, four species of *Leea* have been recorded from Singapore. Today, only two species are still extant, with *Leea indica* listed as "Common", and *Leea angulata* listed as "Critically Endangered", while *Leea aequata*, and *Leea rubra* are now nationally extinct (Tan et al., 2008; Chong et al., 2009).

#### *Leea aequata* L.

This species is nationally extinct in Singapore, and was only collected twice in the past by H. N. Ridley — once in Ang Mo Kio on 8 Mar. 1889, and in 1892 at Blakang Mati (present-day Sentosa) (Table 1). There are also two other records of *Leea aequata* in the herbarium (SING), but these are regarded as being of dubious provenance as their localities and collectors' names are missing. This species is usually a shrub, or less often a treelet growing to 10 m tall (Ridsdale, 1974; 1976). The leaves are 1–3-pinnate, with 5 to numerous leaflets. Leaflets are ovate to ovate-lanceolate or elliptic to elliptic-lanceolate, glabrous to adaxially pubescent, particularly over the nerves, 3–30 cm long by 1.5–12 cm wide (Fig. 6). Brown globular pearl glands are also obvious on the leaflets. The petiole is 5–20 cm long, with oblong-obovate stipules (Figs. 6, 7). The inflorescences are 4–20 cm long and rusty pubescent. The bracts are ovate and up to 8 mm long by 5 mm wide. The peduncles are 1–8 cm long, with lateral and ultimate branches short and condensed. The flowers are greenish white, and the teeth of the stamen tube are bifid. The fruits are depressed globular in shape and nearly black when ripe (Ridley, 1922).

This species is widespread but scattered and rare. It is rather rare in Malaya and Borneo, and is usually found in secondary vegetation up to 1400 m but is more common at lower altitudes (Ridsdale, 1974; 1976).



Fig. 6. The unarmed stem and oblong-obovate stipules of *Leea aequata*. (Photograph by: Christian Puff).



Fig. 7. A new leaf of *Leea aequata* emerging from between the stipules. (Photograph by: Christian Puff).



Table 1. Previous Singapore collections of *Leea aequata* L. deposited in the Herbarium, Singapore Botanic Gardens (SING).

S/No.	Bar Code No.	Herbarium	Collector	Collector's No.	Date	Locality
1.	0011274	SING	H. N. Ridley	1928	8 Mar.1889	Ang Mo Kio
2.	0011273	SING	H. N. Ridley	3708	1892	Blakang Mati (Sentosa)
3.	0042215	SING	Anonymous	s.n.	1 Mar.1997	—
4.	0011275	SING	Anonymous	s.n.	—	—

***Leea angulata* Korth. ex Miq.**

Although this species was collected from five different localities in Singapore, it is reduced to a single, small population known just off Temenggong Road (Table 2) growing in adinandra belukar (Fig. 8). The critically endangered *Leea angulata* grows as a weak strangler, bushy shrub, or tree up to 15 m, often multi-stemmed and suckering (Ridsdale, 1974; 1976; Keng, 1990). The trunk and branches of this species are armed with sharp triangular prickles (Fig. 9). The leaves of this species are 2–3-pinnate, with numerous leaflets (Fig. 10). The petioles are 3–7 cm long and armed with spines, although in lesser density compared to the prickles on the trunk and branches. The stipules of this species are narrow and winged, and are 2–5 cm long by 2–5 mm wide. The leaflets are elliptic to ovate, 7–10 cm long by about 5 cm wide, and glabrous, with crenate to shallowly serrate margins. The bracts are narrow and triangular in shape. The inflorescences are up to 25 cm long, multi-branched and pubescent, with peduncles 4–10 cm long, bearing greenish white flowers that develop into lead-grey berries that are about 1 cm in diameter.

This species is widely distributed and can be found in the Nicobar Islands, Thailand, and throughout Malesia. It is found in secondary vegetation, particularly in sandy heaths and riverine forests, at altitudes up to 1500 m.



Fig. 8. *Leea angulata* growing in the undergrowth along Temenggong Road. (Photograph by: Ang Wee Foong).



Fig. 9. Stems of *Leea angulata* showing thick triangular prickles. (Photograph by: Ang Wee Foong).





Fig. 10. Foliage of *Leea angulata*. (Photograph by: Ang Wee Foong).

Table 2. Previous Singapore collections of *Leea angulata* Korth. ex Miq. deposited in the Herbarium, Singapore Botanic Gardens (SING, with bar code no.) and the Herbarium, Raffles Museum of Biodiversity Research, National University of Singapore (SINU, with accession no.).

S/No.	Accession/Bar Code No.	Herbarium	Collector	Collector's No.	Date	Locality
1.	0011276	SING	H. N. Ridley	10401	1899	Pasir Panjang
2.	0019176	SING	Z. Teruya	2214	26 Jan.1933	Geylang
3.	0011277	SING	J. Sinclair	38565	6 Jun.1949	Pulau Pesek
4.	2007004447	SINU	K. M. Loh	1	12 Apr.1971	Singapore Botanic Gardens.
5.	2007004448	SINU	K. Jumali	J. 891	12 Apr.1971	At Lawn C, Botanic Gardens.
6.	0019175	SING	E. Tang & K. Sidek.	480	13 Apr.1995	Botanic Gardens
7.	2007004458	SINU	Morgany d/o Thangavelu	M 59	22 Dec.1997	Temenggong Road.
8.	2007004459	SINU	Morgany d/o Thangavelu	M 59	22 Dec.1997	Temenggong Road.
9.	2007004433	SINU	C. K. Yeo	314	17 Oct.2000	Abandoned human modified area along Temenggong Road.
10.	2007004434	SINU	C. K. Yeo	315	17 Oct.2000	Abandoned human modified area along Temenggong Road, under a small <i>Leea angulata</i> tree.
11.	2007004435	SINU	C. K. Yeo	315	17 Oct.2000	Abandoned human modified area along Temenggong Road, under a small <i>Leea angulata</i> tree.
12.	2007004436	SINU	C. K. Yeo	315	17 Oct.2000	Abandoned human modified area along Temenggong Road, under a small <i>Leea angulata</i> tree.

NATURE IN SINGAPORE 2011

S/No.	Accession/Bar Code No.	Herbarium	Collector	Collector's No.	Date	Locality
13.	2007004437	SINU	C. K. Yeo	315	17 Oct.2000	Abandoned human modified area along Temenggong Road, under a small <i>Leea angulata</i> tree.
14.	2007004438	SINU	C. K. Yeo	317	17 Oct.2000	Taman Serasi carpark, opposite Singapore Botanic Gardens.
15.	2007004439	SINU	C. K. Yeo	317	17 Oct.2000	Taman Serasi carpark, opposite Singapore Botanic Gardens.
16.	2007004440	SINU	C. K. Yeo	317	17 Oct.2000	Taman Serasi carpark, opposite Singapore Botanic Gardens.
17.	2007004441	SINU	C. K. Yeo	311	17 Oct.2000	Abandoned human modified area along Temenggong Road.
18.	2007004442	SINU	C. K. Yeo	311	17 Oct.2000	Abandoned human modified area along Temenggong Road.
19.	2007004443	SINU	C. K. Yeo	312	17 Oct.2000	Abandoned human modified area along Temenggong Road.
20.	2007004444	SINU	C. K. Yeo	312	17 Oct.2000	Abandoned human modified area along Temenggong Road.
21.	2007004445	SINU	C. K. Yeo	313	17 Oct.2000	Abandoned human modified area along Temenggong Road.
22.	2007004446	SINU	C. K. Yeo	313	17 Oct.2000	Abandoned human modified area along Temenggong Road.
23.	2007004449	SINU	C. K. Yeo	317	17 Oct.2000	Taman Serasi carpark, opposite Singapore Botanic Gardens.
24.	2007004450	SINU	C. K. Yeo	317	17 Oct.2000	Taman Serasi carpark, opposite Singapore Botanic Gardens.
25.	2007004451	SINU	C. K. Yeo	317	17 Oct.2000	Taman Serasi carpark, opposite Singapore Botanic Gardens.
26.	2007004452	SINU	C. K. Yeo	317	17 Oct.2000	Taman Serasi carpark, opposite Singapore Botanic Gardens.
27.	2007004453	SINU	C. K. Yeo	317	17 Oct.2000	Taman Serasi carpark, opposite Singapore Botanic Gardens.
28.	2007004454	SINU	C. K. Yeo	317	17 Oct.2000	Taman Serasi carpark, opposite Singapore Botanic Gardens.
29.	2007004455	SINU	C. K. Yeo	317	17 Oct.2000	Taman Serasi carpark, opposite Singapore Botanic Gardens.
30.	2007004456	SINU	C. K. Yeo	317	17 Oct.2000	Taman Serasi carpark, opposite Singapore Botanic Gardens.
31.	2007004457	SINU	C. K. Yeo	317	17 Oct.2000	Taman Serasi carpark, opposite Singapore Botanic Gardens.
32.	2007004460	SINU	C. K. Yeo	311	17 Oct.2000	Abandoned human modified area along Temenggong Road.
33.	2007004461	SINU	C. K. Yeo	311	17 Oct.2000	Abandoned human modified area along Temenggong Road.
34.	2007004462	SINU	C. K. Yeo	311	17 Oct.2000	Abandoned human modified area along Temenggong Road.
35.	2007004463	SINU	C. K. Yeo	311	17 Oct.2000	Abandoned human modified area along Temenggong Road.
36.	2007004464	SINU	C. K. Yeo	311	17 Oct.2000	Abandoned human modified area along Temenggong Road.
37.	2007004465	SINU	C. K. Yeo	311	17 Oct.2000	Abandoned human modified area along Temenggong Road.
38.	0042466	SING	L. M. J. Chen	143	—	—



S/No.	Accession/Bar Code No.	Herbarium	Collector	Collector's No.	Date	Locality
39.	0042467	SING	L. M. J. Chen	145	—	—
40.	0042468	SING	L. M. J. Chen	145	—	—

***Leea indica* (Burm. f.) Merr.**

This nationally common species is found in many parts of Singapore (Table 3), and is usually a shrub, treelet, or small tree, 2–16 m tall, and can be single-stemmed, although multi-stemmed specimens with numerous stilt roots (Fig. 11) are more often observed (Ridsdale, 1974; 1976; Keng, 1990). The stems are glabrous to pubescent. The leaves of this species are 1–3-pinnate, bearing 7 leaflets, with petioles 7–20 cm long. The leaflets are ovate-lanceolate, 5–23.5 cm long by 3–9 cm wide, glabrous to slightly hairy, with crenate to serrate margins, and with petiolules up to 3 cm long. The stipules are obovate up to 5 cm long and 3 cm wide, usually glabrous to pubescent (Fig. 12). The inflorescences are 5–25 cm long, usually broad and rarely condensed, and are glabrous to slightly pubescent, with triangular to deltoid bracts, and with peduncles up to 20 cm long. The flowers are greenish white and are about 5 mm across (Fig. 13), and have fruits which are about 1 cm in diameter (Fig. 14) that turn purplish black when ripe and usually bearing six seeds.

This species is very widely distributed, found in India, Sri Lanka, Nepal, Bangladesh, Burma, Thailand, Cambodia, Laos, Vietnam, China, throughout Malesia, and extending east towards New Guinea, north Australia, Solomon Islands, Santa Cruz Island, New Hebrides, and Fiji (Ridsdale, 1974; 1976). This species has extremely large ecological amplitude and is extremely widespread: it is found in back mangroves, secondary forests, primary forests in the lowlands and wet ridges up to 1,700 m in altitude. In Singapore, this species is found in many habitats: in coastal vegetation, back mangroves, secondary forests, freshwater swamp forests near the edges or in gaps, and also in the undergrowth of primary forests.



Fig. 11. *Leea indica* showing prop roots. (Photograph by: Alvin Francis Lok Siew Loon).

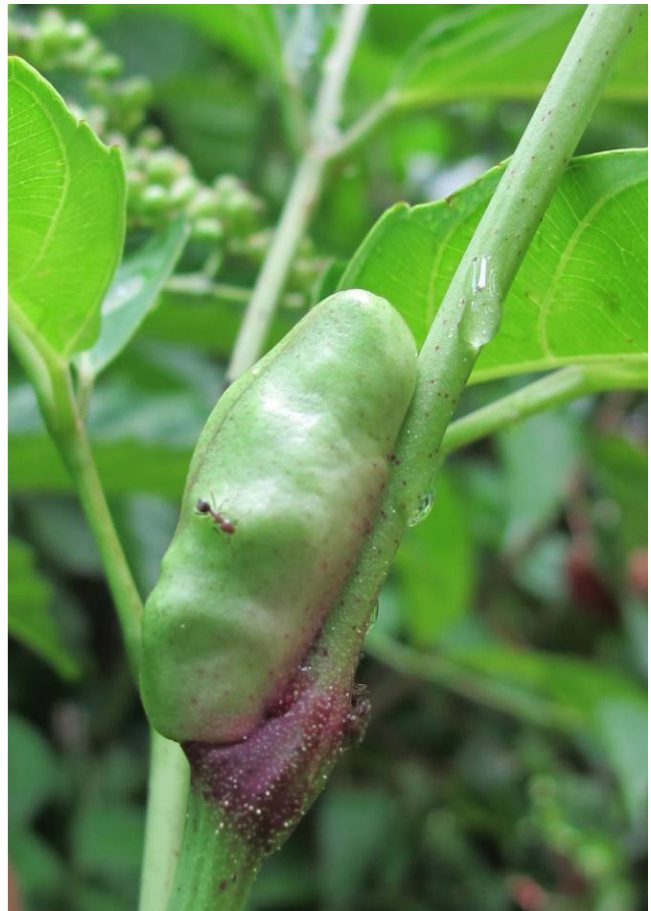


Fig. 12. A stipule of *Leea indica*. (Photograph by: Alvin Francis Lok Siew Loon).



Table 3. Previous Singapore collections of *Leea indica* (Burm. f.) Merr. deposited in the Herbarium, Singapore Botanic Gardens (SING, with bar code no.) and the Herbarium, Raffles Museum of Biodiversity Research, National University of Singapore (SINU, with accession no.).

S/No.	Accession/Bar Code No.	Herbarium	Collector	Collector's No.	Date	Locality
1.	0018263	SING	R. W. Hullett	305	Aug. 1883	—
2.	0018270	SING	H. N. Ridley	s.n.	May 1889	Bukit Murai?
3.	0018269	SING	Anonymous	s.n.	22 May 1889	Bukit Mandai
4.	0018268	SING	H. N. Ridley	4746	1893	Choa Chu Kang
5.	0018262	SING	H. N. Ridley	s.n.	1894	Bukit Timah
6.	0018265	SING	H. N. Ridley	s.n.	1899	Thomson Road
7.	2007004486	SINU	Abu Kassim	533	Jul. 1955	—
8.	2007004476	SINU	Keng	2877	6 Oct. 1960	MacRitchie Nature Reserve
9.	2007004477	SINU	Keng	2877	6 Oct. 1960	MacRitchie Nature Reserve
10.	2007004478	SINU	K. Jumali	J. 892	21 Apr. 1971	Botanic Gardens Jungle near the roadside
11.	2007004479	SINU	K. M. Loh	2	21 Apr. 1971	Botanic Gardens, Maranta Ave
12.	2007004480	SINU	K. M. Loh	3	21 Apr. 1971	Botanic Gardens, Lawn M
13.	2007004481	SINU	K. M. Loh	4	21 Apr. 1971	Botanic Gardens, Lawn M
14.	0001662	SING	A. Samsuri	654	6 Sep. 1971	Botanic Gardens, Lawn M
15.	2007004485	SINU	M. Y. Kok	31	17 Jun. 1990	Pulau Ubin, Sector K
16.	2007004467	SINU	I. M. Turner	NRS 46	1 Apr. 1992	Nature Reserves
17.	2007004468	SINU	I. M. Turner	NRS 46	1 Apr. 1992	Nature Reserves, Sector 13
18.	2007004473	SINU	K. S. Chua	NRS 214	8 Apr. 1992	Nature Reserves, Sector 25
19.	2007004469	SINU	J. W. H. Yong	NRS 439	21 Apr. 1992	Nature Reserves, Sector 47
20.	2007004471	SINU	Y. W. K. Khng	NRS 969	14 May 1992	Nature Reserves, Sector 26
21.	2007004470	SINU	D. P. Y. Lim	NRS 1044	19 May 1992	Nature Reserves, Sector 41
22.	2007004472	SINU	G. C. H. Tan	NRS 1119	26 May 1992	Nature Reserves, Sector 28
23.	0018264	SING	E. Tang	22	28 Aug. 1994	Road leading to Upper Pierce Reservoir Park
24.	2007004487	SINU	Ali Ibrahim	TK 94	22 Aug. 1996	Pulau Tekong Kechil
25.	2007004493	SINU	Ali Ibrahim	TK 94	22 Aug. 1996	Pulau Tekong Kechil
26.	2007004488	SINU	H. T. W. Tan	T 1137	15 Aug. 1996	Pulau Tekong
27.	2007004489	SINU	H. T. W. Tan	SAJ 064	1 Nov. 1996	Pulau Sajahat
28.	0042469	SING	L. M. J. Chen	103	15 Mar. 1997	—
29.	0042470	SING	L. M. J. Chen	154	9 Aug. 1997	Pulau Ubin
30.	0042471	SING	L. M. J. Chen	155	9 Aug. 1997	Pulau Ubin
31.	0042472	SING	L. M. J. Chen	155	9 Aug. 1997	Pulau Ubin
32.	0042473	SING	L. M. J. Chen	155	9 Aug. 1997	Pulau Ubin
33.	0042474	SING	L. M. J. Chen	156	9 Aug. 1997	Pulau Ubin
34.	0042475	SING	L. M. J. Chen	170	26 Aug. 1997	Bukit Timah Nature Reserve
35.	0042476	SING	L. M. J. Chen	170	26 Aug. 1997	Bukit Timah Nature Reserve
36.	0042477	SING	L. M. J. Chen	170	26 Aug. 1997	Bukit Timah Nature Reserve
37.	0042478	SING	L. M. J. Chen	170	26 Aug. 1997	Bukit Timah Nature Reserve
38.	0042479	SING	L. M. J. Chen	170	26 Aug. 1997	Bukit Timah Nature Reserve
39.	0042480	SING	L. M. J. Chen	174	26 Aug. 1997	Bukit Timah Nature Reserve
40.	0042481	SING	L. M. J. Chen	175	26 Aug. 1997	Bukit Timah Nature Reserve
41.	0042482	SING	L. M. J. Chen	176	26 Aug. 1997	Bukit Timah Nature Reserve

S/No.	Accession/Bar Code No.	Herbarium	Collector	Collector's No.	Date	Locality
42.	0042483	SING	L. M. J. Chen	177	26 Aug.1997	Bukit Timah Nature Reserve
43.	2007004482	SINU	A.H.B. Loo	SDC 23	21 Oct.1997	Sentosa
44.	2007004490	SINU	Morgany d/o Thangavelu	M 60	22 Dec.1998	Bukit Timah Nature Reserve
45.	2007004491	SINU	Morgany d/o Thangavelu	M 60	22 Dec.1998	Bukit Timah Nature Reserve
46.	2007004492	SINU	Y. P. Tng	s.n.	2000	Pulau Tekong Kechil, Plot no. 9
47.	2007004516	SINU	C. K. Yeo	23	1 Aug.2000	Along Rock Path, Bukit Timah Nature Reserve, (01° 21.04' N, 103° 46.73' E)
48.	2007004517	SINU	C. K. Yeo	20	1 Aug.2000	In a shallow stream intersecting Taban Loop, Bukit Timah Nature Reserve, (01° 20.91' N, 103° 46.65' E)
49.	2007004501	SINU	C. K. Yeo	37	2 Aug.2000	Secondary forest edge along Dairy Farm Road, Bukit Timah Nature Reserve (01° 21.76' N, 103° 46.64' E)
50.	2007004503	SINU	C. K. Yeo	37	2 Aug.2000	Secondary forest edge along Dairy Farm Road, Bukit Timah Nature Reserve (01° 21.76' N, 103° 46.64' E)
51.	2007004502	SINU	C. K. Yeo	101	9 Aug.2000	Exposed man-made modified site along Rifle Range Road, draped with <i>Cissus hastata</i> (01° 20.77' N, 103° 46.90' E)
52.	2007004496	SINU	C. K. Yeo	93	9 Aug.2000	Along track within the PUB-controlled part of MacRitchie Reservoir at the end of Sime Road (01° 20.81' N, 103° 49.19' E)
53.	2007004498	SINU	C. K. Yeo	114	11 Aug.2000	Old gap along Bamboo Trail, Lower Pierce Reservoir (01° 22.44' N, 103° 49.42' E)
54.	2007004507	SINU	C. K. Yeo	119	11 Aug.2000	Secondary forest edge along Old Upper Thomson Road (01° 22.56' N, 103° 49.56' E)
55.	2007004518	SINU	C. K. Yeo	120	13 Aug.2000	Secondary forest edge along road leading to Upper Pierce Reservoir Park, (01° 22.83' N, 103° 48.91' E)
56.	2007004495	SINU	C. K. Yeo	157	23 Aug.2000	Nee Soon Swamp Forest edge along Mandai Road Track 7 (01° 24.00' N, 103° 48.54' E)
57.	2007004508	SINU	C. K. Yeo	189	25 Aug.2000	Edge of tree stand, Mandai Lake Road Track 9 (01° 22.35' N, 103° 46.84' E)
58.	2007004504	SINU	C. K. Yeo	187	25 Aug.2000	Secondary forest edge along Mandai Lake Road (01° 24.38' N, 103° 47.12' E)
59.	2007004511	SINU	C. K. Yeo	201	28 Aug.2000	Edge of abandoned rubber plantation, Jalan Ulu Sembawang (01° 24.87' N, 103° 47.29' E)
60.	2007004514	SINU	C. K. Yeo	204	28 Aug.2000	Edge of secondary forest, Jalan Ulu Sembawang (01° 24.78' N, 103° 47.30' E)





Fig. 13. Close-up view of *Leea indica* flowers. (Photograph by: Alvin Francis Lok Siew Loon).



Fig. 14. Unripe fruits of *Leea indica*. (Photograph by: Alvin Francis Lok Siew Loon).

***Leea rubra* Blume ex Spreng.**

This species is nationally extinct and was last collected in the wild by H. N. Ridley in 1909 at King's Road (Keng, 1990). All other collections of this species locally are of reintroduced planted specimens, including those in the Bukit Timah Nature Reserve, which are found behind the Visitor Centre (Table 1d). *Leea rubra* is a small semi-herbaceous shrub growing to about 2.5–3 m tall. The leaves are 2–4-pinnate, with numerous leaflets (Fig. 15). The petioles are 6–20 cm long with narrow winged stipules at the base (Fig. 16). The leaflets are generally ovate, but sometimes elliptic or linear-lanceolate, 3–15 cm long by 1.5–5 cm wide. Pearl glands are absent from the leaflets. Leaflet margins are crenate to shallowly serrate. Petioles and petiolules of this species are rusty red, usually green with red spots when young, becoming entirely red when mature. The inflorescences are 5–10 cm long, rusty red turning bright pinkish red at the flowers, with a 4–7 cm long peduncle. Flowers are 5-merous 0.3–0.5 cm across and bright pinkish red in colour with white stamens (Fig. 17). Fruits are dull rusty red, ripening to black, 1–1.4 cm in diameter (Fig. 18).

This species is widely distributed, extending from India, Bangladesh, Myanmar, Thailand, Cambodia, Laos, Vietnam, and throughout Malesia to New Guinea, and North Australia, and is found in dry monsoon forests, savannahs, and secondary forests up to 500 m in altitude (Ridsdale, 1974; 1976).

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

S/No.	Accession/Bar Code No.	Herbarium	Collector	Collector's No.	Date	Locality
1.	0011279	SING	H. N. Ridley	s.n.	Apr.1893	Bukit Timah
2.	0011278	SING	H. N. Ridley	14131	1909	King's Road
3.	0018274	SING	Sidek	600	22 May 1995	Botanic Gardens, Dell
4.	0042485	SING	L. M. J. Chen	117/95	29 May 1995	Bukit Timah Nature Reserve
5.	0018272	SING	E. Tang	918	29 Aug.1995	Bukit Timah Nature Reserve, Bike Trail
6.	0018273	SING	E. Tang	918	29 Aug.1995	Bukit Timah Nature Reserve, Bike Trail
7.	0042486	SING	L. M. J. Chen	166	26 Aug.1997	Bukit Timah Nature Reserve
8.	0042487	SING	L. M. J. Chen	166	26 Aug.1997	Bukit Timah Nature Reserve
9.	0042488	SING	L. M. J. Chen	166	26 Aug.1997	Bukit Timah Nature Reserve
10.	0042489	SING	L. M. J. Chen	167	26 Aug.1997	Bukit Timah Nature Reserve
11.	0042490	SING	L. M. J. Chen	167	26 Aug.1997	Bukit Timah Nature Reserve
12.	0042491	SING	L. M. J. Chen	168	26 Aug.1997	Bukit Timah Nature Reserve
13.	0042492	SING	L. M. J. Chen	168	26 Aug.1997	Bukit Timah Nature Reserve
14.	2007004521	SINU	C. K. Yeo	223	30 Aug.2000	Between Lawns F and G, Singapore Botanic Gardens (01° 18.53' N, 103° 48.90' E)
15.	2007004522	SINU	C. K. Yeo	223	30 Aug.2000	Between Lawns F and G, Singapore Botanic Gardens (01° 18.53' N, 103° 48.90' E)
16.	2007004519	SINU	C. K. Yeo	234	8 Sep.2000	Between Lawns F and G, Singapore Botanic Gardens (01° 18.53' N, 103° 48.90' E)
17.	2007004520	SINU	C. K. Yeo	234	8 Sep.2000	Between Lawns F and G, Singapore Botanic Gardens (01° 18.53' N, 103° 48.90' E)
18.	2007004523	SINU	C. K. Yeo	318	17 Oct.2000	Between Lawns F and G, Singapore Botanic Gardens (01° 18.53' N, 103° 48.90' E)
19.	2007004524	SINU	C. K. Yeo	319	17 Oct.2000	Between Lawns F and G, Singapore Botanic Gardens (01° 18.53' N, 103° 48.90' E)





Fig. 15. Foliage of *Leea rubra*. (Photograph by: Alvin Francis Lok Siew Loon).



Fig. 16. Stipule of *Leea rubra*. (Photograph by: Alvin Francis Lok Siew Loon).



Fig. 17. The distinctive scarlet-red inflorescences and rusty-red petioles of *Leea rubra*. (Photograph by: Alvin Francis Lok Siew Loon).





Fig. 18. Infructescence of *Leea rubra* with rusty-red fruits. (Photograph by: Alvin Francis Lok Siew Loon).

## CONSERVATION

*Leea angulata*, *Leea indica*, and *Leea rubra* all grow easily from seed. The germination success of *Leea aequata* is not known as the authors were unable to obtain plants or seeds of this species. Owing to the critical conservation status of *Leea angulata* in Singapore and the possible prospect of losing the habitat locality to urban development, the ability to propagate and obtain plants in great numbers from the present small numbers is crucial and of utmost importance. Obtaining cuttings of the parent plant would enable the production of sexually mature plants faster than that sown by seed. Propagation experiments were carried out to elucidate the success rates of stem cuttings and leaf cuttings. Initial experiments were carried out on readily available *Leea indica* material followed by *Leea rubra* and *Leea angulata*. Excessive leaflets were removed from the cuttings to reduce water loss via transpiration and were subsequently planted directly into soil without any hormonal treatment. These cuttings initially displayed water stress, with leaves drooping, but all cuttings managed to root and grow after two weeks.

The second phase of the experiments involved the rooting of stem and leaf cuttings in solution, using a hydroponics system, designed by the authors. The system consisted of a water trough made from a large UPVC pipe with large holes drilled into the top for inserting cuttings. Small holes were also drilled at intervals for the insertion of aeration tubes to agitate and aerate the water in the system (Fig. 19a). This agitation and aeration ensured that the water in the hydroponics system was well oxygenated and did not remain stagnant (Fig. 19b). Rubber bungs were also installed to cover up unused openings, to minimise the possibility of mosquito breeding and to reduce the amount of debris falling into the trough that might cause fouling (Fig. 19a). This method of rooting *Leea* stem and leaf cuttings proved to be very effective, with 100% success and no lag time for plant recovery due to transpiration loss. Cuttings placed in the system showed signs of callus formation along the stems and petioles for stem and leaf cuttings respectively within 2–3 days (Figs. 20 & 21), especially at sites with lenticels, which are prominent and abundant in both *Leea indica* and *Leea rubra*. Roots from sites of callusing were observed in about a week (Figs. 22 & 23). These rooted cuttings were then removed from the system, and transferred to planting bags with soil.

During transplanting, care was taken not to damage the delicate roots, and the rooted cuttings established themselves very quickly with no casualties. New shoot growth was observed in stem cuttings after a week; rooted leaf cuttings,



however, though able to root, showed no signs of shoot formation even after a month or so (Fig. 24). This inability of *Leea* leaf cuttings to regenerate into new plants is probably due to the lack of shoot primordia in the leaves of *Leea* species. Owing to the success with *Leea indica* and *Leea rubra*, this method was employed for *Leea angulata* cuttings (Figs. 19–20, 22) and was found to achieve high success rates of rooting and establishment as well.



Fig. 19. (a) *Leea angulata* cuttings being rooted in a bubbling hydroponics system. (b) Bubbling using an air stone keeps water aerated and circulating within the system. (Photographs by: Alvin Francis Lok Siew Loon).



Fig. 20. Callus formation seen on *Leea angulata* stems just before root initiation. (Photograph by: Alvin Francis Lok Siew Loon).



Fig. 21. Callus formation seen on *Leea rubra* stems just before root initiation. (Photograph by: Alvin Francis Lok Siew Loon).





Fig. 22. Roots emerging from calluses on the stem cutting of *Leea angulata*. (Photograph by: Alvin Francis Lok Siew Loon).



Fig. 23. Roots emerging from calluses on the stem cutting of *Leea rubra*. (Photograph by: Alvin Francis Lok Siew Loon).



Fig. 24. (a) Plants regenerated from stem cuttings after a month. (b) Rooted leaf cuttings unable to regenerate shoots even after a month. (Photograph by: Alvin Francis Lok Siew Loon).



## CONCLUSIONS

The loss of two out of four of our beautiful native *Leea* species from Singapore is indeed regrettable. The dire situation of *Leea angulata* thriving in a single, unprotected locality warrants immediate action. Preservation of the last, single locality in Temenggong Road from urban development should be undertaken so as to prevent the loss of mature plants of local genotype. Reintroduction of extinct and critically endangered species into the nature reserves should also be carried out. Currently, only *Leea rubra* is known to have been planted in Bukit Timah Nature Reserve. The reintroduction of *Leea aequata*, a rare, locally extinct species, to the nature reserves in Singapore along with *Leea angulata* are recommended, so as to provide nectar and food to support native fauna, and also to increase the number of localities of *Leea angulata* in Singapore. Although currently common in the wild, conservation measures for *Leea indica* should not be overlooked as well. These plants can be cultivated in parks and urban areas for the ecological services that they provide to native fauna.

*Leea* species have much horticultural potential, such as the scarlet-red flowers and rusty-red stems of *Leea rubra*, and the unique prickly stems of *Leea angulata* which can be used along fence perimeters as a deterrent to intruders in 'defence horticulture'. These plants also provide abundant nectar and fruits year round that attract and support native fauna such as butterflies and birds. *Leea rubra*, which can survive under low light-flux, also has potential to be grown as an indoor ornamental plant (Sarracino et al., 1992a, 1992b).

## ACKNOWLEDGEMENTS

We would like to express our gratitude to the National Parks Board (NParks) for granting us permits for collection in the Nature Reserves and also for access to the collections of the Herbarium, Singapore Botanic Gardens (SING), Mr. Chua Keng Soon of the Herbarium, Raffles Museum of Biodiversity Research, National University of Singapore (SINU) for facilitating access to the collections, John X. Q. Lee for identification of the wasp seen visiting *Leea indica* flowers, Christian Puff for generously providing photos of *Leea aequata* and Chan Wei Luen for providing the photo of the straw-headed bulbul eating *Leea indica* fruits.

## LITERATURE CITED

- Angiosperm Phylogeny Group (APG), 2003. An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG II. *Botanical Journal of the Linnean Society* **141**(4): 399–436.
- Keng, H., 1990. *The Concise Flora of Singapore: Gymnosperms and Dicotyledons*. Singapore University Press, Singapore. 222 pp.
- Ridsdale, C. E., 1974. A revision of the family Leeaceae. *Blumea* **22**(1): 57–100.
- Ridsdale, C. E., 1976. Leeaceae. *Flora Malesiana, Series I*, **7**: 775–782.
- Sarracino, J. M., R. Merritt & C. K. Chin, 1992a. Morphological and physiological characteristics of *Leea coccinia* and *Leea rubra* in response to light-flux. *HortScience* **27**(5): 400–403.
- Sarracino, J. M., R. Merritt & C. K. Chin, 1992b. Light acclimatization potential of *Leea coccinia* and *Leea rubra* grown under low light-flux. *HortScience* **27**(5): 404–406.
- Stevens, P. F., 2001 onwards. *Angiosperm Phylogeny Website. Version 9, June 2008* [and more or less continuously updated since]. <http://www.mobot.org/MOBOT/research/APweb/>. (Accessed on 31 Dec.2009).
- H. T. W. Tan, K.-x. Tan, A. Ibrahim, P. T. Chew, K. S. Chua, H. Duistermaat, S. K. Ganesan, M. W. K. Goh, A. T. Gwee, R. Kiew, S. M. L. Lee, P. Leong, J. Lim, A. F. S. L. Lok, A. H. B. Loo, S. K. Y. Lum, T. Morgany, S. Suran, S. Sim, H. S. Haji Ahmad, Y. C. Wee, K. F. Yap, C. K. Yeo, & J. W. H. Yong, 2008. Checklists of Threatened Species — Seed Plants. In: Davison, G. W. H., P. K. L. Ng & H. C. Ho (eds.), *The Singapore Red Data Book. 2nd Edition*. The Nature Society (Singapore), Singapore. Pp. 213–244.
- Wen, J., 2007. Leeaceae. In: Kubitzki, K. (ed.), *The Families and Genera of Vascular Plants, Volume IX: Flowering Plants, Eudicots (Berberidopsidales, Buxales, Crossosomatales, Fabales p.p., Geraniales, Gunnerales, Myrtales p.p., Proteales, Saxifragales, Vitales, Zygophyllales, Clusiaceae Alliance, Passifloraceae Alliance, Dilleniaceae, Huaceae, Picramniaceae, Sabiaceae)*. Springer, Berlin Heidelberg. Pp. 221–225.