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An annotated list of new records for Singapore: results from large-scale tree surveys at the Bukit Timah Nature Reserve

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ABSTRACT. We report new records for Singapore of 16 tree species discovered between 1993 and 2008 during large-scale surveys of Bukit Timah Nature Reserve. These species are: *Aglaia crassinervia* Kurz ex Hiern (Meliaceae), *Alphonsea johorensis* J.Sinclair (Annonaceae), *Dacryodes nervosa* (H.J.Lam) Leenh. (Burseraceae), *Dehaasia cuneata* (Blume) Blume (Lauraceae), *Drypetes* crassipes Pax & K.Hoffm. (Putranjivaceae), *Dysoxylum grande* Hiern (Meliaceae), *Endiandra maingayi* Hook.f. (Lauraceae), *Gluta malayana* (Corner) Ding Hou (Anacardiaceae), *Hopea ferruginea* Parijs (Dipterocarpaceae), *Lepisanthes fruticosa* (Roxb.) Leenh. (Sapindaceae), *Mangifera gracilipes* Hook.f. (Anacardiaceae), *Neoscortechinia philippinensis* (Merr.) Welzen (Euphorbiaceae), *Palaquium impressionervium* Ng (Sapotaceae), *Sindora echinocalyx* Prain (Fabaceae), *Terminalia citrina* (Gaertn.) Roxb. (Combretaceae) and *Vatica odorata* (Griff.) Symington subsp. *odorata* (Dipterocarpaceae). Voucher specimens have been deposited in SING.

Keywords. Anacardiaceae, Annonaceae, Burseraceae, Combretaceae, Dipterocarpaceae, Euphorbiaceae, Fabaceae, Lauraceae, Meliaceae, Putranjivaceae, Sapindaceae, Sapotaceae

Introduction

Botanical collection in Singapore has been the most intensive in Tropical East Asia, given the relatively small size of the island nation (Niissalo et al., 2014). Since British colonisation of Singapore in 1819, numerous botanists and ecologists have made collections from Singapore and deposited hundreds of thousands of plant specimens in various herbaria. More than 4000 species of vascular plants are known to occur or be cultivated in Singapore (Chong et al., 2009) of which 2141 are considered native (Chong et al., 2011). However, fertile specimens are typically preferred in botanical collections and collecting efforts tend to be biased towards more accessible areas, e.g. along trails. Given that most tree species are not in flower most of the time and that most trees are not adjacent to trails, it is therefore not surprising that many forest tree

species may still remain undiscovered in Singapore, despite their large sizes and the small forest fragments of Singapore.

Here we document 16 species of trees that are new records for Singapore. These were found during botanical surveys conducted deep within the Bukit Timah Nature Reserve (BTNR) from 1993 to 2008. The 164-ha BTNR contains the largest contiguous patch of primary forest in Singapore, which few have accessed because of the steep topography. The botanical surveys were collaborative efforts between the Center for Tropical Forest Science - Arnold Arboretum (CTFS-AA) Asia Program, the National Institute of Education - Nanyang Technological University (NIE-NTU), and the National Parks Board to understand the forest dynamics of BTNR, and as part of a global network of Forest Dynamics Plots set up by the Smithsonian Tropical Research Institute. The BTNR plots were initiated in 1993 with a 2-ha plot within the primary forest along the Catchment Path ('Primary Plot') and followed in 2004 by a 2-ha plot in the adjacent secondary forest ('Secondary Plot'). All trees larger than 1 cm in diameter at breast height (dbh) were measured, mapped, identified and tagged. From 2005–2008, the work extended to the entire BTNR, where all trees larger than 30 cm dbh were surveyed ('Bukit Timah Big Trees Survey', henceforth BTBT).

At the end of 2008, from the 2003 census of the Primary Plot, the 2004 census of the Secondary Plot and the 2005–2008 BTBT, we recorded a total of 671 tree species from just over 28,000 tree individuals. Of these we identified 18 species that were, to the best of our knowledge, not previously known to occur naturally in Singapore, although some were overlooked new records and mis-identifications. Due to the infrequent flowering nature of West Malesian tropical rain forest trees, many of these identifications were based on sterile specimens, albeit after making careful reference to published Floras and herbarium specimens. Two of the 18 species, *Cryptocarya nitens* (Blume) Koord. & Valeton and *Lophopetalum pallidum* M.A.Lawson, have since been published by De Kok (2015) and Ganesan (2009) respectively. Here we present the other 16 new records of tree species, with justifications for our determination. Notes on reproductive and population status were also presented wherever applicable. Voucher specimens have been deposited at the Herbarium of the Singapore Botanic Gardens (SING). Do note that some of our specimen collection numbers include the year of collection as part of the number, while some do not.

In addition to a comparison of the material with specimens in the SING herbarium, they have also been compared to type material online via JSTOR (https://plants.jstor.org/plants, accessed in January 2018) when necessary.

New records

1. *Aglaia crassinervia* Kurz ex Hiern (Meliaceae)

Sterile specimens were matched to *Mhd Nur 34278* (SING [SING0141381]) from Peninsular Malaysia. Following *Flora Malesiana* (Pannell, 1995) and the description in *Tree Flora of Malaya* (Mabberley & Pannell, 1989, under "Aglaia sp. 6") this

species is distinguished by twigs, petioles, rachises and petiolules that are covered by pale peltate scales. The scales have fimbriate margins and the peltate scales are also scattered over the undersurface of the leaves. *Aglaia crassinervia* can be distinguished from *Aglaia sexipetala* Griff. by the numerous dense brown stellate scales on the lower surfaces of the leaflets in the latter species (Mabberley & Pannell, 1989; Pannell, 1995, under "Aglaia sp. 5"). An individual tree (*Khoo KMS 100* (SING)) was recorded as a 2008 recruit in the Primary Plot and was initially thought to be the offspring of a nearby *Dysoxylum densiflorum* (Blume) Miq. It was only in the BTBT that a large tree of *Aglaia crassinervia* was included in the survey and correctly identified (*Khoo KMS 36* (SING)).

Specimens examined. SINGAPORE: **Bukit Timah Nature Reserve:** 11 Dec 2008, *Khoo KMS 36* (SING [SING0137253]); ibid., 9 Jun 2009, *Khoo KMS 100* (SING [SING0145736]).

2. *Alphonsea johorensis* J.Sinclair (Annonaceae)

This is an overlooked record for Singapore as it has been collected several times previously but never recorded for Singapore before. The sterile specimen *Khoo KMS 21* (SING) was matched to the holotype specimen *Kiah SF32139* (SING [SING0048651]) from Johor in Peninsular Malaysia, *Sinclair 40024* (SING [SING0042168]) from Mandai Rd, and *Sinclair 39666* (SING [SING0042169]) from Bukit Timah. We recorded more than a dozen small trees along the Catchment Path, in both the Primary and Secondary Plots. Its black twigs, once peeled, release a strong smell of the isotonic drink '100 Plus'. The leaves are elliptic with *Xylopia*-like boxy reticulation and are glabrescent. It differs from the one other local species in this genus, *Alphonsea maingayi* Hook.f. & Thomson, which is rusty-pubescent on the midrib below.

Specimen examined. SINGAPORE: **Bukit Timah Nature Reserve:** 26 Jun 2008, *Khoo KMS 21* (SING [SING0123457]).

3. *Dacryodes nervosa* (H.J.Lam) Leenh. (Burseraceae)

The sterile specimens *Khoo KMS 28* (SING) and *Khoo KMS 63* (SING) were matched to the descriptions in the *Tree Flora of Malaya* (Kochummen, 1972) and the specimen *Muas 13389* (SING [SING0238500]) from Sarawak. It is the only *Dacryodes* Vahl species with stellate hairs and hence very distinct from the other local *Dacryodes* spp. We recorded only two trees in BTBT and have yet to discover any smaller individuals. We also observed horn-like galls of Psyllidae lice (cf. *Creiis* sp., ZRC.6.21652) in many leaves which could be specific to this plant.

Specimens examined. SINGAPORE: **Bukit Timah Nature Reserve:** 5 Dec 2008, *Khoo KMS 28* (SING [SING0137242]); ibid., 30 Jan 2009, *Khoo KMS 63* (SING [SING0137243]).

4. *Dehaasia cuneata* (Blume) Blume (Lauraceae)

The sterile specimen *Khoo KMS 47* (SING) was matched to the type specimen *Blume s.n.* (L [L0036313]), as well as to *Ridley s.n.* (SING [SING0222800]) from Perak. The distinctive characteristic is the terminal bud covered with golden silky hairy bud scales, and obovate leaves that dry purplish-black with contrasting black petiole and white twigs (Kochummen, 1989b). The secondary veins are raised above. These differ from the one other native species, *Dehaasia incrassata* (Jack) Kosterm., which has whitish twigs but whose leaves are elliptic, dry greenish and the secondary veins are sunken above. *Dehaasia incrassata* also differs in the glabrous terminal bud that dries black. We recorded only one individual in the BTBT by the very edge of the Singapore Quarry, but also encountered a 30 cm dbh tree in McRitchie near Plot 19 of Wong et al. (1994) during the NParks Tree Flora Survey (Chew P.T., unpublished data).

Specimen examined. SINGAPORE: **Bukit Timah Nature Reserve:** 19 Dec 2008, *Khoo KMS 47* (SING [SING0123470]).

5. *Drypetes crassipes* Pax & K.Hoffm. (Putranjivaceae)

The sterile specimen *Faizu NF 5* (SING) was matched to SING collections from Sarawak, namely *Pickles SAR2919* (SING [SING0238499]) and *Ilias S.16981* (SING [SING0238498]), and also to *Ridley 6068* (SING [SING0110189]) which was previously determined as *'Drypetes longifolia*, but midrib raised above'. The leaves are glabrous, thick leathery and dry dull grey-green with petioles that are 2–3 mm long. The midrib below darkens from the leaf tip to the petiole, while the twig is paler. The leaf tips tend to fold. We recorded only one 23 cm dbh tree in the Primary Plot, the species identity of which was not determined in previous censuses (BT 586 = *Drypetes* aff. *curtisii* (Hook.f.) Pax & K.Hoffm., LaFrankie et al., 2005). Since the tree was located at the northern edge of the plot, we expect more conspecifics to be found in the nearby PUB catchment area just outside the Primary Plot.

Specimen examined. SINGAPORE: **Bukit Timah Nature Reserve:** 22 Jan 2008, *Faizu NF 5* (SING [SING0123563]).

6. *Dysoxylum grande* Hiern (Meliaceae)

The sterile specimen *Khoo KMS 18* (SING) was matched to *Whitmore FRI 20238* (SING [SING 0178503]) and also to *Abu Kassim 1486* (SINU), collected from MacRitchie. The distinctive characteristics are the yellowish velutinous twigs and leaflets that are brown-yellowish tomentose below and on the midrib above. It also has more leaflets, each with more veins than *Dysoxylum excelsum* Blume, which may also be pubescent below. The collections from BTNR are notably much hairier than those

from Peninsular Malaysia. We recorded five trees in BTBT, of which one beautiful individual can be found next to the South View Path boardwalk.

Specimen examined. SINGAPORE: **Bukit Timah Nature Reserve:** 25 May 2007, *Khoo KMS 18* (SING [SING0137258]).

7. *Endiandra maingayi* Hook.f. (Lauraceae)

This is an overlooked record for Singapore as a sterile specimen was collected from BTNR in 1971 but was not determined (*Ming 268* (SING [SING 0074135]). This and our sterile specimen *Khoo KMS 40* (SING) were also matched to *Corner 26196* (SING [SING0042461]), which was collected from Jurong in 1933, as well as to the type specimen *Maingay 2456* (K [K000009823]) collected from Malacca, Malaysia, in 1867. Leaves of *Endiandra maingayi* are simple, alternate, elliptic-lanceolate, coriaceous and dry an ochre colour with dark petioles. Both leaf surfaces have minute areoles on both surfaces with very faint secondary veins. No other native species of *Endiandra* R.Br. has been recorded in Singapore. We found eight trees in the BTBT, located mostly in the valleys.

Specimen examined. SINGAPORE: **Bukit Timah Nature Reserve:** 12 Dec 2008, *Khoo KMS 40* (SING [SING0123471]).

8. *Gluta malayana* (Corner) Ding Hou (Anacardiaceae)

The sterile specimen *Khoo KMS 2009-59* (SING) was matched to several fertile collections from Peninsular Malaysia, such as *Corner s.n.* (SING [SING0222802]) from Johor, Malaysia and *Henderson 10729* (SING [SING0222803]) from Pahang, Malaysia. The leaves are obovate, sessile (petiole <3 mm), hairy on veins, and dark purplish brown when dry. These characters distinguish *Gluta malayana* from the one other native species in Singapore, *Gluta wallichii* (Hook.f.) Ding Hou, which has smaller leaves with petioles that are 2–6 cm long. We observed three trees in BTNR, of which two were tagged in the BTBT. None of the trees flowered in the study period and no seedlings were found in the vicinity.

Specimen examined. SINGAPORE: **Bukit Timah Nature Reserve:** 22 Jan 2009, *Khoo KMS 2009-59* (SING [SING124454]).

9. *Hopea ferruginea* Parijs (Dipterocarpaceae)

A medium-sized tree with flaky bark and stilt roots. Leaves from *Khoo KMS 27* (SING) were matched to *Ganesan SKG 119* (SING [SING094721]). The thin leathery leaves are ovate to lanceolate, with the petioles and midribs above covered with fine greyish

pubescence. These characters distinguish it from the other two local species *Hopea mengarawan* Miq., whose coriaceous leaves dry golden brown, and *H. griffithii* Kurz, whose leaves dry purplish brown above and yellow brown below. Fruits were collected near NParks' Bukit Kallang office during the 2005 masting but it remained unreported in the literature. We recorded three trees in BTBT and observed flowering in two of those trees in May 2009 (*Khoo KMS 90* (SING)). However, no smaller individuals were seen in BTNR whereas the Bukit Kallang population encompassed adult trees to seedlings.

Specimens examined. SINGAPORE: **Bukit Timah Nature Reserve:** 5 Dec 2008, *Khoo KMS 27* (SING [SING0137273]); ibid., 27 May 2009, *Khoo KMS 90* (SING [SING0137274]).

10. *Lepisanthes fruticosa* (Roxb.) Leenh. (Sapindaceae)

This species is distinguished by its glabrous rachis, persistent pseudostipules (lower pair of leaflets) and coriaceous leaflets (Adema et al., 1994). The leaves are paripinnate and, compared to the other two local species, have more leaflets than *Lepisanthes senegalensis* (Juss. ex Poir.) Leenh. and is glabrous while *L. rubiginosa* (Roxb.) Leenh. has a woolly rachis. The sterile specimen *Faizu NF 4* (SING [SING0137248]) was matched to many vouchers in the SING herbarium (*e.g. Corner SFN 32230* (SING [SING 0188353])). Previously collected from Mandai Road and correctly determined (*Kiah s.n.* (SING [SING 0110191])) but apparently overlooked for publication. All three trees recorded in the Primary Plot were previously mistaken as *Lansium domesticum* Corrêa (BT 101, 103, 104, LaFrankie et al., 2005).

Specimen examined. SINGAPORE: **Bukit Timah Nature Reserve:** 14 Jan 2008, *Faizu NF 4* (SING [SING0137248]).

11. *Mangifera gracilipes* Hook.f. (Anacardiaceae)

Leaf specimens, collected from a single tree in Fern Valley during the BTBT, were matched to *HAR 016602* collected from Kuantan, Malaysia in 1920 and to the type collection *Maingay 1454* (K [K000695129]). The Singapore tree also concurred with the description in the *Tree Flora of Malaya* (Kochummen, 1989a) in its leaves small (<10 cm), petiole slender, midrib raised above and drying yellow below, and secondary and tertiary veins inconspicuous. This species has a smaller average leaf size than most of the other local *Mangifera* L. spp., except *M. paludosa* Kosterm., which has a blunt leaf tip, and *M. parvifolia* Boerl. & Koord., which has distinct reticulations on both leaf surfaces. Flowering specimens, collected in Jan 2009, were the first to be deposited in SING (*Khoo KMS 2009-58* (SING)). However, we did not find any fruit when the tree was revisited in April 2009, nor did we observe any seedlings or saplings.

Specimen examined. SINGAPORE: **Bukit Timah Nature Reserve:** 22 Jan 2009, *Khoo KMS 2009-58* (SING [SING0137247]).

12. *Neoscortechinia philippinensis* (Merr.) Welzen (Euphorbiaceae)

The sterile specimen *Khoo KMS 24* (SING) was determined using Van Welzen (1994) and was matched to *Corner 29250* (SING [SING0222801]) collected from Johor, Malaysia as well as a type specimen *Elmer 21078* (MO [MO260259]). It differs from the more common *Neoscortechinia kingii* (Hook.f.) Pax & K.Hoffm. mainly by having more serrated leaf margins, lighter-coloured dried leaves, and has two glands at the base of the upper leaf surface. All three individuals we recorded in the BTBT were found in Fern Valley. This specimen was previously wrongly identified as *Neoscortechinia forbesii* (Hook.f.) S.Moore, as mentioned by Ang et al. (2010).

Specimen examined. SINGAPORE: **Bukit Timah Nature Reserve:** 4 Dec 2008, *Khoo KMS 24* (SING [SING0123538]).

13. *Palaquium impressionervium* Ng (Sapotaceae)

The leaves are glabrous with the midrib above sunken into a very narrow grove. The clear distinction from the other local *Palaquium* Blanco spp. is the conspicuously impressed secondary and reticulate tertiary veins above when dried (Ng, 1969). The secondary veins also form faint intramarginal veins that distinguish it from *Palaquium ridleyi* King & Gamble, which has sunken tertiary veins above and beneath. BTBT no. 70, at the boardwalk of South View Path (*Khoo KMS 19* (SING)), was matched to the holotype *Haniff and Nur SFN2726* (KEP [KEP181369]). A previous mis-identification includes *Ali H. s.n.* (SING [SING0037622]), which was collected in BTNR in 1974 and determined as *Palaquium* cf. *rostratum* (Miq.) Burck. The population in BTNR appeared to be healthy with more than 70 individuals of various size classes recorded. However, we did not observe any flowering or fruiting during the study period, which included the mast year 2005.

Specimen examined. SINGAPORE: **Bukit Timah Nature Reserve:** 25 May 2007, *Khoo KMS 19* (SING [SING0137290]).

14. *Sindora echinocalyx* Prain (Fabaceae)

Sterile specimens *Khoo KMS 16* (SING) and *Khoo KMS 65* (SING) were determined as this species based on the characters highlighted in the *Tree Flora of Malaya* (Whitmore, 1972) of reticulations prominent on both surfaces of the leaflets (as opposed to *Sindora wallichii* Benth., where reticulations are not visible on the upper surface of the leaflets) and thinly velvety below, in juveniles as well as adults (as opposed to *Sindora coriacea* (Baker) Prain, which has glabrous leaflets). The spiny round pods also distinguish *Sindora echinocalyx* from *S. coriacea,* which has smooth pods.

Specimens examined. SINGAPORE: **Bukit Timah Nature Reserve:** 12 Oct 2006, *Khoo KMS 16* (SING [SING0123508]); ibid., 30 Jan 2009, *Khoo KMS 65* (SING [SING0123509]).

15. *Terminalia citrina* (Gaertn.) Roxb. (Combretaceae)

Leaves and fruits of *Khoo KMS 54* (SING) were matched to two specimens of *King's Collection 3173* (SING [SING055418], K [K000786159]). Opposite or subopposite leaves with glands on the petiole near the leaf base distinguish this species from the other local *Terminalia* L. spp. However, the glands may not always occur in every leaf, which was the main reason why we erronously matched some earlier, glandless leaves to *Lophopetalum floribundum* Wight. We recorded four enormous individuals (54–91 cm dbh) in the BTBT but not a single small tree. Fruiting was observed for a tree (BTBT no. 3972) in Feb 2007 and Dec 2008 – Jan 2009. However, all but one seed collected in Jan 2009 failed to germinate (S. Teo, pers. comm.).

Specimen examined. SINGAPORE: **Bukit Timah Nature Reserve:** 8 Jan 2009, *Khoo KMS 54* (SING [SING0123496]).

16. *Vatica odorata* (Griff.) Symington subsp. ***odorata*** (Dipterocarpaceae)

The leaves are penni-veined and the main veins are lighter-coloured. Flowers are bright yellow with a velvety light-brown calyx. The sterile specimens *Khoo KMS 29* (SING) and *Khoo KMS 30* (SING) were matched to *Shah MS 3927* (SING [SING0000813]) collected from MacRitchie in 1976, and which was previously determined as *Vatica nitens* King, and redetermined to *V. odorata* by Newman in 1998. Fertile specimens collected in 2009, namely *Khoo KMS 80* (SING), *Khoo KMS 92* (SING) and *Khoo KMS 103* (SING), confirmed the initial determination. We recorded two mature individuals in BTBT and also observed trees along the MacRitchie Nature Trail and at Bukit Kallang.

Specimens examined. SINGAPORE: **Bukit Timah Nature Reserve:** 5 Dec 2008, *Khoo KMS 29* (SING [SING0137282]); ibid., 5 Dec 2008, *Khoo KMS 30* (SING [SING0137283]), 5 Dec 2008, *Khoo KMS 80* (SING [SING0137284]); ibid., 8 Jun 2009, *Khoo KMS 92* (SING [SING0145336]); ibid., 8 Jun 2009, *Khoo KMS 103* (SING [SING0145344]).

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