Conservation status of *Paraboea* species (Gesneriaceae) in Malaysia

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ABSTRACT. *Paraboea* (including *Trisepalum*) is represented by 36 species in Malaysia and displays a high level of endemism (80%) and 31 of its species are restricted to limestone habitats. Two species are endemic in Sabah, of the 11 species in Sarawak 10 are endemic, and in Peninsular Malaysia 16 of the 24 species are endemic. *Paraboea culminicola* K.G.Pearce and *P. obovata* Ridl. are reinstated as distinct species and *P. madaiensis* Z.R.Xu & B.L.Burtt is reduced to synonomy in *P. sabahensis* Z.R.Xu & B.L.Burtt. Based on information from the Taxon Data Information Sheet, 15 species fall within the IUCN Category of Least Concern, four as Near Threatened, three as Vulnerable, eight as Endangered, four as Critically Endangered, and three as Data Deficient. None is Extinct. Most of the endangered species (94%) grow in Peninsular Malaysia on limestone hills that do not lie within the network of Totally Protected Areas and which are threatened by burning, quarrying and habitat destruction or disturbance, from resort development or recreation or temple activities. Assignment of conservation status is the first step in planning conservation management of endangered species, through advocating legal protection of a network of limestone hills, particularly those where critically endangered species grow (e.g., Tambun Hot Springs, Perak and the Lambok hills, Kelantan), monitoring populations of Critically Endangered species, taking steps towards resolving the status of the poorly known Data Deficient species, and the establishment of endangered species *ex situ*.

Keywords. Conservation, Gesneriaceae, Malaysia, *Paraboea*

Introduction

In Malaysia, *Paraboea* (including *Trisepalum*) is a genus predominantly of obligate limestone species with only five of the 36 species growing on other rock types, either on soils derived from quartz (*P. elegans*), sandstone (*P. obovata*), igneous rocks (*P. leopoldii*) and apparently from granite (the poorly known *P. deterigibus* and *P. paraprimulina* from Sarawak). *Trisepalum speciosum* (Ridl.) B.L.Burtt is here included because molecular work by Moeller et al. (2009) shows that it belongs in *Paraboea*.

Limestone in Malaysia is mostly of the tower karst type with a few raised coral islands in Sabah (Lim & Kiew 1997). Although limestone occupies only a very small fraction of the land area, it harbours disproportionate biodiversity, for example, in Peninsular Malaysia almost 14% of the seed plant flora grows on limestone that covers only 0.3% of the land surface (Chin 1977). There are more than 550 limestone karst hills in Malaysia, the majority being found in Peninsular Malaysia. Sabah and Sarawak

have about 60 each where in Sabah most are clustered along the Sungai Kinabatangan (Lim & Kiew 1997). In Sarawak, the largest number is found in the Kuching Division and the highest karst hills in Malaysia, the massive Gunung Api and Gunung Benarat towering to 1700 m, are in the Gunung Mulu National Park (NP) (Kiew 2004). In Peninsular Malaysia, the largest number of limestone hills occur in Kelantan (about 70 are named but there are many more small outcrops), followed by Perak with about 45 named hills. Of particular importance is the limestone in Langkawi, both on the main island and about 17 islands that have been visited botanically. A few other scattered hills occur in Kedah, Pahang, Perlis, Selangor and Terengganu.

In common with other obligate limestone species, such as balsams, begonias and microchiritas, many of the species are narrow endemics that make them especially vulnerable to habitat disturbance (Kiew 1991, 2001) and the flora of these isolated limestone tower karsts are vulnerable to a variety of threats. Quarrying for cement, road metal and marble is often considered the most severe threat but, in terms of damage to the flora, the removal of the surrounding forest causes greater damage (Kiew 1997) because the vegetation of the limestone hills become vulnerable to burning associated with agricultural practices in the surrounding areas. In Sabah, secondary and logged-over forests are also prone to burning in the El Niño years (Kiew 2001). With increasing mobility, tourist and recreational activities associated with caving or rock climbing are becoming a threat and in Peninsular Malaysia construction of temples in caves and in Sabah the collecting of birds' nests from caves (Kiew 1997) all contribute to endanger the flora. Protection of the tower karst ecosystem is only assured when they fall within national or state parks or geoparks. Forest reserves offer protection provided their status does not change. However, many limestone hills are on state land and are unprotected. For these reasons, the limestone ecosystem has long been identified as one of the most endangered ecosystems in Malaysia (Davis et al. 1995a, 1995b; Saw et al. 2009; Chua et al. 2009).

The conservation status of *Paraboea* is a good indicator of the general state of conservation of the limestone flora, because its species are found on almost every limestone hill. Preliminary conservation assessments were provided in the monograph on *Paraboea* by Xu et al. (2008), who noted that the assessments would need to be revised once more accurate data were available. 'Ground truthing' is especially important in assessing the threats to the flora of limestone hills because local destructive activities have a disproportionate impact on these relatively small limestone hills and the often narrow distributions of plant species. Local knowledge largely accounts for differences between the categories assigned here compared with those of Xu et al. (2008).

Endemism and distribution

Endemism is extremely high in *Paraboea*. There are no species in common among Peninsular Malaysia, Sarawak and Sabah. The majority (23 species) of the 36

Malaysian *Paraboea* species occur in Peninsular Malaysia, with 11 species in Sarawak and two species in Sabah and within each of these areas, many species are restricted to one hill or a group of adjacent hills. Of the 23 Peninsular Malaysian species, five species extend into Peninsular Thailand that shares the same climate and topography (the political boundary cutting through a floristic zone) and two are also recorded from Sumatra (Xu et al. 2008).

Paraboea is poorly represented in Sabah. *Paraboea leopoldii* is known only from Bodgaya Island (Wong et al., 1999) while *P. sabahensis* (Fig. 3C) is more widespread. In Sarawak, paraboeas cluster in three limestone areas: Gunung Mulu NP is the most biodiverse with six species (*P. apiensis*, *P. bayengiana*, *P. candissima*, *P. clarkei*, *P. effusa* and *P. meiophylla*), two (*P. speluncarum* and *P. culminicola*, Fig. 2C) on Gunung Subis with the latter species also known from Bukit Sarang with two (*P. clarkei* and *P. havilandii*) on the many limestone hills in the Kuching Division (Kiew et al. 2004). Only *P. clarkei* (Fig. 1C) occurs on limestone in both the Kuching Division and the Gunung Mulu NP. The two non-limestone species (*P. deterigibilis* and *P. paraprimuloides*) are poorly known and are as yet each known from a single locality (See Appendix A).

In Peninsular Malaysia, the two non-limestone species are *P. obovata* that grows on sandstone in Langkawi and *P. elegans* (Fig. 2B) that grows on quartzite in Kedah, Kelantan and Selangor. The limestone species are grouped within three main phytogeographical zones. The northern floristic zone is most biodiverse with 10 species. Most are found in Langkawi and associated islands (*P. acutifolia*, *P. divaricata*, *P. ferruginea*, *P. lanata*, *P. laxa*, *P. regularis* and *P. suffruticosa*) with a few in Perlis (*P. gracillima*) or on both Langkawi and in Perlis (*P. bintangensis* and *Trisepalum speciosum*, Fig. 3B). Of these, four also occur in Peninsular Thailand.

The west coast zone (mainland Kedah, Perak and Selangor) is home to six species (*P. caerulescens* (Fig. 2A), *P. capitata* (both varieties), *P. paniculata*, *P. parviflora*, *P. verticillata* and *P. vulpina*), of which one also occurs in Sumatra. All six occur in Perak with *P. paniculata* spreading to Selangor and *P. verticillata* distributed from Selangor north to Kedah.

The central and northern zone (Kelantan, Terengganu and Pahang) is home to six species and one variety (*P. bakeri* (Fig. 1A), *P. brachycarpa* (Fig. 1B), *P. capitata* var. *oblongifolia*, *P. lambokensis* (Fig. 3A), *P. nervosissima*, *P. treubii* and *P. vulpina*), of which one species is also found in Sumatra. Only *P. capitata* var. *oblongifolia* and *P. vulpina* occur on both sides of the Main Range, i.e., in both the west coast and in the central and northern zones.

Three species, *P. gracillima*, *P. obovata* and *P. regularis* are known from a single hill and a further seven from less than five hills (*P. bakeri* (Fig. 1A), *P. bintangensis*, *P. divaricata*, *P. elegans* (Fig. 1B), *P. lambokensis* (Fig. 3A), *P. vulpina* and *P. parviflora*).

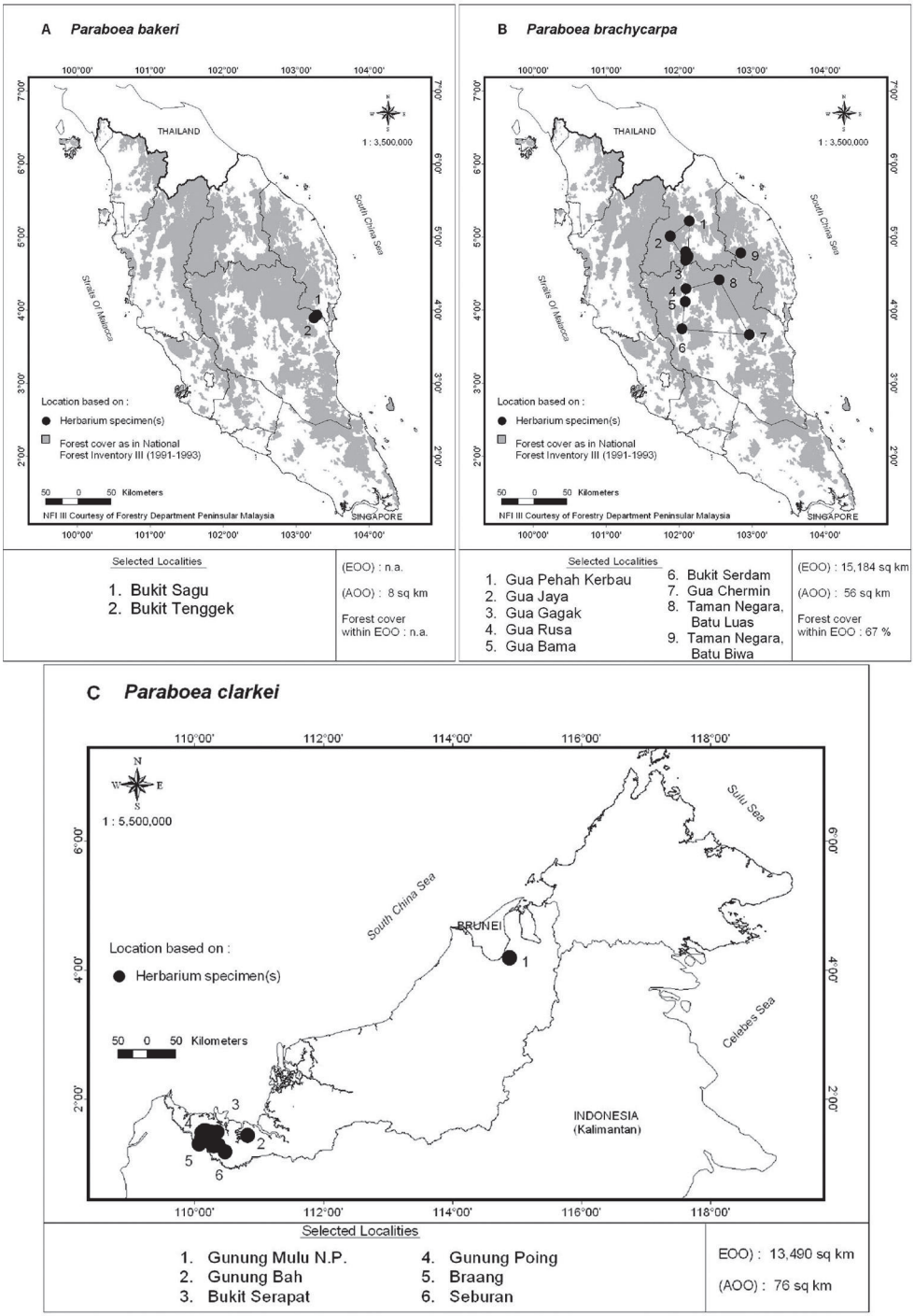

Fig. 1. Distribution of *Paraboea bakeri*, *P. brachycarpa* and *P. clarkei* in Malaysia. EOO = extent of occurrence and AOO = area of occupancy.

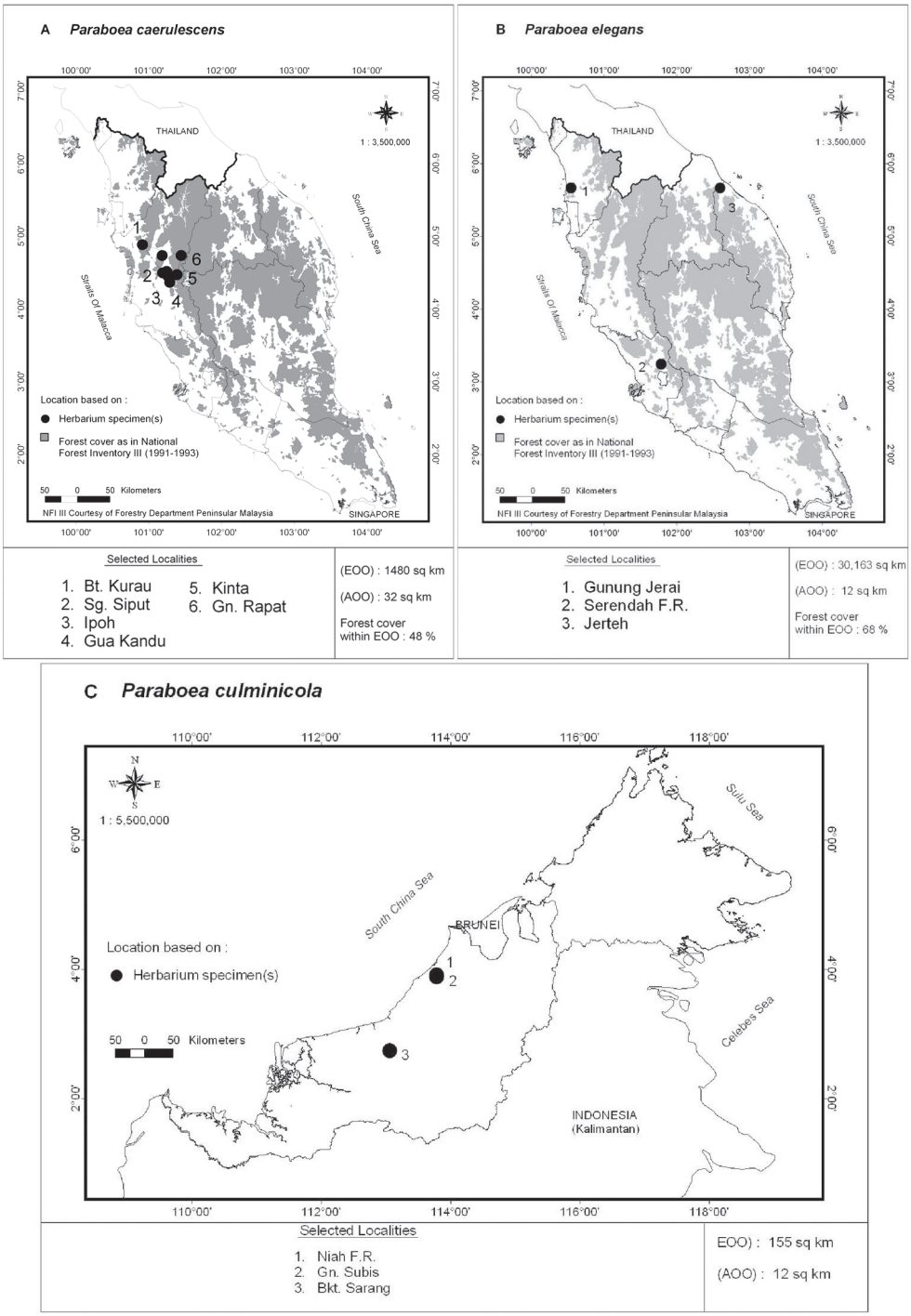

Fig. 2. Distribution of *Paraboea caerulescens*, *P. elegans* and *P. culminicola* in Malaysia. EOO = extent of occurrence and AOO = area of occupancy.

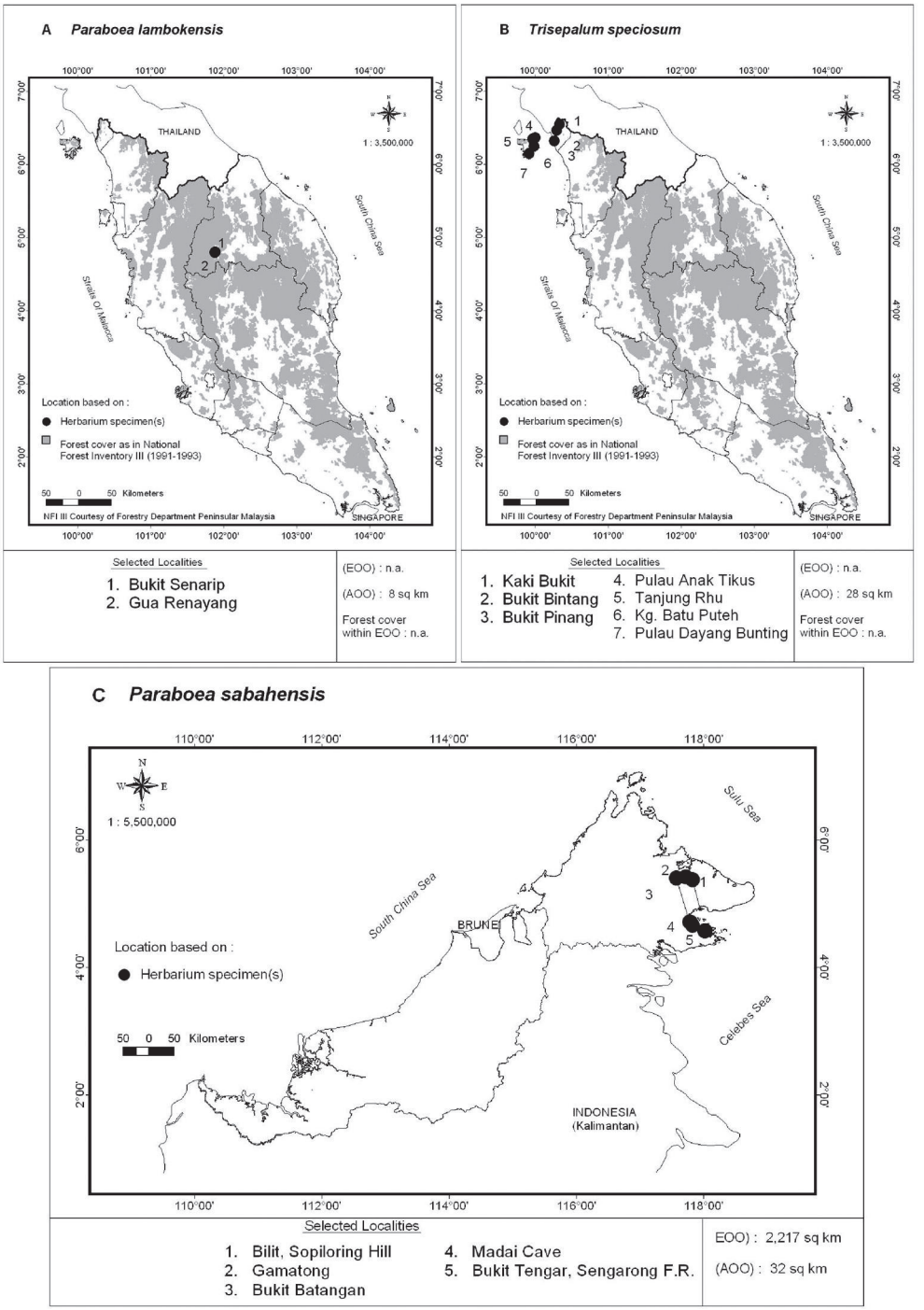

Fig. 3. Distribution of *Paraboea lambokensis*, *Trisepalum speciosum* and *Paraboea sabahensis* in Malaysia. EOO = extent of occurrence and AOO = area of occupancy.

Conservation status

To assess the conservation status of each taxon, the Taxon Data Information Sheet (TDIS) is completed to provide the baseline data for the assessment (Chua & Saw 2006). This includes taxonomic information, habitat and distribution, mapping of the extent of occurrence (EOO) and area of occupancy (AOO), legal protection status, threats and population decline, current conservation measures, utilisation, and finally the Red List category and criteria based on the IUCN Red List Categories & Criteria, Version 3.1, 2001 (hppt://www.iucn.org/) including the arguments for listing. For these *Paraboea* species, data are based on the literature, herbarium specimens and field work over a 30-year period. The information in the TDIS is then discussed with one of the national assessors before it is accepted. The conservation status applies to the situation in Malaysia, i.e., it is a regional conservation status except for endemic species, where it becomes the global status.

The most commonly used criteria are geographic distribution, limited number of populations, protection status and population decline. For the last criterion, ground truthing is essential. In a few cases an entire hill has been given over for quarrying, e.g., Gunung Pondok (Perak) and Bukit Sagu (Pahang), are currently being quarried and eventually will be razed to the ground. In most cases, only part of a hill is affected by quarrying. In other cases, where the hills are on stateland, burning associated with agricultural practices poses the major threat. This affects *Paraboea* species differently depending on their niche requirements.

There are basically two groups of paraboeas in Malaysia, the ones with erect stems, whorled decurrent leaves that are often covered in silvery indumentum, and have purple flowers and twisted fruits; compared with the other group that are rosette plants, with opposite petiolate leaves, white or pinkish flowers and straight fruits. The former group grows in full sun on sheer vertical rock faces above the tree canopy or on jagged summits. They are relatively resilient to disturbance because they may be positioned above the burning of the surrounding vegetation and because their seeds can invade bare rockfaces. In addition, they often occur in large numbers. The latter group, in contrast, in most cases (*P. laxa* is an exception) are species that grow at the base of the hill below the tree canopy on damp shaded rocks or rock faces, where they are found as small local populations. These species are particularly vulnerable to all types of disturbance. Because paraboeas occupy these different microhabitats, it is common to find two species occurring on the same hill, for example, in the Kuching limestone *P. havilandii* grows exposed on the summits and *P. clarkei* in damp shaded habitats below the canopy.

No Malaysian species is extinct but 40% (VU, EN and CR species) are endangered, with most (93%) of these occurring in Peninsular Malaysia (Table 1). This is because most of the limestone areas in Sarawak (Gunung Mulu and Niah NPs) are totally protected. In contrast in Peninsular Malaysia, the great majority fall outside protected areas, namely the Langkawi World Heritage Geopark, Perlis State Park, or on the six limestone hills in Taman Negara (Gunung Peningat, Batu Luas, Batu Subis, Gua Telingga, Batu Biwa and Batu Ta'at), so that only eight species are

Table 1. Conservation status of Malaysian taxa of *Paraboea* following IUCN Categories & Criteria, ver. 3.1 (2001).

	Number of taxa		
Category	*Peninsular Malaysia*	*Sarawak*	*Sabah*
Extinct (EX)	0	0	0
Critically Endangered (CR)	4	0	0
Endangered (EN)	7	0	1
Vulnerable	3	0	0
Near Threatened (NT)	3	1	0
Least Concern (LC)	6	8	1
Data Deficient (DD)	1	2	0

totally protected. In addition, in Peninsular Malaysia relatively few hills fall within Permanent Reserved Forests.

Species that require conservation action are those that fall within the CR and DD categories. The three DD species (*P. deterigibilis*, *P. paraprimuloides* and *P. regularis*) are all poorly known species, known from single specimens, some with doubtful taxonomic standing (see Appendix A). Efforts need to be made to obtain better material before their conservation status can be assessed.

Four species, all from Peninsular Malaysia, fall within the CR category. All, *P. bakeri* (Fig. 1A), *P. lambokensis* (Fig. 3A), *P. parviflora* and *P. vulpina*, are known from three or fewer localities where they have small populations that grow on the damp shaded base of a hill or in mossy damp crevices or on hills that are particularly vulnerable to disturbance. All the hills where they are found are on state land. The most critically endangered is without doubt *P. bakeri* because the only two hills from where it is known are both actively being quarried. For these CR species, a three-pronged approach needs to be taken. The first is to monitor the populations to ensure that further population decline does not occur, the second is to inform the relevant stakeholders of their existence and to enlist their support in protecting the areas from further disturbance, and thirdly to collect seed or leaf material for *ex situ* collections. Already a plant-rescue project to grow and propagate *P. bakeri ex situ* has started.

Conservation of the limestone flora

The totally protected areas in Sarawak and in Langkawi and Taman Negara, Peninsular Malaysia, offer protection to about half the species of *Paraboea*. Conservation of paraboeas highlights the situation facing the limestone flora in general because, in common with groups of plants that are restricted to limestone habitats, most species

are not widespread but have restricted distributions and lie within a particular floristic zone and a few are confined to one or a few hills. Therefore, a network of hills, as is the case in Sarawak, needs to be legally protected because with the high biodiversity of the limestone flora, no single hill conserves more than a fraction of the flora. There is now sufficient data to identify hills that either harbour narrow endemics or are particularly rich in endangered species.

In protecting these tower karsts, it is important that a buffer zone of forested vegetation surrounds them to protect against accidental burning as a result of agricultural practices. This is crucial in preserving the damp, shaded habitat that many paraboeas (and other limestone species) need. In addition, regular monitoring of critically endangered species is necessary to prevent population decline.

In Malaysia, the limestone flora has repeatedly been recognised as one of the critically endangered habitat types (Davis et al. 1995a, 1995b; Kiew 1994; Saw et al. 2009; Chua et al. 2009) and has been identified as one of the Important Plant Areas (IPAs). One of the targets in the Malaysian National Strategy for Plant Conservation is to conserve 50% of the IPAs (Saw et al. 2009). For example, Chua et al. (2009) have already suggested that the limestone hills in the Meropoh/Gua Musang area of Kelantan be included within Taman Negara. This would conserve at least one population of CR species, *P. vulpina*, as well as *P. nervosissima*.

Mapping distribution patterns and assigning conservation status is the first step in identifying endangered species and biodiversity hotspots that will enable a holistic programme to be formulated that can balance the protection and conservation of the limestone ecosystem with the various commercial, recreational and religious uses. This is particularly critical in Perak where as yet no hill is protected and where many hills are actively being quarried or the flora is being degraded by resort or recreational development or activities associated with temples. Mapping shows that the most important hill in Perak from the point of view of conservation of *Paraboea* species is the Tambun Hot Springs (sometimes called Ayer Hangat), which is home to two CR species *P. parviflora* and *P. vulpina*, as well as the Perak endemic *P. capitata* var. *capitata*. Mapping also pinpoints those species that are known from a single or very few hill(s), such as *P. lambokensis* from Gua Renayang and Gua Senarip, Kelantan.

This study on the conservation status of *Paraboea*, being based on sound taxonomy and recent field surveys, serves as a model for the study of other groups of plants that are either obligate limestone species or are endemic to Peninsular Malaysia, Sabah and Sarawak. It aims at producing a map to show the distribution of endangered species and those hills that require gazetting as Totally Protected Areas.

ACKNOWLEDGEMENTS. This study was carried out as part of the Flora of Peninsular Malaysia Project (Project No. 01-04-01-0000 Khas) funded by the Ministry of Science, Technology and Innovation. We are indebted to the Curators of the KLU, SAN, SAR and SING herbaria for permission to examine specimens in their care; to D.J. Middleton for supplying images of the type of *Paraboea treubii*, to various agencies that have funded surveys of limestone hills, namely, the Malaysian Nature Society (Perak and Taman Negara); WWF-

Malaysia (Perlis and Kelantan) and IPRA funding (Pahang and Sabah) and all those who have accompanied us in the field, in particular S. Anthonysamy, G.W. Davison, C. Geri, B.H. Kiew, S.P. Lim, A. Piee, A.R. Rafidah, J. Sang, J.H. Tan, Dennis G.C. Yong and many others, and to BRAHMS (Botanical Research and Herbarium Management System) for enabling data access from the KEP collection and mapping of localities.

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Appendix A. Conservation status of *Paraboea* and *Trisepalum* species (Gesneriaceae) in Malaysia.

1. *Paraboea acutifolia* (Ridl.) B.L.Burtt
Distribution: Peninsular Malaysia and S Thailand
Habitat: On limestone rocks in forest
Conservation status: LC in Malaysia
Notes: Some populations lie within the Langkawi World Heritage Geopark. Xu et al. (2008) note that it is considered threatened in Thailand.

2. *Paraboea apiensis* Z.R.Xu
Distribution: Endemic in Sarawak (Gunung Api)
Habitat: On limestone rocks.
Conservation status: LC
Notes: Gunung Api lies within the Gunung Mulu National Park.

3. *Paraboea bakeri* M.R.Hend. (Fig. 1A)
Distribution: Endemic in Peninsular Malaysia (Bukit Sagu, Pahang)
Habitat: Small populations on moss cushions in high shaded crevices in limestone hills where water seeps down
Threats: Bukit Sagu and the adjacent small Bukit Tenggek are in the process of being totally destroyed by quarrying.
Conservation status: CR B2b(iii) + c(iv)
Notes: Xu et al. (2008) gave this species a conservation status of EN B1ab(ii, iii, iv) based on one collection from a second locality, Gua Charas. However, this species has not been recollected from this hill suggesting that this specimen is wrongly localised. In 2011, both these hills were surveyed and the small population of plants discovered was collected for *ex situ* propagation in the Forest Research Institute Malaysia Nursery. Eventually this species will certainly become extinct in the wild.

4. *Paraboea bayengiana* B.L.Burtt
Distribution: Endemic in Sarawak (Gunung Mulu and Gunung Benarat)
Habitat: On limestone rocks
Conservation status: LC
Notes: All its populations fall within the Gunung Mulu National Park.

5. *Paraboea bintangensis* B.L.Burtt
Distribution: Endemic in Peninsular Malaysia (Langkawi, Perlis)
Habitat: On limestone rockfaces in light shade
Threats: Its three localities fall outside totally protected areas.
Conservation status: EN B1ab(iii)
Notes: Xu et al. (2008) gave this species a conservation status of VU D2.

6. *Paraboea brachycarpa* (Ridl.) B.L.Burtt (Fig. 1B)
Distribution: Endemic in Peninsular Malaysia (Kelantan, Pahang and Trengganu)
Habitat: On summits and exposed limestone cliff faces, where it occurs in sizeable populations.
Conservation status: LC
Notes: Known from many hills, including two within Taman Negara.

7. *Paraboea caerulescens* (Ridl.) B.L.Burtt (Fig. 2A)
Distribution: Endemic in Peninsular Malaysia (Perak)
Habitat: On summits and exposed vertical limestone rock faces
Threats: It is recorded from 6 hills, none of which fall within the network of Totally Protected Areas and many are actively being quarried or house temples or are on state land that is disturbed by development and/or agriculture.
Conservation status: EN B2ab(iii)
Notes: The Batu Kurau locality is part of the Gunung Pondok massif that is currently being razed to the ground for cement. Xu et al. (2008) gave this species a conservation status of LC on the assumption that it is known from 'several sites over a wide area and there are no major threats'. The specimen from Pahang (Gua Charas) listed in Xu et al. (2008) is based on a misidentification.

8. *Paraboea candidissima* B.L.Burtt
Distribution: Endemic in Sarawak (Gunung Buda and Gunung Benarat)
Habitat: On limestone rocks
Conservation status: LC
Notes: All localities lie within the Gunung Mulu National Park.

9a. *Paraboea capitata* Ridl. **var. *capitata***
Distribution: Endemic in Peninsular Malaysia (Perak).
Habitat: Near base of limestone hills, on damp shaded rocks faces and in gullies
Threats: Although it is recorded from about 5 hills, none falls within the network of Totally Protected Areas and many are actively being quarried or house temples or are on state land that is disturbed by development and/or agriculture.
Conservation status: EN B2ab(iii)
Notes: The type specimen of *P. capitata* (together with the type specimens of its synonyms *P. curtisii* Ridl. and *P. polita* Ridl.) were all collected by Curtis on 28th December 1895 from Gunung Bujang Melaka, Perak. However, this is a granite mountain and apart from these collections *P. capitata* has never been collected on anything other than limestone and, although Gunung Bujang Melaka has been visited by other botanists on several occasions, this species has not been recollected from there. Prior to visiting Gunung Bujang Melaka on the way from Ipoh to Kuala Dipang, Curtis had 'examined the limestone hills at three or four places' (Curtis 1896) so it is probable that a mistake was made in labelling these specimens.

9b. *Paraboea capitata* Ridl. **var. *oblongifolia*** Ridl.
Distribution: Endemic in Peninsular Malaysia (Perak and Kelantan)
Habitat: Near base of limestone hills, on damp shaded rocks faces and in gullies
Threats: Although it is recorded from two states and from about four hills, none falls within the network of Totally Protected Areas and many are actively being quarried or house temples or are on state land that is disturbed by agriculture and/or development.
Conservation status: EN B2ab(iii)
Notes: The two varieties are distinct in the lamina size and shape. Collections from limestone labelled Bukit Kurau and Padang Rengas both refer to different parts of the Gunung Pondok massif that is currently being razed to the ground for cement.

10. *Paraboea clarkei* B.L.Burtt (Fig. 1C)
Distribution: Endemic in Sarawak (Kuching Division and Gunung Mulu National Park)
Habitat: On shaded limestone rocks below the tree canopy, common where it occurs.
Conservation status: LC
Notes: It is protected within the G. Mulu National Park. It is the only species in Sarawak to be collected from more than one phytogeographical area. The Mulu population has much larger leaves (24–26.5 × 11.5–12 cm) as compared with the Kuching Division specimens (11.5–16 × 6–8.5) and perhaps deserves to be recognised as a distinct variety.

11. *Paraboea culminicola* K.G.Pearce (Fig. 2C)
Distribution: Endemic in Sarawak (Gunung Subis, Bukit Sarang)
Habitat: On summits and exposed vertical limestone cliffs
Conservation status: NT
Notes: It is protected within the Niah National Park. Xu et al. (2008) considered this species synonymous with *P. treubii*. *Paraboea culminicola* is clearly different in its oblanceolate leaves in whorls of 4 with 35–40 pairs of veins and cinnamon-brown undersides, and in its inflorescences with large floral leaves and the peduncles of the side branches that are c. 8 times longer that the ultimate branches. So it is here treated as a distinct species.

12. *Paraboea detergibilis* (C.B.Clarke) B.L.Burtt
Distribution: Billiton, Bangka and W Sumatra, Indonesia, and Sarawak (Gunung Gaharu).
Habitat: Not known but Gunung Gaharu, Kuching Division, is not a limestone mountain.
Conservation status: DD in Malaysia
Notes: Xu et al. (2008) reported this species in Sarawak from a single specimen. The population on Gunung Gaharu needs to be relocated before the status of this species can be assessed.

13. *Paraboea divaricata* (Ridl.) B.L.Burtt
Distribution: Endemic in Peninsular Malaysia (Langkawi).
Habitat: On limestone rocks
Threats: Known from 2 or 3 localities, it nowhere occurs within a Totally Protected Area.
Conservation status: EN B2ab(iii)
Notes: Xu et al. (2008) gave this species a conservation status of VU D2 on the grounds that the Ayer Hangat site falls within a Forest Reserve.

14. *Paraboea effusa* B.L.Burtt
Distribution: Endemic in Sarawak (Gunung Mulu National Park)
Habitat: On limestone rocks in forest and also on the summit of limestone karsts.
Conservation status: LC
Notes: Fully protected within the Gunung Mulu National Park.

15. *Paraboea elegans* (Ridl.) B.L.Burtt (Fig. 2B)
Distribution: Peninsular Malaysia (Kedah, Kelantan and Selangor) and S Thailand.
Habitat: In light shade on quartzite outcrops, on Gunung Jerai, Kedah, at 1000 m and in Kelantan and Selangor at c. 300 m.
Threats: The rocky habitats where it grows are vulnerable to disturbance, for example, on Gunung Jerai by tourist pressure, at the Kelantan site by maintenance work to the nearby hydroelectric dam and in Selangor by logging that has caused landslips at the base of the outcrop.
Conservation status: VU B2ab(iii) in Malaysia
Notes: Xu et al. (2008) included *P. obovata* as a synonym of this species but it is quite different (see 25. *P. obovata* below).

16. *Paraboea ferruginea* (Ridl.) Ridl.
Distribution: Endemic in Peninsular Malaysia (Langkawi)
Habitat: On limestone rocks in damp, shaded places
Conservation status: NT
Notes: Known from several sites on the main and smaller islands of Langkawi, some of which lie within the Langkawi World Heritage Geopark.

17. *Paraboea gracillima* Kiew
Distribution: Peninsular Malaysia and S Thailand
Habitat: It occurs in small populations on shaded limestone cliffs from the base under forest canopy to near the summit
Conservation status: LC in Malaysia
Notes: It grows within the Perlis State Park.

18. *Paraboea havilandii* (Ridl.) B.L.Burtt
Distribution: Endemic in Sarawak (Kuching Division)
Habitat: On the summit and on exposed limestone cliffs where it is quite common
Conservation status: LC
Notes: This species is common and collected from many hills. The specimen cited by Xu et al. (2008) from Pahang (*Henderson SFN 25250*) is in fact the type specimen of *Emarhendia bettiana* (M.R.Hend.) Kiew et al.

19. *Paraboea lambokensis* Kiew (Fig. 3A)
Distribution: Endemic in Peninsular Malaysia (Kelantan)
Habitat: Small populations grow at the base of limestone cliffs or around cave mouths in light shade
Threats: The two hills (Gua Senarip, Gua Renayang) are on state land surrounded by agriculture that has removed the surrounding forest cover leaving the population vulnerable to burning.
Conservation status: CR B1b(iii) + c(iv)

20. *Paraboea lanata* (Ridl.) B.L.Burtt
Distribution: Endemic in Peninsular Malaysia (Langkawi).
Habitat: On limestone rocks by the seashore or in rocky hillsides on limestone islands.
Conservation status: VU B2ab(iii)
Notes: Known from several localities on Langkawi and several minor islands, some of which fall within the Langkawi World Heritage Geopark.

21. *Paraboea laxa* Ridl.
Distribution: Endemic in Peninsular Malaysia (Langkawi).
Habitat: On limestone rock faces and summits
Conservation status: VU B1ab(iii)
Notes: Known from several localities on Langkawi and several minor islands, some of which fall within the Langkawi World Heritage Geopark.

22. *Paraboea leopoldii* K.M.Wong, J.T.Pereira, Sugau & S.P.Lim
Distribution: Endemic in Sabah (Bodgaya Island)
Habitat: Its localised populations grow on exposed igneous rocks from 4 m above the shoreline to high up on vertical cliffs.
Threats: Its population is difficult to access since it grows on rocky headlands and along the coast.
Conservation status: LC
Notes: Xu et al. (2008) erroneously recorded this species from limestone.

23. *Paraboea meiophylla* B.L.Burtt
Distribution: Endemic in Sarawak (Gunung Benarat)
Habitat: On limestone rocks
Conservation status: LC
Notes: Totally protected within the Gunung Mulu National Park.

24. *Paraboea nervosissima* Z.R.Xu & B.L.Burtt
Distribution: Endemic in Peninsular Malaysia (Kelantan, Pahang)
Habitat: Exposed summit and vertical limestone cliffs
Conservation status: LC
Notes: Quite widespread with some localities lying within Taman Negara.

25. *Paraboea obovata* Ridl.
Distribution: Endemic in Peninsular Malaysia (Langkawi).
Habitat: In heath forest, in light shade on sandstone rocks.
Conservation status: LC
Notes: This species is known only from Gunung Machinchang, a sandstone hill that lies within the Langkawi World Heritage Geopark. *Paraboea obovata* has been considered as a synonym of *P. elegans* (Burtt 1984, Xu et al. 2008), perhaps because both species do not grow on limestone. However, they are clearly different. *Paraboea obovata* has opposite, obovate leaves that measure 6–7.5 × 2.2–4 cm and has a distinct petiole 1.2–4.5 cm long and peduncles 9–11 cm long. In contrast, *P. elegans* has whorled, narrowly lanceolate leaves 4 × 1.7 cm and either lacks a petiole or has a short petiole c. 1 cm long, and it has long peduncles 15–18.5 cm long. For these reasons, *P. obovata* is therefore here reinstated as a distinct species.

26. *Paraboea paniculata* (Ridl.) B.L.Burtt
Distribution: Peninsular Malaysia (Perak, Selangor) and Sumatra.
Habitat: On the summit and vertical limestone cliffs
Threats: None of the hills where it is found lies within the network of Totally Protected Areas. Only Bukit Takun lies within a Forest Reserve but vegetation of this hill is disturbed by the activities of rock climbers.
Conservation status: EN B2ab(iii) in Malaysia
Notes: Xu et al. (2008) gave this species a conservation status of LC because it 'has been collected at several sites over a wide area and there are no major threats'.

27. *Paraboea paraprimuloides* Z.R.Xu
Distribution: Endemic in Sarawak (Hose Mountains)
Habitat: Growing on cliffs, but not on limestone
Threats: Unknown.
Conservation status: DD
Notes: This species is known only from the type collection made in 1967 and is still incompletely known. Until the population has been relocated, its conservation status cannot be assessed. Xu et al. (2008) gave this species a conservation status of CR B1ab(ii,iii,v) on the presumption that species known only from the type are confined to the area where they were collected and that their extent of occurrence is below 100 km^2.

28. *Paraboea parviflora* (Ridl.) B.L.Burtt
Distribution: Endemic in Peninsular Malaysia (Perak)
Habitat: Very uncommon and where it occurs it is found in small populations in shaded gullies in limestone cliffs below the tree canopy.
Threats: None of the four limestone hills where it occurs lies within the network of Totally Protected Areas and all are no longer surrounded by forest but are heavily disturbed by tourism (Gunung Tempurung), resort development (Ayer Hangat as the Tambun Hot Springs is sometimes known) or quarrying (Kinta).
Conservation status: CR B2ab(iii)
Notes: Xu et al. (2008) gave this species a conservation status of LC stating that 'the relatively few collections ... are almost all from protected areas and there are no major threats'.

29. *Paraboea regularis* (Ridl.) Ridl.
Distribution: Endemic in Peninsular Malaysia (Langkawi) and S Thailand.
Habitat: Not known
Conservation status: DD in Malaysia
Notes: For Peninsular Malaysia, it is known only from the type specimen which comprises detached leaves and inflorescences taken from a plant grown in the Singapore Botanic Gardens in 1893. In spite of Langkawi being well-collected, this species has not re-found, which raises the possibility that it is a Thai species.

30. *Paraboea sabahensis* Z.R.Xu & B.L.Burtt, Edinb. J. Bot. 48 (1991) 12. Type: Sabah, Kinabatang District, Bilit, Sopiloring Hill, *Ampuria SAN 35269* 18 April 1963 (holo E; iso K, L, SAN, SAR). (Fig. 3C)
Synonym nova: Paraboea madaiensis Z.R.Xu & B.L.Burtt, Edinb. J. Bot. 48 (1991) 4. Type: Sabah, Semporna District, Madai Caves. *Tamura & Hotta 722* (holo E; iso KYO).

Distribution: Endemic in Sabah (Kinabatangan and Semporna Districts)
Habitat: On exposed summits and vertical limestone hills, quite common locally
Threats: Batu Tengah Cave, Bilit, and Bukit Batangan limestone hills lie within very disturbed forest or secondary forest that in Sabah is prone to burning in El Niño years, while the limestone vegetation is somewhat disturbed on Gunung Madai and Bukit Dulong Lambu (Gomantong) because they are the most important caves in Sabah for the collecting of bird nests. However, a summit species can withstand some disturbance, for example, the population on Bukit Dulong Lambu has spread onto summit areas laid bare by the Great Burn in 1982/83.
Conservation status: EN B2ab(iii)
Notes: With the collection of specimens from more populations, it has become clear that the differences in lamina shape and size, including shape of the leaf base, and petiole length that were used to distinguish between *P. sabahensis* and *P. madaiensis* are not discrete. *Paraboea sabahensis* is preferred for the name of this species because of its wider distribution with the consequence that *P. madaiensis* is reduced to synonomy.

31. ***Paraboea speluncarum*** (B.L.Burtt) B.L.Burtt
Distribution: Endemic in Sarawak (Gunung Subis).
Habitat: On limestone growing in light shade on stalactites from the arch of cave mouths.
Conservation status: LC
Notes: It lies within the Niah National Park.

32. ***Paraboea suffruticosa*** (Ridl.) B.L.Burtt
Distribution: Endemic in Peninsular Malaysia (Langkawi).
Habitat: On limestone karsts
Conservation status: NT
Notes: It is known from several localities on the main island and from smaller islands, some of which lie within the Langkawi World Heritage Geopark.

33. ***Paraboea treubii*** (H.O.Forbes) B.L.Burtt var. *treubii*
Distribution: Peninsular Malaysia (Kelantan, Pahang) and Sumatra.
Habitat: Not common, it grows exposed on summits and on vertical limestone cliffs.
Conservation status: LC in Malaysia
Notes: Some of the hills on which it occurs lie within Taman Negara.

34. ***Paraboea verticillata*** (Ridl.) B.L.Burtt
Distribution: Endemic in Peninsular Malaysia (Kedah, Perak, Selangor)
Habitat: Common, growing exposed on summits and vertical limestone cliffs
Threats: None of the hills where it is found lie within the network of Totally Protected Areas. Only Bukit Takun lies within a Forest Reserve but vegetation of this hill is disturbed by the activities of rock climbers.
Conservation status: EN B2ab(iii)
Notes: Xu et al. (2008) gave this species a conservation status of LC because it ‘has been collected at several sites over a wide area and there are no major threats’.

35. ***Paraboea vulpina*** Ridl.

Distribution: Peninsular Malaysia (Kelantan, Perak) and S Thailand.

Habitat: Small, local populations on the shaded base of vertical limestone cliff faces.

Threats: None of the three hills from where it is known is protected within the network of Totally Protected Areas or is surrounded by forest. All are in heavily disturbed areas close to agriculture or tourist developments.

Conservation status: CR B2ab(iii) in Malaysia

Notes: Xu et al. (2008) gave this species a conservation status of LC because 'although this species is only known from a few collections it is found over a large area and several of the known sites are in protected areas and there are no major threats'.

36. ***Trisepalum speciosum*** (Ridl.) B.L.Burtt (Fig. 3B)

Distribution: Peninsular Malaysia (Langkawi, Perlis) and S Thailand.

Habitat: On exposed summits of limestone hills

Conservation status: NT in Malaysia

Notes: It is known from several localities on the main island of Langkawi and from smaller islands, some of which lie within the Langkawi World Heritage Geopark. It also grows on the mainland.