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# REDISCOVERY OF *Shorea kuantanensis*, A DIPTEROCARP BELIEVED EXTINCT IN MALAYSIA

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**_Shorea kuantanensis_ was only found in Bukit Goh (Pahang) and unfortunately, the area had been converted to oil palm plantations in the mid 1960's. The species was considered extinct in Malaysia in 2010 when attempts to find the species in adjacent remaining forest remnants were met empty handed (Chua *et al.*, 2010).**

The holotype FMS 31771 and paratype FMS 31806, were collected from Bukit Goh in 1936 and curated in KEP herbarium. A holotype is a single type specimen upon which the description and name of a new species is based, whereas a paratype is a representative specimen other than the holotype, referred to in the original description.

In 2014, former Ranger Salleh Endot came across a fruiting tree in Lata Tembakah Recreational Forest in Pelagat Forest Reserve (FR), Besut, Terengganu, with fruits that were similar to those of *S. kuantanensis*. Based on the tree and fruit morphology, it was subsequently identified as *S. kuantanensis* by Nasir *et al*. (2017) and confirmed by Dr. Peter Ashton who is an authority on the taxonomy of the Dipterocarpaceae. This news naturally caused a stir of excitement and renewed interest in *S. kuantanensis* among foresters and researchers.

Immature fruit from Lata Tembakah (Photo: M. Hatta)

***Shorea kuantanensis*** **: Holotype FMS31771;**


**Paratype FMS31806**

Although the fruits of this newly found population matched those of the type specimens, the leaf shape was different, being more rounded or cordate at the base compared to cuneate or wedge-shaped, in the types. To further confirm its identity as *S. kuantanensis*, we conducted DNA matching with the original type specimens from Bukit Goh.

Efforts to extract and sequence the DNA from the type specimens using parts of the leaf, twig and fruit via Sanger and Next Generation Sequencing methods proved futile. We were unable to retrieve any good quality DNA from the types. These old herbarium specimens had most likely been treated with mercuric chloride which was a common practice in the past. The poorly preserved DNA was fragmented and of low quality. As a result, we were unable to match the identity of *S. kuantanensis* from Lata Tembakah with the type specimens via genetic approaches. Nevertheless, our preliminary reconstruction of a phylogenetic tree for Meranti Damar Hitam group of the Dipterocarpaceae revealed that *S. kuantanensis* from Lata Tembakah is closely related to *S. balanocarpoides* (Tnah LH *et al.,* unpublished data). For now, the species from Lata Tembakah is identified as *S. kuantanensis* based on morphological characters, especially the fruit.

FRIM (Forest Research Institute Malaysia) has embarked on a population search for *S. kuantanensis* in Lata Tembakah. The area has a rich and abundant group of Damar Hitam species, namely, *S. balanocarpoides, S. faquetiana, S. longisperma* and *S. multiflora*. To date, we have searched an area of approximately 6 $km^2$ (600 ha) of the lowland dipterocarp forest, much of which consists of hilly terrain. We were worried to find only 4 trees of *S. kuantanensis* confined to a very small area of less than 900 $m^2$ (< 0.1 ha) and nowhere else in the FR. These trees, with diameter at breast height (DBH) of between 26 and 75 cm, are found at an altitude of between 29 and 33 m on flat terrain.

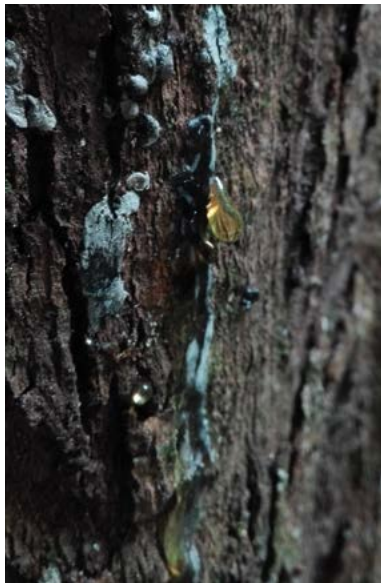
Between April and July 2019, many dipterocarp species in the FR including *S. kuantanensis* flowered and fruited. Two trees of *S. kuantanensis* (DBH 75 and 46 cm) flowered but only the larger tree produced mature fruits. Unlike the adult trees, the seedlings of *S. kuantanensis* have peltate leaves, similar to those of *S. balanocarpoides* and *S. faquetiana.*

From these findings, it appears that *S. kuantanensis* at Lata Tembakah is very localised and rare in numbers. More extensive efforts are needed to expand the search throughout the large FR and adjacent forested areas. The Lata Tembakah population is currently protected in the recreational forest; additional *ex situ* conservation measures that include germplasm collection of seed materials, establishment of seedlings and propagation efforts are being undertaken.

*S. kuantanensis* (right photo: M. Hatta)

*S. balanocarpoides*

To the uninitiated, the leaves of *S. kuantanensis* may look similar to those of *S. balanocarpoides* but the twigs and leaves of *S. balanocarpoides* are thicker and more rigid.



Fresh cut bark and a leaf sample of *S. kuantanensis*. The fresh damar produced was clear, sparse and flowed slowly. The damar would eventually turn blackish and is thus called 'damar hitam'.

Seedlings of *S. kuantanensis* with peltate leaves.

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We thank Muhamad Hatta, Salleh Endot & Siti Eryani for field assistance, Dr. Kevin Ng & Dr. Lee Soon Leong for helping in the genetic work, supporting staff of the Forest Biodiversity Division and Forest Biotechnology Division, and Dr. Richard Chung for allowing photography and providing samples of the type specimens.

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Nasir MM, Richard AM, Akhirrudin MN, Endot S & Latiff A. 2017. New discovery of *Shorea kuantanensis* Ashton (Dipterocarpaceae) in Peninsular Malaysia. *Malaysian Forester* 80: 125-128.

# CONFIRMATION OF AN ELUSIVE MOSS FROM KARST LIMESTONE IN PENINSULAR MALAYSIA

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A curious bryophyte was recently collected during a recent survey as part of the Batu Caves Scientific Expedition. The sample was first identified as a liverwort due to its flattened stem plant habit, but later examination under the microscope revealed it was actually *Erpodium biseriatum* (Aust.) Aust., an interesting, elusive moss. Generally, mosses and liverworts can be distinguished morphologically through several characteristics as shown in Table 1.



Left: Searching for bryophytes in all possible microhabitats at Batu Caves (Photo by Yee C.W.). Right: Plant forming dense mats resembling leafy liverworts on a shaded limestone rock surface.

**Table 1**. Differences between mosses and liverworts.

| | Mosses | Liverworts |
|---|---|---|
| Leaf arrangement (on stem and branch) | Usually in spiral row, rarely flattened. | In flattened rows. |
| Leaves | Undivided. Costa (midrib) present or lacking. | Undivided or lobed. Costa lacking. |
| Rhizoid (root-like structure) | Multicellular and uniseriate (single cell row), often reddish brown. | Single cell, often transparent (without pigmentation). |
| Sporophyte (spore-producing structure developed from the fusion of sperm and egg) | Capsule with peristome (fridge of teeth surrounding the mouth) teeth. | Capsule without peristome teeth. |
| Stomata | Present | Absent |

*Erpodium biseriatum* is the only species of the Erpodiaceae reported from Peninsular Malaysia (Manuel, 1981; Mohamed & Tan, 1988; Yong *et al.*, 2013). Despite the species being first documented by Manuel in 1981, where its habitat was recorded as rupicolous (on limestone) and lowland forest in general, neither locations nor herbarium samples are available to confirm its presence in Peninsular Malaysia. Therefore, our discovery is the first confirmation of the occurrence of this species in Peninsular Malaysia, besides providing an opportunity to better understand it.

*Erpodium biseriatum* is a tiny moss, no longer than 1 cm, and only about 1 mm wide. In the wild, the plant is found appressed on the substrate. It has a creeping stem anchored by abundant reddish brown rhizoids and leaves in two horizontal ranks. This growth habit is common to the liverworts but not for mosses. The species can be recognized by its dimorphous (two different forms) leaves, arranged in four rows (Fig. 1). The dorsal leaves are larger, asymmetric, broadly elliptic to oblong-ovate with rounded apices, while the ventral leaves are always much smaller, nearly lingulate (tongue-shaped) and with rounded obtuse apices. These smaller leaves are often hidden when viewed from above. The leaf cells are mostly rhomboidal and pluripapillose (with many small protuberances) with solid, simple, bi- or tri-fid papillae (tip of protuberance split into two or three parts) (Fig. 2).

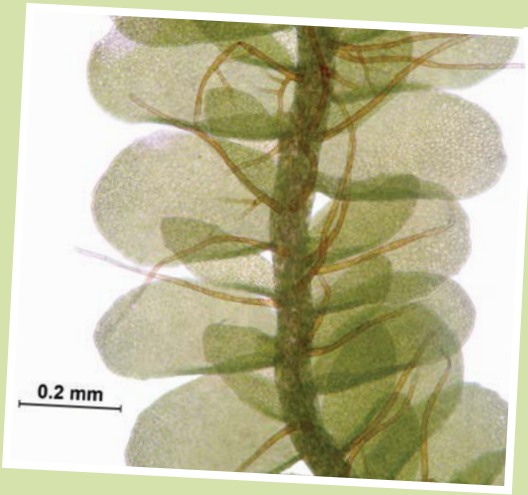


**Fig. 1.** Close-up of an individual *Erpodium biseriatum* showing dimorphous leaves in four rows, two large and two small. Reddish brown rhizoids can be seen emerging from its stem.

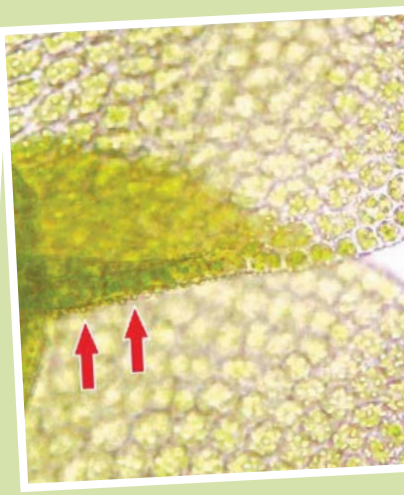

**Fig. 2.** Leaf cell walls covered with distinct, solid papillae (red arrows).

At Batu Caves, *E. biseriatum* grows on vertical surfaces of limestone rocks. This growth habit is rather unusual because elsewhere it is mostly found on tree bark (Crum, 1972). This moss has an almost pan-tropical distribution, occurring from tropical America, Africa (Tanzania), India, Sri Lanka, Taiwan, Indochina, Peninsular Malaysia, Java, the Philippines to northern Australia. It is, nevertheless, rarely collected, possibly being overlooked owing to its minute size, and also because it can easily be mistaken for a liverwort. In this survey of bryophytes of Batu Caves, eight trips were made to search for bryophytes in various microhabitats within the Batu Caves complex. However, this species was only found in one location on two separate trips, both in the vicinity of the Gua Damai area at different entrances, suggesting it is a rare and local species.

**Specimens Examined**:
Peninsular Malaysia – Selangor, Batu Caves, Gua Damai, *Cheah & Yong FRI 95560* 28 November 2018 (KEP, KLU), *Cheah & Yong FRI 95601* 6 December 2018 (KEP, KLU).

**Habitat**:
It grows on shaded limestone rock surfaces at around 130 m altitude.

**Conservation status:**
Only one population is currently known in Gua Damai, Batu Caves. It is therefore assessed as Critically Endangered A3*, B2ab(iii)** (IUCN, 2019) as the location is currently used for recreational activities and is also prone to fire resulting from anthropogenic activities associated with nearby residential settlements.
* denoting the species is threatened from now onwards resulting in population size reduction in near future.
** referring to the single location where this species occurs, its geographical range in Peninsular Malaysia may experience continuing decline.

**Acknowledgements**:
The authors would like to thank the Ministry of Water, Land and Natural Resources (KATS) for financial support, the Malaysian Cave and Karst Conservancy for organising the Batu Caves Scientific Expedition, Dr Nur Atiqah Abd. Rahman for coordinating the fieldwork, Yee Chun Wah for his kindness in sharing his photograph, and Dr Ruth Kiew for her comments on the draft.

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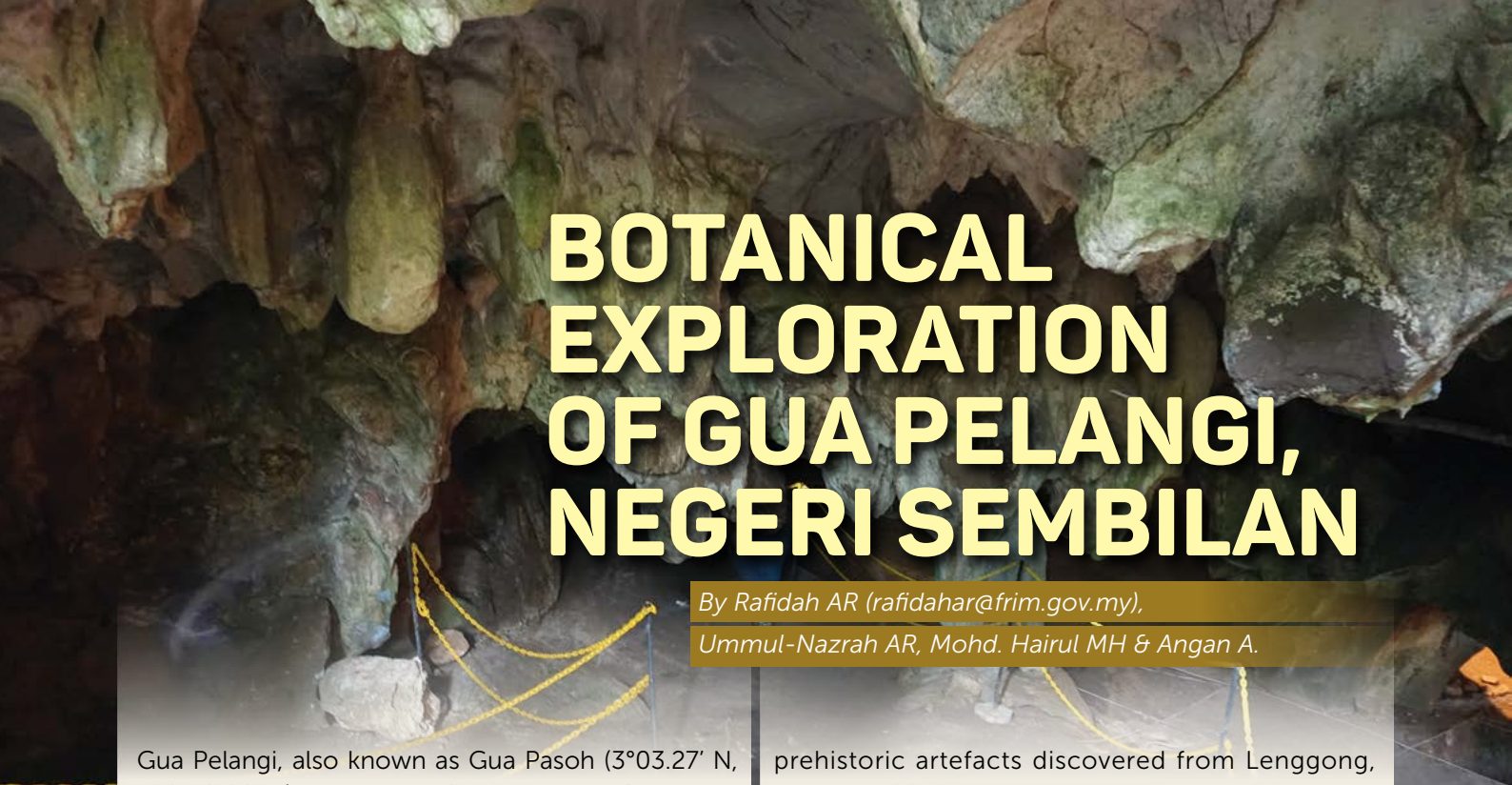

# BOTANICAL EXPLORATION OF GUA PELANGI, NEGERI SEMBILAN

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Gua Pelangi, also known as Gua Pasoh (3°03.27' N, 102°19.02' E), located in Compartment 81, Pasoh Forest Reserve, Negeri Sembilan, is one of the southernmost limestone outcrops of Peninsular Malaysia. This limestone outcrop is miles away (about 150 km) from the nearest limestone hill, Batu Caves, Selangor. To reach Gua Pelangi, visitors need to drive about 10 minutes through the oil palm and rubber plantations in the Felda Pasoh 4 Scheme, which lies about 20 km from the small town of Simpang Pertang, Negeri Sembilan.

Gua Pelangi is a small, low, limestone outcrop which is about 30 m average in height with the highest peak reaching 150 m asl. Three caves have been discovered in Gua Pelangi, namely, Gua Pelangi itself, Gua Kelawar and Gua Tirai. Price (2014) recorded the hill as Bukit Pelangi with its cave, Gua Gelanggi (a misspelling of Pelangi), but it was not mapped by Liew and his co-workers (2016). Nearby in Compartment 79, about half a kilometre away from Gua Pelangi, there are other tiny limestone outcrops called Gua Waris and Gua Telaga by local residents. All these outcrops are still intact within a small fragment of lowland forest of about 16 ha. The forest was logged about 10 to 15 years ago, leaving the outcrops as isolated islands.

The Gua Pelangi outcrop was proven to be composed of limestone by researchers from the Centre for Global Archaeological Research, Universiti Sains Malaysia (USM) in 2015. They discovered artefacts there dating back to prehistoric times about 14,000 years ago, believed to be from the Palaeolithic era. The excavation site inside Gua Pelangi contained several hunting tools and snail shells similar to the prehistoric artefacts discovered from Lenggong, Perak in 1991. An active local ecotourism operator with support from the Negeri Sembilan Forestry Department and *Lembaga Pelancongan Negeri Sembilan* has taken the initiative to develop Gua Pelangi into an archeo-tourism heritage site or as a living gallery, while at the same time protecting the outcrops from any anthropogenic destruction.

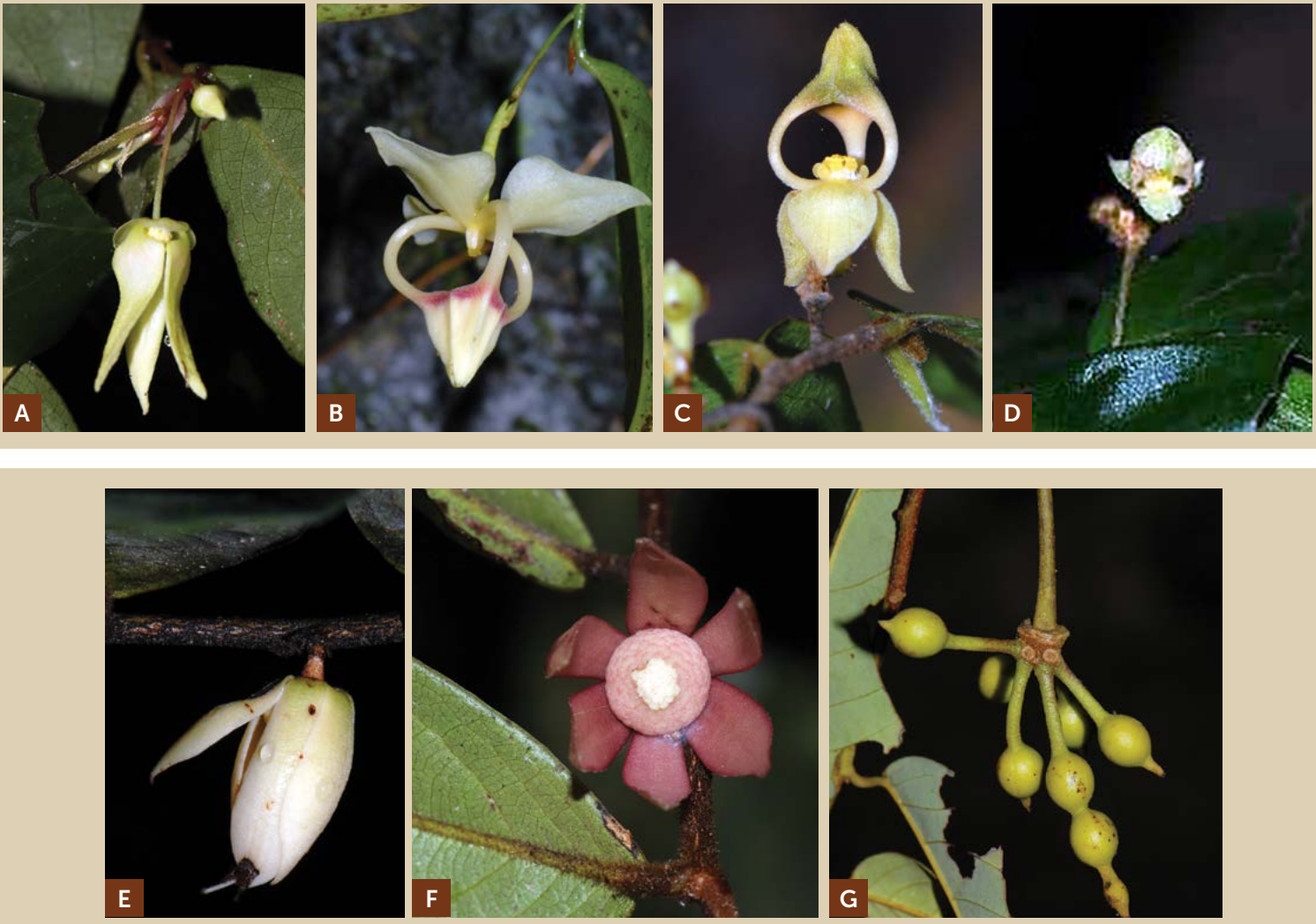
Gua Pelangi and its adjacent outcrops are not well-botanised. In 1996, about 20 years ago, Dr Ruth Kiew conducted a brief botanical survey and made very few collections. Therefore, to document in detail plants that now grow in Gua Pelangi, a short trip was conducted in mid-February 2020. During this botanical sampling, we collected flowering and fruiting specimens of about 54 species and vouchers (which are sterile leaf collections) of approximately 90 tree species. Several typical limestone plants were observed and collected in Gua Pelangi i.e., we found scattered patches of *Begonia foxworthyi* (Begoniaceae) hanging on the rock wall outside the cave mouths and *Epithema membranaceum* (Gesneriaceae) on rocks near cave entrances. Both species are endemic to Peninsular Malaysia.

From the base of the outcrop up to the ridge and to the summit, populations of several species of Annonaceae were recorded with flowers and fruits, such as species of *Orophea*, *Goniothalamus*, *Polyalthia* and *Trivalvaria*. *Orophea enterocarpa, O. malayana* and *O. hirsuta* are limestone plants that are also found on other limestone outcrops in Peninsular Malaysia. The 'real' summit of Gua Pelangi is connected to the surrounding lowland forest by a ridge. *Micromelum minutum* (Rutaceae) and *Rinorea*

*bengalensis* (Violaceae), common limestone plants, can also be found on Gua Pelangi. There are also many big trees on the hill including *Cratoxylum formosum* and *C. cochinchinense* (Hypericaceae), *Pentaspadon velutinus* (Anacardiaceae), *Saraca declinata* (Leguminosae), *Shorea leprosula* and *S. maxwelliana* (Dipterocarpaceae), *Styrax benzoin* (Styracaceae) and *Xerospermum noronhianum* (Sapindaceae). The outcrop is surrounded by shrubs, climbers and secondary species such as *Aidia densiflora* (Rubiaceae), *Antidesma* sp. (Phyllanthaceae), *Desmos dumosus* (Annonaceae), *Gnetum gnemon* (Gnetaceae), *Paropsia vareciformis* (Passifloraceae) and *Rinorea anguifera* (Violaceae).

The vegetation of Gua Pelangi is still diverse with a good representation of species characteristic of the limestone flora as well as of lowland dipterocarp species. This outcrop has a slightly different limestone flora compared to that of limestone hills in northern Peninsular Malaysia, for example, a noticeable absence of typical limestone genera such as *Impatiens*, *Paraboea, Ophiorrhiza* and *Elatostemma*. The outcrop also has a diversity of several species of Annonaceae within a small remnant area. Other plant families present are those with a wide distribution within the fringe of surrounding lowland forest. The presence of various animals (birds, small and big mammals, insects, snails and snakes) shows that this area is still an important habitat (*pers. comm*. with Gua Pelangi operator).

Efforts are being made by the local eco-tourism operator to manage Gua Pelangi for conservation and sustainable utilisation by the public. These efforts are important so that local communities and societies can experience the natural forest and its ecosystems.




Flowers (A-F) and fruit (G) of Annonaceae (*Mempisang* family) recorded from Gua Pelangi, Negeri Sembilan. A, *Orophea malayana;* B, *O. enterocarpa*; C, *O. polycarpa*; D, *O. hirsuta*.; E, *Polyalthia* sp; F, *Trivalvaria* sp.; G, *Desmos dumosus*.

*Rinorea bengalensis*, Violaceae (left) and *Micromelum minutum,* Rutaceae (right) are common limestone species.

*Begonia foxworthyi* (top) and *Epithema membranaceum* (bottom) are limestone species endemic to Peninsular Malaysia.

Flowers (inset) and fruits of *Paropsia vareciformis*, Passifloraceae.

*Urceola laevigata* (Apocynaceae) is occasionally found on limestone. The flowers are sweet-scented.

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