

Lessons from the Gua Musang Massif for Conservation of the Malaysian Limestone Flora

Gua Musang limestone hill located beside Gua Musang old railway station.

Aliaa-Athirah, A.M., Kiew, R., Rafidah, A.R.
(rafidahar@frim.gov.my), Ummul-Nazrah, A.R. & Ong, P.T.

Gua Musang town in Kelantan, Malaysia would not be memorable, if not for the presence of three karst hills, Gua Musang, Gua Serai and Gua Batu Boh. Gua Musang dominates the town, being located on the opposite side of the railway line that runs beside the town. It is 180 m high and covers 0.1951 km². It is a popular recreational area famous for its large cave that uniquely is entered by squeezing through a narrow crack in the rock face. Then at the far end of the cave, a scramble up a cliff face gives access to the summit with a panoramic view over the town and surrounding countryside. To the south, the other two karst hills are separated by the Kota Bharu-Gua Musang Highway connecting Gua Musang and Kuala Krai. Gua Serai is the smallest hill, covering an area of 0.0754 km², while Gua Batu Boh is the largest covering 0.3722 km² (Liew *et al.*, 2016). Both these hills are surrounded by the Ann Lin Lee oil palm plantation.

Before the 1960s, botanical exploration of Gua Musang was sporadic because it was accessible only from the railway line with just two botanical visits in the decade 1920-1929. Following the completion of the Kota Bharu-Gua Musang Highway, botanical collecting increased significantly with three between 1960-1969, and since 1980 FRIM botanists have been carrying out regular collecting trips (Figure 1). Although all collectors follow the same route to the summit, Figure 1 clearly illustrates that (a) a single visit does not result in collecting more than a fraction of its flora and that repeated visits continued to record more species, and that (b) even now the species curve

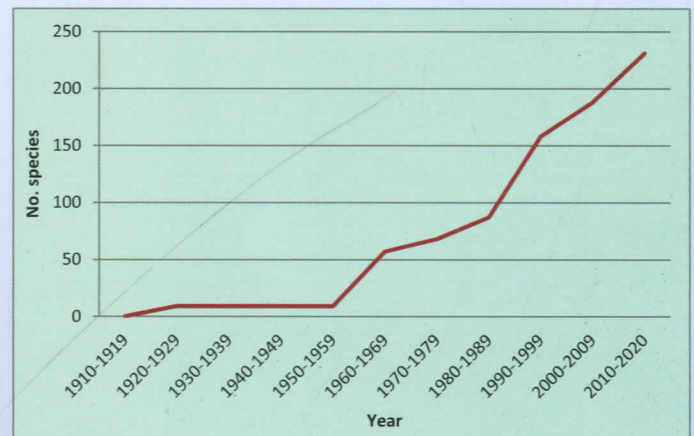


Figure 1: Collecting effort on Gua Musang, Kelantan, by decade based on herbarium specimens collected. Each increase in the number of species is the result of new 'finds' by a succession of botanical collecting trips.

is not leveling off, indicating that there are yet more species to be recorded.

Among the karst hills in Peninsular Malaysia, Gua Musang is one of the three most biodiverse hills with 223 species recorded and it is one of the three hills with the highest number of rare species (Kiew *et al.*, 2017). The total number of species collected from Gua Musang is far higher than that collected from Gua Batu Boh (96 species), although the latter covers a larger area. This is because for plant biodiversity, the variety of microhabitats rather than size determines species richness (Kiew *et al.*, 2019).



Borassodendron machadonis (Palmae) grows on Gua Batu Boh but not on the other two hills.



Microchirita sericea (Gesneriaceae) in Kelantan is known only from one site on Gua Serai.

Can conserving a single hill conserve the Malaysian limestone flora?

While Gua Musang is outstanding for its biodiverse flora with 223 species, it is home to only a fraction of Peninsular Malaysia's limestone flora of 1216 species (Chin, 1977) clearly demonstrating that a single hill can conserve only a fraction of Malaysian limestone flora. It is a common phenomenon of the limestone flora that different hills harbour different assemblages of species. Even adjacent hills have different species including different rare and endangered species (Kiew *et al.*, 2019). This is illustrated by the three hills at Gua Musang. Most of the rare species occur on Gua Musang alone (Table 1), while only one, *Ophiorrhiza longerepens* occurs on both Gua Musang and Gua Batu Boh, but not on Gua Serai. On the other hand, among the three hills, *Microchirita sericea* grows only on Gua Serai while *Borassodendron machadonis*, *Deeringia amaranthoides*, *Gymnostachyum cf. robinsonii* and *Paraboea brachycarpa* grow only on Gua Batu Boh.

Table 1. Distribution of rare species on Gua Musang, Gua Serai and Gua Batu Boh.

Family	Species	Gua Musang	Gua Serai	Gua Batu Boh
Annonaceae	<i>Polyalthia guamusangensis</i>	+		
Cyperaceae	<i>Carex speciosa</i>	+		
Myrsinaceae	<i>Ardisia biflora</i>	+		
Palmae	<i>Calamus elegans</i>	+		
Moraceae	<i>Bleekrodea malayana</i>	+		
Rubiaceae	<i>Ophiorrhiza longerepens</i>	+		+
Palmae	<i>Borassodendron machadonis</i>			+
Gesneriaceae	<i>Paraboea brachycarpa</i>			+
Gesneriaceae	<i>Microchirita sericea</i>		+	

Effect of fire on Gua Musang and Gua Serai

While quarrying karst hills for cement and other products is often considered the main threat to the limestone flora, fire has become a major hazard as land development destroys the protective buffer zone and open burning is used for clearing vegetation. There are no detailed studies of the effect of fires on the loss and subsequent recovery of the limestone flora apart from that of Chin (1977) for the Gua Musang hills. According to Chin, there were widespread fires in mid-1969 presumed to have been started by lightning. The vegetation on the summits of Gua Musang and Gua Serai was almost completely burnt but a few species managed to survive the disaster. *Radermachera lobbii* trees that are slender and less than 4 m tall burned to the ground, but they produced sucker-shoots that grew about 2 m tall and flowered by August the following year. Trees such as *Cratogeomys maingayi* and *Podocarpus polystacha*, survived the fire due to their thick bark. Fifty years later, the summit vegetation appears to have totally recovered, probably due to the thick peat layer that covers the summit that provided a substrate for re-establishment. The summit of Gua Serai presumably lacked this peat layer and subsequent exposure to rain washed away the soil layer leaving it without a substrate for re-establishment of vegetation. Until today its summit vegetation has not recovered and it remains conspicuously bare.

None of the three hills has a buffer zone of forest, which makes the limestone vegetation vulnerable to fire. During dry weather in 2014, a major fire started on Gua Musang from a discarded cigarette butt and burned from the base up the side of the limestone hill. In 2018, no regeneration was observed in the burnt area when we surveyed the massif. Anthropogenic activities are now the major cause of fire and are particularly destructive because most limestone hills lack an adequate buffer zone (Davison & Kiew, 1990).

What are the implications for conservation?

From botanical surveys of the limestone flora over the past 30 years, patterns of species distributions are becoming clearer.

- Currently, limestone hills with the highest biodiversity are those that have been visited many times over a period of years (Figure 1). Conversely, hills with 'low' biodiversity may rather indicate lack of collecting. This shows that to build up a more complete and reliable database much more investment in time and resources is required. Kelantan with 220 limestone karsts has more than any other state in Peninsular Malaysia but they are still poorly known botanically.
- Many endemic, rare or endangered species are confined to fewer than five hills. At the last count, 80 different hills were home to at least one of these species (Kiew *et al.*, 2017). Conserving just one hill from among a group of hills will not necessarily conserve all the rare and endangered species because, as the flora of these three hills illustrate, they may harbour different assemblages of rare and endangered species. Therefore, a network of hills needs to be conserved in order to protect maximum limestone flora biodiversity, and to prevent the extinction of species.
- The largest hills are not always home to the most species-rich flora, for example, Gua Batu Boh although larger, has fewer species than does Gua Musang.
- Fire is increasingly becoming a major threat to the limestone flora, emphasizing the need for an adequate buffer zone of trees around the base of the hill.

All these points illustrate: (a) the need for intensive botanical collecting to ascertain which rare and endangered species are present before decisions are made on whether a particular hill can be exploited, (b) because no single hill harbours more than a fraction of the flora, a network of hills needs to be legally protected to safeguard maximum biodiversity.

Gua Musang is of particular importance because it is an iconic landscape feature of the town; it is a popular recreational site, has high biodiversity and is home to a significant number of rare and/or endemic species. In addition, it is an outdoor laboratory for studies on the effects of fire on the limestone flora. It requires total protection. Management intervention is needed to establish a forest buffer zone at least 200 m wide around the base of the Gua Musang massif to prevent accidental fires and to preserve the habitat for species at its base (Davidson & Kiew, 1990). These interventions depend on the legal status of the land, and need to be carried out through legislation. The

two adjacent hills, Gua Serai and Gua Batu Boh, should also be conserved because they too harbour rare species not found on the Gua Musang massif. Gua Musang lies on state land while Gua Serai and Gua Batu Boh lie within private property. Limestone hills are nationally designated as Environmentally Sensitive Areas. Gazettement of limestone hills as Totally Protected Areas is strongly recommended (Chua *et al.*, 2009) and where settlements and recreational areas are close to limestone hills, close monitoring of land development by local district authorities is required. A town park comprised of the three hills would be a great idea as they are iconic landscape features of the town.

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Left to right: Gua Batu Boh, Gua Serai and Gua Musang. After almost 50 years since the 1969 fire, the vegetation on the summit of Gua Serai has still not recovered.

Bearish or bullish?

The Market for Ornamental Palms, *Johannesteijsmannia*, in Peninsular Malaysia

Tan Kok Kiat (tankokkiat@frim.gov.my) & Chan Yoke Mui

To investigate the market trend of *Johannesteijsmannia* palms, we surveyed 36 nurseries in Perak, Selangor, Negeri Sembilan and Johor. The demand for these palms has declined, and the market is very much driven by the number of landscaping projects, choice of the contractors or landscape designers, and on an individual's interest in this genus. The prices of the palms varied among nurseries, ranging from RM6 to RM1,000 per palm, based on palm height, years of planting and the quantity requested. Although the local market seems bleak, the potential for international markets in the future seems bright.



Johannesteijsmannia magnifica (behind) and *J. lanceolata* (front).

Introduction

Ornamental plants such as palms are often used as indoor plants or for landscaping purposes. The large-leaved forest palm, *Johannesteijsmannia* (i.e. *J. altifrons*, *J. lanceolata*, *J. magnifica* and *J. perakensis*) which is generally known as Sakai palm by nursery owners, has been commercialised as ornamental plants since the late 1980s (Kiew & Pearce, 1991). The trade of Sakai palms in Peninsular Malaysia was first surveyed 10 years ago (Chan & Saw, 2009) and it was found then that market demand was lukewarm. The palms are mainly traded domestically because export is prohibited (Chan & Saw, 2009). The survey

also indicated that seeds were harvested from the wild for the trade, and there was concern that over-harvesting of seeds could cause regeneration problems of affected populations in the long term.

To reduce exploitation of seeds from wild populations, some 20 years ago a private company in Sarawak, namely, Malesiana Tropicals Sdn. Bhd., made an effort to domesticate *J. altifrons* and *J. magnifica* (Peter Boyce, pers. comm.). The venture started to reap its fruits when the palms began to reproduce regularly 11 years after planting. Although the company has customers worldwide (e.g. in the USA, Brazil, France and Thailand), the trade is still very small with limited sales of seeds (about 50–100 seeds per year) and seedlings (Juliana Chong, pers. comm.). According to Peter Boyce, the palm trade has been brisk since the last decade with markets mainly in the southern parts of North America and Japan. Presently, there is a growing demand from Japan and Taiwan. In the past, the palms were also marketed to Northern Australia but now the demand has ceased because the climate there is not suitable for growing these palms.

Market survey

In October 2018, we conducted a follow-up survey to gauge the current trade of Sakai palms in Peninsular Malaysia with five objectives (Box 1). We either visited or made phone calls to 36 plant nurseries, including 2 wholesalers and 34 middlemen in the states of Perak (Ipoh, Gopeng, Kuala Kangsar and Sitiawan), Selangor (Sungai Buloh), Negeri Sembilan (Mantin) and Johor (Batu Pahat, Muar, Parit Sulong and Yong Peng). We also e-mailed a dealer in Thailand and another in Sarawak, and did some on-line research to investigate the international market.

The objectives of the survey were to determine:

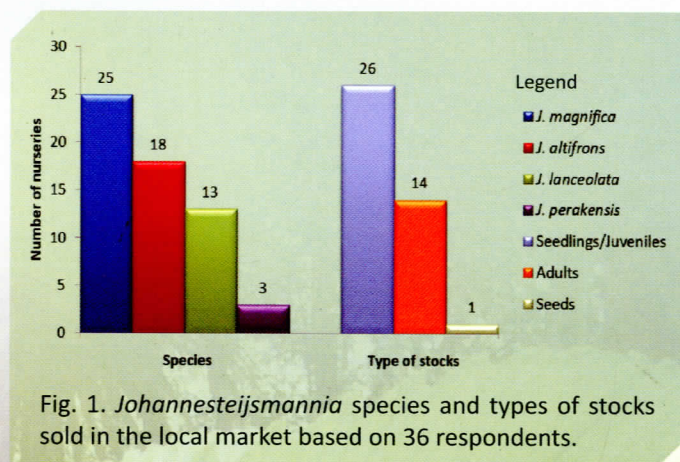
1. What species of *Johannesteijsmannia* are being sold in the market?
2. Whether seeds/plant materials are still being sourced from wild populations?
3. What is the current market demand; has it increased or declined and what are the possible reasons for it?
4. The problems of domestication.
5. The future market potential of the palms.

Major palm supplies came from producers and wholesalers in Muar, Parit Sulong and Yong Peng. From our 36 local samples, only 21 (58.3%) nurseries were selling Sakai palms with stocks ranging from 1–400 palms. Eleven other nurseries would only source the palms from wholesalers, in particular, from Muar, or other local nurseries if there were orders from customers. Another 4 nurseries would source the palms (*J. altifrons*) from Thailand and/or Indonesia.

Among the four species of *Johannesteijsmannia* available in the market (Fig. 1), *J. perakensis* is less commercialised or traded because not many people know of its existence and also perhaps because nursery owners are unable to identify or differentiate this species from *J. altifrons* since both species appear similar at the seedling and juvenile stages. Thus, it is possible that *J. perakensis* is being mistakenly sold as *J. altifrons*. The most common species found in the market are *J. altifrons* and *J. magnifica* because both have attractive diamond-shaped leaves, but customers prefer *J. magnifica* which has leaves with

whitish undersides. On the other hand, not many nurseries want to sell *J. lanceolata* because of its smaller leaf shape.

There are three types of stocks available in the market, namely, seeds, seedlings/juveniles and adult plants. Seedlings or juveniles are the most sought after (Fig. 1). One wholesaler from Thailand and another local nursery sell seeds on-line. Two nurseries in Johor sell more than 400 seedlings per year of all species, except *J. perakensis*.



Seed sources

From our surveys, we found that a wholesaler in Parit Sulong and 2 middlemen still source seeds and seedlings from the local Orang Asli (indigenous people). This particular wholesaler had the largest supply of seedlings of *J. magnifica*, *J. altifrons* and *J. lanceolata*, with the seeds mostly coming from the Orang Asli and some from nurseries in Batu Pahat. When asked about the source of seeds, however, the wholesaler was reluctant to reveal the forest location or the contact number of the Orang Asli who supplied the seeds.

About 10 years ago, a nursery owner from Kuala Kangsar only sold the Sakai palm when customers ordered it. The nursery owner used to go to Bukit Kledang to meet an Orang Asli, to ask him to find the Sakai palm. During one trip, they found three Sakai palms (*J. perakensis*) of adult and juvenile forms, excavated them and sold them to the customers. Now, the nursery owner no longer sells *J. perakensis* because there is no demand, but he can get the stock if there is an order.

Market trend and price

Local demand for the Sakai palms has declined since about 5 years ago. In the past, most of the palms were used for landscaping projects undertaken by the government and private companies. When budgets were reduced in recent years, fewer palms were used and other easy-to-care-for palms such as *Licuala grandis* were preferred. Currently, most of the Sakai palms are sold to locals for house decoration.

Only 10 (27.8%) of the 36 local nurseries surveyed sell Sakai palms domestically and internationally. Customers from Singapore (the Singapore Zoo, Gardens by the Bay and Universal Studios) used to order *J. magnifica* from nurseries in Muar, and the price is higher for Singapore customers than for locals. For example, the export price of a 5-foot tall *J. magnifica* can go up to RM 900 (~S\$ 300) compared to the local median price of RM 200 (Table 1), and if more than 100 seedlings of 3-4 feet height are ordered from Singapore, each is sold at RM 120.

In contrast, according to the dealer from Thailand, demand there has been increasing over the past 20 years, most probably because the genus is much more well-known now. The Thai dealer has been selling between 5,000 and 30,000 seeds of *J. altifrons* every year, mostly to local Thais. The export price was approximately RM 1.25 (US\$ 0.30) per seed. However, sales of other *Johannesteijsmannia* species have been much lower due to the rarity of the species, with prices ranging from RM 4.18 to RM 16.72 (US\$ 1–4) per seed.

Prices of the Sakai palms depend on palm height (from 0.5 foot seedling to 5.5 feet tall adult), years planted and the quantity requested (Table 1); the larger the quantity ordered, the lower the price. Most of the nurseries sell plants of 3-4 feet height for more than RM 100 per plant. Prices were neither stable nor standardised among nurseries. Some small nurseries may sell the palms at a lower price if the palms have been kept unsold for several years. For example, one nursery owner in Muar has only one plant of about 1 foot height that has been kept for more than 5 years. He wanted to dispose of it, so much so that he offered it to the first author for a mere RM 10 compared to the ceiling price of RM 200 in the market. Among the four species, *J. magnifica* is the most popular for its large and elegant leaves with whitish undersides. The price for a palm of 5-6 feet height can range from as high as RM 900 to as low as RM 80, if more than 300 palms are ordered.

Table 1. The range of prices for *Johannesteijsmannia* palms at local nurseries (median in brackets).

Criteria	Price in Ringgit Malaysia (RM)			
Palm Height	<i>J. altifrons</i>	<i>J. lanceolata</i>	<i>J. magnifica</i>	<i>J. perakensis</i>
<1 foot	6–68 (17.5)	6–68 (17.5)	6–68 (15)	6–68 (13)
1–2 feet	15–200 (120)	15–200 (90)	10–200 (80)	20–68 (50)
3–4 feet	50–400 (150)	50–500 (135)	20–600 (142.50)	50–400 (225)
5–6 feet	120–500 (400)	200–500 (280)	80–900 (200)	-
Years planted				
<2 years	120	-	-	-
2–10 years	-	500	500	-
>10 years	-	1,000	-	-
No. of seeds				
1	1–2	1–2	1–2	1–2
10 (packets)	-	-	114.95	-

Table 2: Prices of *Johannesteijsmannia* palms published on websites or from other countries.

Criteria	Price in Ringgit Malaysia (RM)			
Palm Height	<i>J. altifrons</i>	<i>J. lanceolata</i>	<i>J. magnifica</i>	<i>J. perakensis</i>
1–2 feet	-	40	364.80 (S\$120)	-
>10 feet	844.32* (US\$ 201.99)	-	-	-
No. of seeds				
10 (packets)	-	-	114.95* (US\$ 27.50)	250.59* (US\$59.95)
100 (wholesale)	392.20* (€82.60)	-	-	-
1000 (wholesale)	2,231.66* (€470.00)	-	-	-

* Conversion rate based on currency exchange rate in Dec 2018: € 1=RM 4.75, US\$ 1=RM 4.18, S\$ 1=RM 3.02. Original quoted prices in brackets.

Johannesteijsmannia palms were found to be traded online on six websites (accessed on 18th Dec 2018), two in the United States of America, and the one each in Thailand, Malaysia, Singapore and Brunei, respectively. A packet of 100 seeds of *J. altifrons* costs approximately RM 392 while 1000 seeds cost approximately RM 2,231 (Table 2). The average price of a seed of *J. altifrons* in the international market is about RM 2.23.

In the past, seeds of *Johannesteijsmannia* spp. were sold locally at RM 0.50–2.10 each (Chan & Saw, 2009), which is not much different from the current local price i.e. RM 1.00–2.00 per seed. However, this data came from only one nursery because very few local nurseries sell the seeds. Prices for seedlings and juveniles are not stable locally but the prices have increased in certain nurseries over the last few years. Between 2009 and 2018, the price of a packet of 10 seeds of *J. magnifica* sold online or in the international market increased nearly 25%, from RM 91.96 (Chan & Saw, 2009) to RM 114.95, whereas the price of 100 seeds of *J. altifrons* increased about 10% from RM 355.30 to RM 392.20. However, the price of 1000 seeds of *J. altifrons* decreased 9.5%, from RM 2466.20 to RM 2231.66. Possible factors that affect the prices are stock availability and currency conversion rates.

Problems of domestication

Although domestication is very much needed and encouraged for a sustainable trade in palms, it is not without its problems. The Sakai palm is easy to grow under the right conditions but its growth is slow. It may be difficult to convince investors to domesticate Sakai palms which require almost a decade to grow from seed to flowering. In Sarawak, seed set of cultivated Sakai palms is low, e.g., about 300 flowering plants of *J. magnifica* produce only 50 seeds per year (Peter Boyce, pers. comm.). One of the reasons could be that the local climate is very different in the Sarawak nursery from that in the forests of Peninsular Malaysia where this species originates. Furthermore, the seeds of the Sakai palms are recalcitrant and cannot be stored long. They are also big and heavy, making shipment costly (Juliana Chong, pers. comm.). In small nurseries, space constraint is a problem as when the palms grow larger, a leaf can grow up to 3 m long. In certain nurseries, we found that the palms were not well cared for as the leaves were scorched because the plants were not properly shaded.

What is the future market potential for *Johannesteijsmannia* palms?

The majority of the nursery owners (68.4% out of 38 respondents, the 36 local nurseries plus one dealer in Sarawak and another in Thailand) were not sure about the future trade of these palms (Fig. 2). Only seven respondents (18.4%) believed that the palms have market potential in the future because of their rarity, unique shapes and suitability as indoor ornamentals. However, the market is very much driven by the number of projects for landscaping and the choice of plants selected by the contractors or landscape designers. The export market is also restricted by permits and is limited to countries with tropical climates. In conclusion, the Sakai palms are still in demand, albeit with lukewarm response locally, whereas the international market is more promising, where seeds, adult and juvenile palms are in short supply to meet increasing demand.

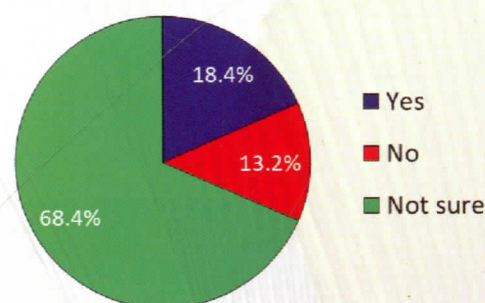


Fig. 2. Response of 38 respondents when asked whether there is a future potential for *Johannesteijsmannia* palms.

The growing demand in the international market is a good sign for the trade, but it also raises our concern about illegal and over-harvesting of seeds from wild populations. Although there is some information on seed production of Sakai palms (Chan & Chua, 2019), we lack data on the current harvesting practices and the proportion of seeds removed, and also studies on how these practices will affect the natural populations. For sustainable utilisation, there is a need to regulate harvesting from the wild and to find ways to encourage domestication of the palms.



Rows of juvenile *Johannesteijsmannia* palms in one of the nurseries in Johor.

Brief facts about *Johannesteijsmannia*:

- Obligate under-storey palms found in primary tropical rainforests.
- Four species in the genus, all endemic to Peninsular Malaysia except *J. altifrons*. These palms are relatively rare and endangered (Dransfield, 1972).
- Conservation status: Endangered (*J. perakensis*, *J. magnifica* and *J. lanceolata*) and Vulnerable (*J. altifrons* which also occurs in Thailand and Indonesia) (Chan *et al.*, 2011).
- Depending on localities, they are known as *daun sang*, *daun payung*, *segalok*, *chica*, *selibar* or Joey palm (Chan & Saw, 2009).
- Average number of fruits produced per year by a natural population (N sample = 30 adults): *J. perakensis* (229), *J. magnifica* (82), *J. lanceolata* (69) (Chan & Chua, 2019).



Healthy Sakai palms of a man's height in a lush nursery at Jalan Sungai Buloh, selling for RM 500 per plant.



Two year-old *Johannesteijsmannia magnifica* (about 1.2 m in height).

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Online survey

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Obituary: Peter O'Byrne (1955-2018)

Ong Poh Teck (ongpohteck@frim.gov.my)

Peter O'Byrne was born in Croydon, United Kingdom. After obtaining a post-graduate teaching qualification at Exeter, Peter and his wife, Judy, went to live and teach in Nigeria and Swaziland followed by Papua New Guinea. During his days in Papua New Guinea, Peter published his first orchid book *Lowland Orchids of Papua New Guinea*, detailing 402 species in 106 genera accompanied by many accurate botanical drawings which he had produced as a self-taught artist.

Peter and his family moved to Singapore after living in Papua New Guinea for 22 years. Peter was an active member, judge, and once, Vice-President of the Orchid Society of South East Asia (OSSEA). He spent much of his time traveling and hunting for orchids in the Malesian region. On these fieldtrips, Peter would be able to climb the steepest mountains so long as he got enough supplies of nicotine and caffeine. When Peter was not in the field, he spent time identifying orchids at the Singapore Botanic Gardens Herbarium and at the Kepong Herbarium, Forest Research Institute Malaysia (FRIM).

Being a flora writer of the Forest Research Institute Malaysia (FRIM) since 2008, Peter revised *Cleisostoma*, *Dendrobium* section *Crinifera* (in part), *Dipodium*, *Robiquetia* and *Stichorkis* for the Flora of Peninsular Malaysia Project. Besides that Peter also authored and co-authored various orchid books including *A to Z of South East Asian Orchid Species* (2 volumes), *Bulbophyllum of Sulawesi*, *Bulbophyllum of Borneo*, *Wild Orchids of Peninsular Malaysia* and *Checklist of Orchids of Peninsular Malaysia*.

His contribution to the knowledge of orchids was enormous – being a polymath, Peter was highly knowledgeable when it came to field trips, cultivation, photography and taxonomy of orchids. He was also a highly skilled botanical illustrator. Most importantly, he was very generous in passing on his knowledge to anyone who was keen to learn about orchids. Peter has mentored several young researchers in the South-East Asian region, turning them into qualified orchidologists.

Being genuinely passionate about orchids, Peter was very concerned about orchid conservation. He frequently expressed great concern about the drastic and rapid depletion of wild orchid populations caused by commercial collectors as well as by habitat destruction. He instilled integrity in his students when collecting wild orchids, that is, to collect just enough materials for scientific purposes.

The demise of Peter O'Byrne on 11th August 2018 is a huge loss not only for his family and friends but to Orchidology as well. Peter set a very high benchmark in Orchidology and it is hoped that the younger generation will carry on his legacy by producing concise orchid accounts in their respective regions.



We welcome articles on new research information on flora or fauna and discussions related to biodiversity or conservation. Please send articles to The Editor, Conservation Malaysia Bulletin, Forest Research Institute Malaysia, 52109 Kepong, Selangor (attn: Dr. Lillian Chua, lilian@frim.gov.my). Conservation Malaysia is published twice a year and hardcopies are free upon request. Please contact the editor for queries or comments. Past issues are available at <http://www.mybis.gov.my/one/publication.php?menu=27&g=1>. Funded by the Ministry of Water, Land and Natural Resources. Editorial team: Dr. Lee Su See, Dr. Lillian Chua and Dr. Chan Yoke Mui.