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THE CRITICALLY ENDANGERED SOUTHERN *LICUALA WHITMOREI* SAW

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Globally there are about 150 *Licuala* species and Malaysia has the most, with 82 species. Regionally, Peninsular Malaysia has 41 species of *Licuala*, while Borneo has 46 (Saw, 1997; 2012). All species, with the exception of *L. spinosa*, are understorey palms found in close canopy forests. They thrive in intact forest under heavy shade and often suffer when exposed in open areas, e.g. after an area is logged. In our forests, they often grow gregariously in huge populations and sometimes different species grow sympatrically. LaFrankie and Saw (2005) have shown that ecologically, these gregarious populations will suppress tree regeneration by each individual creating a dome-like canopy of foliage that will further shade the already shaded forest floor.

Licuala whitmorei at Mersing F.R. under Kapur forest.

In Peninsular Malaysia, Licualas are mostly small to medium-sized palms, and some are tiny, less than 0.5 m tall. The largest palms are just a few metres tall. They exhibit a range of habits, from stemless to stemmed, solitary to clustered, and a combination of these habits. They are attractive plants with fan-shaped, often segmented leaves. They are, however, slow growing plants and are not well featured in the horticulture trade.

In 1997, when I published the revision of the genus, I described a new species honouring Timothy Charles Whitmore (1935–2002), namely, *L. whitmorei*. Tim Whitmore first appeared on the Malaysian forestry scene in late 1965 under a Colombo Plan technical co-operation programme to initiate the Tree Flora of Malaya project. He subsequently edited two of the four volumes of the Tree Flora (Whitmore, 1972; 1973a). He is also particularly remembered for his contributions to synthesising the standard ecological handbook to the forests of Southeast Asia, "Tropical Rain Forests of the Far East" and the textbook "An Introduction to Tropical Rain Forests" (Whitmore, 1975; 1990). Tim as he is known, was also particularly interested in palms. In fact, the success of my Ph.D. research was in part due to the exceptionally large collection of *Licuala* he amassed while he was running the Tree Flora of Malaya project. From his experience while in Peninsular Malaysia, he published the "Palms of Malaya" in 1973 (Whitmore, 1973b).

Licuala whitmorei in polybags photographed in 2005; plants were collected from Mersing F.R. in 1991.

Licuala whimorei is one of the rarest palm species in Malaysia. The description of this new species was based on two specimens collected by Whitmore from Mersing Forest Reserve (F.R.) on 19 September 1970. While conducting the revision of the genus, I tried to visit and recollect Licualas from as many sites where they are found as possible. As the two specimens collected by Whitmore were a new species, I had wanted to relocate the species again. So in July 1991, I went to Mersing F.R. together with Kamarudin Saleh and Mustapa Datah.

Timothy Charles Whitmore (1935–2002)

We found *Licuala* plants there but unfortunately they were all sterile. In *Licuala*, it is difficult to determine species based on sterile material. So we collected a few seedlings from the site and took them back to FRIM to grow. It was indeed exciting when in June this year, a visitor informed me that he saw the species in fruit at Kepong Botanic Gardens (KBG). A later visit confirmed that it was indeed *L. whitmorei* in fruit. The plants had been planted along Razak Trail in 2006 shortly after the trail was created. So this would be about ten years since the collected plants had been planted into the ground and 25 years since I had collected them from Mersing. Only two plants now survive in KBG along the Razak Trail.

Licuala whitmorei, planted along Razak Trail, Kepong Botanic Gardens which fruited in June 2016.

Following the fruiting of the species in KBG, I was very keen to know if the species was still growing in Mersing F.R. We had the opportunity to visit Mersing F.R. again in September 2016, following the Ulu Sg. Sedili Besar expedition organised by the Johor National Parks Corporation, and I am happy to report that the species is still there under Kapur (*Dryobalanops aromatica*) forest. As on our first visit in 1991, the plants were also sterile this time. Vegetatively, the plants looked like our two KBG individuals and I am certain the plants in Mersing F.R. are the same species as we were in a site very similar to where I had first collected the live plants. Unfortunately, we had a rather short excursion and were only able to locate five mature plants. Other Licualas found there were *L. ferruginea* (mostly in the valley areas) and *L. glabra* var. *selangorensis* (sympatric with *L. whitmorei*). Individuals of *L. whitmorei* were found mostly on the middle and upper slopes of the forest; none were found in the valleys. Other palms in the area included *Areca montana*, *Eugeissona tristis*, *Johannesteijsmannia altifrons*, *Calamus lobbianus*, *C. filipendulus* and *Pinanga simplicifrons*.

Herbarium specimens of *Licuala whitmorei* as vouchers from Kepong Botanic Gardens.

Licuala whitmorei is a solitary and acaulescent (stemless) palm with petioles to about 1.3 – 1.5 m long; fronds fan-shaped and segmented. It produces inflorescences extending sometimes beyond the fronds, up to 1.4 m long with 4 first-order branches. The rachilla on the inflorescence is glabrous and corky, cracking into characteristic angular plates in dried herbarium specimens. Fruits are globose, glabrous, green ripening red, about 1 cm across.

The species is endemic to Johor, currently only known in a Kapur forest in Mersing F.R. It is among quite a number of species endemic to southern Peninsular Malaysia. It is rather unfortunate that the compartment where this species is found will be logged soon. A sign has been put up just at the roadside of the compartment boundary informing of a Pre-felling inventory conducted in 2015. As mentioned above, *Licuala* does not do well in exposed conditions. Therefore, I am concerned about the population once the logging starts. The species is assessed as Critically Endangered (CR) based on its limited distribution and the threat to its survival from logging.

It cannot be over-stressed that Peninsular Malaysia contains many species with very narrow endemism and *L. whitmorei* is one such species. This species will survive well if its natural habitats are kept intact. It was first collected in 1970 as a herbarium specimen, live collection made in 1991, and subsequently described in 1997. It fruited in KBG in 2016 and the species is still doing well in Mersing F.R. It is only hoped that the species will survive the impending logging in the forest reserve.

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THE DEATH GRIP OF ANTS INFECTED BY THE BRAIN-MANIPULATING FUNGUS *OPHIOCORDYCEPS UNILATERALIS*

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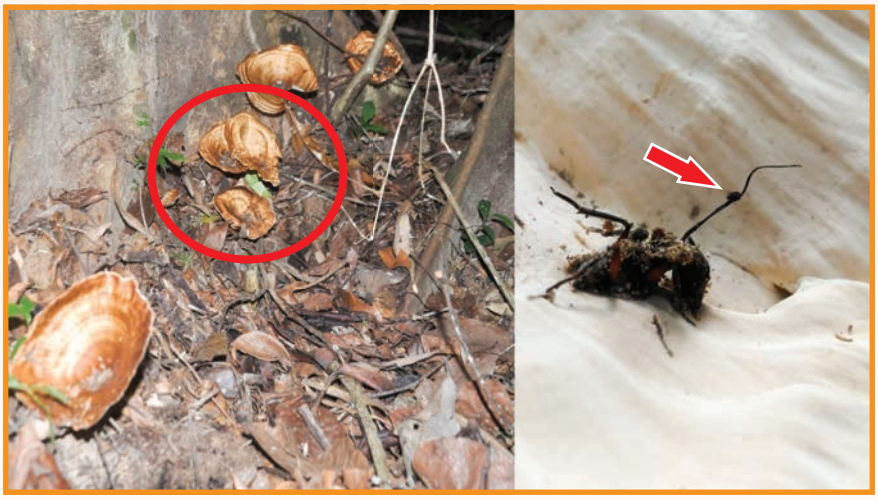
The discovery of *Ophiocordyceps unilateralis* (Tul. & C.Tul.) Petch at Ulu Muda Forest Reserve, Kedah, in April 2016 came as an unexpected surprise while we were conducting a mushroom and insect survey. We found an ant, almost rotted but with an unusual long stalked outgrowth, clamped to the underside of a *Microporus xanthopus* mushroom. Upon closer inspection, we found that this ant had been infected by the brain-manipulating fungus, *Ophiocordyceps unilateralis*. *Ophiocordyceps unilateralis* is an entomopathogenic fungus from the family Ophiocordycipitaceae, order Hypocreales, class Sordariomycetes, and is commonly known as the zombie fungus or brain-manipulating fungus. This fungus has been given such a name because of its ability to take over and completely control the behaviour of its host ant, causing it to grip the vegetation with its mandibles and hang upside down before it dies. In tropical forests, the occurrence of *O. unilateralis* sensu lato on ants from tribe Componotini is common (Evans & Samson, 1984; Evans *et al*., 2011).

Its main host, *Camponotus leonardi* (Hymenoptera: Formicidae), are large ants (size: 0.7 to 2.5 cm), commonly found in tropical forests. Also known as carpenter ants, these ants build nests consisting of galleries chewed out with their mandibles, inside preferably dead or damp wood. However, unlike termites, they do not consume the wood. In nature, these ants nest in trees but can commonly be seen foraging on the ground scavenging for food. The *Ophiocordyceps* fungus which infects ants is known to be host specific with different species infecting different species of Camponotini ants (Araúja *et al*., 2015). Previous studies have also shown that the carpenter ant, *C. leonardi* acts as the principal host for the fungus but it can also occasionally infect ants from the sister genus, *Polyrhachis*, with a lower success rate (Kobmoo *et al*., 2012).



A dead *Camponotus leonardi* (right) infected by *Ophiocordyceps unilateralis* (arrow) attached to the underside of a *Microporus xanthopus* fruiting body (left – red circle).

Ophiocordyceps unilateralis hyphae emerging from the ant's exoskeleton.

The infection of the ant begins when *O. unilateralis* ascospores (sexual spores that are produced inside an ascus) become attached to or are deposited on the worker ant's body and start to germinate. The ascospore forms a germ tube (a germination hypha which is formed by a germinating spore) which is able to penetrate the host's tough exoskeleton by secreting certain enzymes that dissolve chitin. Once the fungus is inside the host, it starts to colonize the host by growing and spreading, eventually taking control of the host's central nervous system. The infected host then develops erratic behaviour that includes leaving its nest and foraging trails. During this event, the exoskeleton of the host remains intact but its innards are eventually consumed by the yeast-like cell phase of the fungus.

The infected ant starts to climb up vegetation and hang upside down on the underside or edge of leaves, twigs, branches, etc. and in our case, the underside of a polypore fungus. It does so by using its mandibles to exert a strong grip onto the underside of the vegetation and remains there until it dies, i.e., a death grip. The attachment of the ant to the vegetation is further secured by a fungal mycelial mat which fastens the tips of the ant's legs to the surface where it is attached. This action is essential to ensure an optimum microclimatic site and prime location (at the proper height above the forest floor) for the next steps of fungal development and spore release (Andersen *et al*., 2009).

View of the stalked fruiting body (stroma) of *Ophiocordyceps unilateralis* on the *Camponotus leonardi* ant under the microscope.

Under suitable temperature and humidity conditions, the stalked stroma (fruiting body) which bears the spores grows out from the back of the host ant's head, and the mature ascospores will be disseminated onto the forest floor. The spores which reach the ground will then infect other ants, and the infection cycle repeated.

Currently in Malaysia, our understanding of the *Ophiocordyceps* genus is very limited compared to our nearby neighbour, Thailand. Further studies on this fungus may contribute to the elucidation of taxonomic, phylogenetic and ecological issues involving this insect-fungus relationship. This record of *O. unilateralis* in the Ulu Muda Forest Reserve, Kedah, highlights the importance of this area as a possible reservoir of undocumented species in Malaysia.

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POLYRHACHIS, THE SPINY ANT

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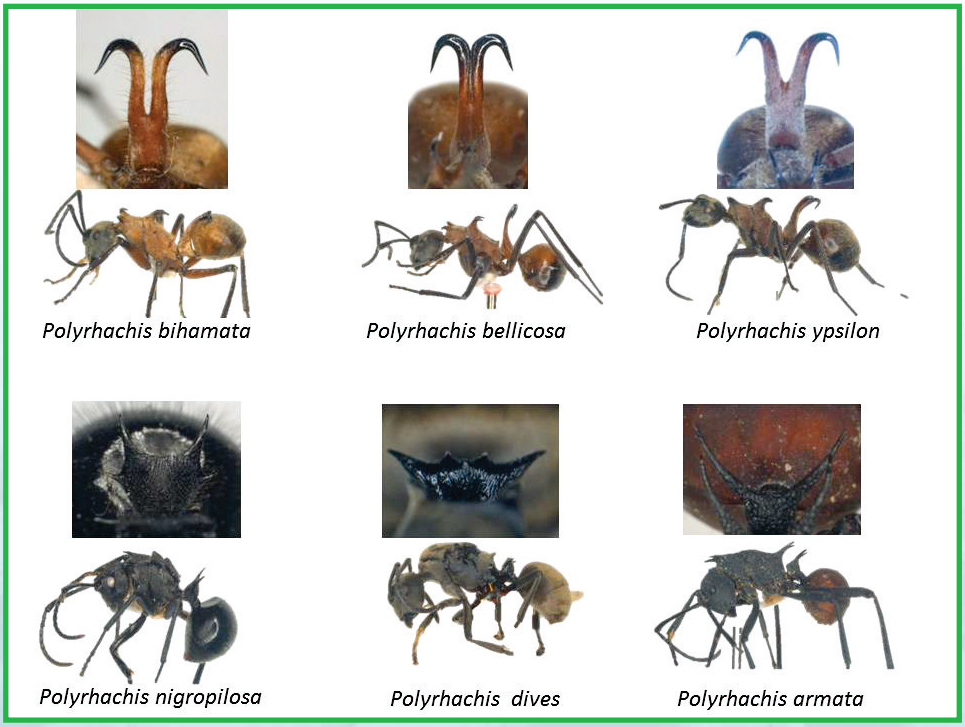
Do you know that ants are not as dull as they seem to appear to our naked eyes? Upon microscopic examination, we will see that there are actually many variations in their features. One of the most beautiful ants that I've ever encountered are ants in the genus *Polyrhachis*. Belonging to the subfamily Formicinae, this genus is different from other ant genera because of the uniqueness of its petiole (commonly called the waist) which is armed with spines or teeth. Most species are black in colour, but many have parts of their bodies, particularly the abdomen, covered in a thick layer of bronze, silver or golden hairs. Every time I encounter this genus of ants in the forest, the petiole will be the first body part that I would examine using a hand lens.

Polyrhachis bellicosa, one of the species covered with bronze hairs foraging on the forest floor. Note the armed petiole (red circle).

The shape of the petiole is one of the key features in the identification of the various species (Kohout, 2014). In some species, the spines may look like a bull's long horns (e.g. *P. bellicosa, P. bihamata* and *P. ypsilon*) while in others they may be a simpler spine-like shape (e.g. *P. armata*, *P. dives* and *P. nigropilosa*).

Hook-like spines on the petiole of the workers in some species of *Polyrhachis* appear to be a very powerful defense apparatus (Hermann & Blum, 1981). The study by Ito and his co-workers (Ito *et al.*, 2016) showed that the presence of spines in *Polyrhachis* provides an effective defense against their predators. Their experimental study using frogs as the predator revealed that the experimental frogs refused to eat *Polyrhachis* sp. which had intact armored petioles. Only a few frogs attempted to eat the ants with the ants ending up stuck in the frogs' mouths. Differences in spine morphology between the queen and the workers also affect the defense potential of the ants. The queen, which mostly remains in the nest and is less likely to be attacked by predators, has much smaller spines compared to the workers that defend their nest and the colony.



Different species of *Polyrhachis* spp. with different forms of the armed petiole.

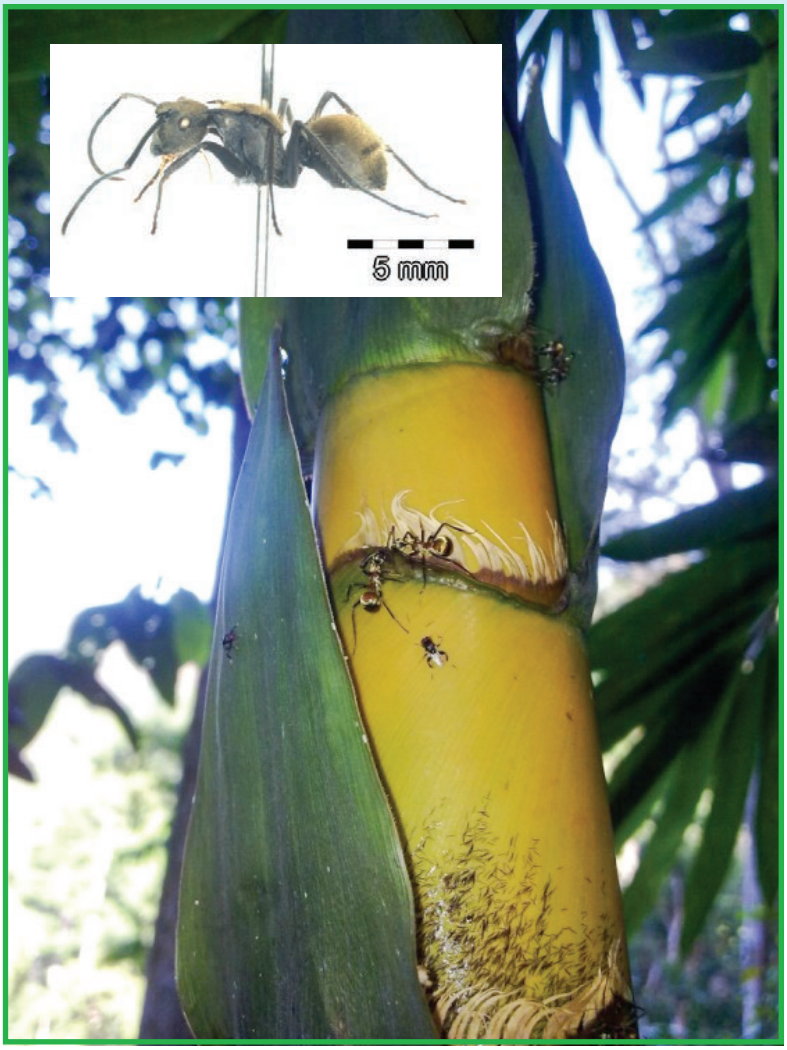
The genus *Polyrachis* is one of the most taxonomically and ecologically diverse ant genera, with over 500 described species, but the complexity of their distribution throughout the forest makes the taxonomical study of this species difficult and far from complete. They are mostly arboreal nesting species and are seldom found in urban areas. These quite large (5 – 10 mm long) and often attractive

ants forage on the ground and run up and down the trunks of trees during the day. However, a number of species are strictly nocturnal.

These ants occupy most of the forest strata and include nest weavers, soil and tree dwellers (Wilson, 1963). The nest weaver *Polyrhachis* (e.g. *P. dives*) nest amongst the foliage of trees and shrubs and build their nest by webbing leaves together with silk produced by the larvae. This behavior is similar to that exhibited by another species of ants, *Oecophylla smaragdina*, locally known as the weaver ant or kerangga.

Polyrhachis illaudata, is one of many spiny ant species that nest in the ground or in fallen tree trunks or large branches. This ant is black but covered by short dense hairs that gives it a metallic golden colour. The workers are active during the day and are usually seen running up and down tree trunks foraging for food.

Polyrhachis ants are relatively shy and will retreat back into their nest when disturbed. However, there are some exceptions. During several expeditions, we encountered *P. nigropilosa*, the black spiny ant, which nests in hollowed bamboo and makes a unique rattle-like sound caused by the workers rushing out from the nest and shaking their bodies violently against the bamboo walls when disturbed.



Polyrhachis illaudata foraging on bamboo shoot. Inset: *P. Illaudata* magnified.

The variation in the spines and hairs of *Polyrhachis* makes them one of the most interesting species of ants to be discovered. Not only do these ants have interesting features, they are also good indicator species of disturbance due to their vulnerability and dependence on undisturbed natural habitats. Their presence is significantly reduced in open logged over areas compared to forested areas (Nur-Zati *et al.*, 2011).

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BEGONIA PHOENIOGRAMMA RIDL. IN BUKIT TAMPIN

The first record for Negeri Sembilan

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Two colour morphs of *Begonia phoeniogramma* – one with leaves which are bluish green above and magenta below (left), and the other with light green leaves (right).

A new record of *Begonia phoeniogramma* (Begoniaceae) for Negeri Sembilan was made when I first collected the species in 2008, from Bukit Tampin recreational forest in the Tampin Forest Reserve. At that time, I found only two tiny plants growing on a single rock in a tributary of Sungai Tampin, with one of them in flower. I trekked along the stream but couldn't find any other plants nearby, and wondered where the main population was. It was not until recently in June 2016, when I was on a trip to monitor the population of *B. tampinica* in the same area, that I made this discovery. I had mistakenly deviated from the usual trail and ended up at a massive boulder sitting on the hill slope. On top of the boulder, there was a clump of about 20 plants of *B. phoeniogramma*, partially covered with leaf litter. Many more seedlings were growing on the vertical rock face. The population has two morphs: one with concolourous light green leaves, and the other with leaves which are bluish green above and magenta underneath. Both morphs lack spots. The small flowers (c. 1.5 cm diameter) are pretty – the white tepals are ornamented with red stripes (a distinctive character for the species) and the stamens and stigmas are yellow.

From my personal observations on the flowering of a potted individual, a male flower opened first, followed by a female flower, nine days after the male flower had dropped off. This temporal gap between male and female flowering in an inflorescence is a strategy to avoid selfing and promote outcrossing. However, self-compatibilty or selfing within the same plant was possible when another male flower of a new inflorescence, opened one day after the female flower of the first inflorescence was receptive. In the absence of pollination, the male flowers lasted for 7–9 days before they abscised, whereas the female flower was open for a week. Both male and female flowers were wide open in the morning, half closed in the evening and fully open again the next morning. In the wild, the flowers are visited by stingless bees, which presumably are also the pollinators.

Close-up of the plant and male flowers.

Female flower

The discovery of *B. phoeniogramma* in Tampin marks its southernmost distribution. Prior to this collection, the species was mainly found in the Gombak area (i.e., Ampang, Batu Caves, Bukit Lagong, Gabai and Genting Bidai), Sungai Lalang and Sungai Buloh in the state of Selangor (Kiew, 2005). It was never recorded outside Selangor until a specimen was collected from Bentong in 2006, which represents a new record for Pahang (KEP herbarium database, FRIM). The population at Bukit Lagong has two colour morphs similar to that of Tampin, whereas, the one at Batu Caves has spotted and unspotted leaves. The conservation status of the species in Malaysia is near threatened (NT), caused by a combination of threats from human settlements and tourism (Malaysia Plant Red List assessment, unpublished data).

To the untrained eye, *B. phoeniogramma* may easily be confused with *B. integrifolia* which looks very similar (Kiew, 2005). *Begonia integrifolia* differs in not having prominent red stripes on the tepals. The close morphological similarities in both species suggests that they may share the same ancestor, but genetic studies would be needed to elucidate whether they are distinct species.

Begonia phoeniogramma from Bukit Lagong, Selangor. Left: Female flower and bud with inferior ovaries. Right: The dark-leaved morph with reddish male flowers.

For now, *B. phoeniogramma* joins the list of a treasure trove of rare or threatened species recorded from the Bukit Tampin area (Table 1). Among them is *B. tampinica*, which is critically endangered and endemic only to Bukit Tampin. *Begonia tampinica* also shares the same niche with *Argostemma tenue*, another narrow endemic (see back issue 14, 2011). All these three species are highly niche specific and localised (they are found within a short stretch of 500 m of the riverine system). Hence, it is highly recommended that Bukit Tampin be gazetted as a High Conservation Value Area (HCVA) to protect and conserve these highly sensitive and vulnerable species.

Begonia integrifolia in Langkawi, Kedah (left) and Bintang Hijau, Perak (right).

Unspotted (left) and spotted (right) leaves of *B. phoeniogramma* from Batu Caves, Selangor.

Table 1. Rare or threatened species found in Bukit Tampin and nearby areas.

Locality	Family	Species	Conservation Status*
Tampin F.R.	Thymelaeaceae	*Aquilaria malaccensis*	VU[1,2]
Tampin F.R., Bukit Tampin	Begoniaceae	*Begonia phoeniogramma*	NT[1]
Tampin F.R., Bukit Tampin	Begoniaceae	*Begonia tampinica*	CR[1], endemic
Tampin F.R., Bukit Tampin	Rubiaceae	*Argostemma tenue*	unknown
Tampin F.R., Gunung Tampin	Memecylaceae	*Memecylon floridum*	LC[1], VU[2]
Tampin F.R., Gunung Tampin	Myristicaceae	*Knema hookeriana*	VU[2]
Tampin Road	Dipterocarpaceae	*Anisoptera laevis*	VU[3], EN[2]
Tampin	Dipterocarpaceae	*Anisoptera megistocarpa*	VU[3], CR[2]

* CR: critically endangered, EN: endangered, VU: vulnerable, NT: near threatened, LC: least concern [1] Malaysia Plant Red List, [2] IUCN Redlist, [3] Chua *et al*., 2010.

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