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# The Grim Reaping of Gaharu – a tale of greed, gold and gored trees

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*Gaharu* has been coveted for thousands of years by many different communities for its scent as well as for medical and cultural applications, commanding high prices as a valuable trading commodity. *Aquilaria malaccensis* and *A. hirta*, locally known as *karas*, are the main sources of *gaharu* in Peninsular Malaysia. The trees produce the much sought-after resin as a wound reaction, usually due to a secondary invasion of the wound by pathogenic fungi. Once common in our forests, natural stands today have been decimated by the ruthless harvesting of whole trees, including their roots and branches. Enormous demand over the past three decades has driven up the market value of first grade *gaharu* to *ca.* RM 30,000/kg, and wealthy end-user markets in the Middle East and Japan are willing to fork out princely sums for the commodity.

The four native species of *Aquilaria* (Thymelaeaceae), namely *A. malaccensis*, *A. hirta*, *A. beccariana* and *A. microcarpa* are listed as vulnerable on the IUCN Red List of Threatened Plants, while the genus is listed on CITES Appendix 2, primarily because of their heavy exploitation as *gaharu* producing trees. The first two species are more well-known and more widely distributed compared to the latter two.

In view of the increasingly critical outlook for the survival of wild stands, a research project that includes conservation, genetics and tissue culture studies was initiated by FRIM in 2007. A population mapping exercise of both *A. malaccensis* and *A. hirta* at five different locations in Peninsular Malaysia collected data that provided preliminary insights into the viability, reproductive capacity, and anthropogenic interference levels, and provided a background for parallel genetic and tissue culture protocols aimed at producing better varieties for *gaharu* plantations. The locations chosen for the mapping exercises were Sg. Udang Forest Reserve (FR), Melaka (*A. malaccensis*), Hulu Terengganu FR Tambahan, Terengganu (*A. hirta*), Bukit Bauk FR, Terengganu (*A. hirta*), Lata Kekabu, Perak and Tasik Bera (Ramsar Site), Pahang (*A. malaccensis* and *A. hirta*).

The data collected revealed a worrying scenario characterised by signs of unabashed human greed. All populations surveyed are located in protected areas, but in each, man-made wounds to induce *gaharu* response was evident, though to varying extents. In three populations 50 to more than 80% of all plants were affected by slashing, and more than 50% of those plants were seriously compromised by cuts that reached deep into the heartwood; stems were bent over due to deep slashes beyond crown-bearing capacity, or cuts had been made over a substantial part and

At Lenggong. This mature tree contained *gaharu*, which cost its life. It was found chopped down to chips. The location?...right next to the cobbled walkway in the main recreation area at Lata Kekabu, Tasik Raban, Lenggong, Perak!

At Sg. Udang FR. Makeshift scaffolding allows collectors to reach higher locations on the trunk which is slashed mercilessly in attempts to force the production of *gaharu*.

▲ At Bukit Bauk FR. Greed for quick profit does not stop at protected sites or at immature trees. Almost all the individual plants were slashed, often severely enough such that the injured stems were unable to bear the crown and bent over.

▲ At Sg. Udang. The bole of this tree was devoid of its bark and slashed all around to a height of about 3.5 m, likely with an axe that caused deep incisions in the outer cortex.

▼ Twig of *Aquilaria malaccensis*. The graceful appearance of a young twig of *A. malaccensis*, taken in Tasik Bera, betrays the peril faced by these plants.

length of the stem. In several populations mature trees were scarce or absent, and few of the observed predominantly juvenile plants had a diameter of more than 5 cm; one population of a total of 130 recorded plants counted only 4 individuals with a diameter of more than 10 cm.

Although extinction of these trees may not be imminent, the merciless exploitation and with it population decimation, coupled by shrinking habitats, complex reproductive ecology, recalcitrant seeds and irregular reproductive cycles (Soehartono & Newton, 2000), portend a potentially dire outlook for their survival. Urgent, committed conservation is needed to stem the decline of populations in the wild. Tasik Bera, which had the most encouraging population profiles of both *A. hirta* and *A. malaccensis*, holds potential for engaging indigenous people in the conservation process. The Semelai communities living around Tasik Bera have a strong sense of ownership for the forests, and provide a constant presence on and around the lake system, likely discouraging poaching and unauthorised access to the forests.

Equally important is intensified research into efficient means of artificial propagation that would reduce reliance on wild-collected seed material that further burdens natural stands. The high price of *gaharu* and continued increasing demand justify the establishment of plantations, but priority needs to be given to research into unlocking the secret to first-grade *gaharu* production in plantation trees before such plantations can be profitable. Several Malaysian institutes, including FRIM, have researched the genetic make-up, pathogenic inoculation agents, period of exposure to causative agents, artificial propagation, chemical composition, and the effects of tree maturity and environmental factors on *gaharu* production. However, to date, we have yet to develop the protocols required for plantation-scale production of *gaharu*. The protocol currently available to stimulate the production of *gaharu* in the Malaysian populations of *A. malaccensis* and *A. hirta* has not been put to test on a commercial scale. There is much ground to cover, and little time.

*Gaharu* has delighted mankind for centuries with a unique blend of scents that artificial means have up to this day not fully succeeded in reproducing. Instead of safeguarding this treasure, the sad situation of *karas* once again painfully demonstrates some of the dubious apocalyptic tendencies of human nature.

**Suggested reading:**
**Soehartono T. & Newton AC. 2000. Conservation and sustainable use of tropical trees in the genus *Aquilaria* 1. Status and distribution in Indonesia. Biological Conservation 96: 83-94.**

# Weevil Knievel – pinning down the coleopteran pollinators of Malaysian *Cycas*

By Jutta, M. (waldelf@gmail.com), Shahlinney, L., Azmi, M., Ong, S.P. & Saw, L.G.

Microsporophylls of *Cycas macrocarpa* showing the exit holes of young beetles after hatching (circle).

*Cycas macrocarpa*

Beetles on the prowl, on a pre-anthesis male cone *C. litoralis*.

Pollen-coated beetles on a *C. clivicola* cone in full anthesis.

*C. clivicola* perching comfortably on a sheer vertical rockface.

Cycads were long believed to be anemophilous (wind pollinated). Mounting evidence from recent studies, however, indicate highly specific and interdependent relationships with insect pollinators. Thrips, stingless bees and a variety of beetles have been implicated as potential pollinators, but most of the evidence points towards a group of host-specific weevils in the superfamily Cucurlionoidea, the largest known family group in the animal kingdom, with 62,000 described species in 5,800 genera (Oberprieler *et al.,* 2007). Cycads in different continents are associated with different genera of these snout-nosed arthropods (Oberprieler, 2004).

Work on the pollination ecology of Asian *Cycas,* the oldest extant cycad genus, began only recently. A study conducted in the mid-90s yielded 26 new weevil species from South East Asian *Cycas*. Most belonged to the genus *Tychiodes* (Cucurlionoidae) with a lesser number from the genus *Xenocryptus* (Erotylidae).

These studies, however, did not include populations from Peninsular Malaysia. Recent weevil collections from three native species of *Cycas,* namely *C. litoralis*, *C. clivicola* and *C. macrocarpa* plus specimens collected from a recently discovered population in the Ledang district of Johor have yielded new insights into the identity of *Cycas* pollinators. The findings corroborate other data on Asian Cycas, with most insects found in this study being *Tychiodes,* and to a lesser extent, *Xenocryptus* and bees of the genus *Trigona* (Apidae).

Specimens of *Tychiodes* were harvested from all four indigenous species of *Cycas*. Specimens harvested from *C. clivicola* and *C. macrocarpa* were identical in morphology, but may represent two separate species due to a distinct difference in size. Collections from *C. litoralis* were overall the smallest and different in size, width and colour compared to the other species. Specimens from the Ledang population were morphologically different from all other collections, indicating a separate species of *Tychiodes* (M. Azmi & S.P. Ong, pers. comm.).

Identification of weevil specimens beyond the genus level is complicated by the lack of a reliable key for this group of beetles. Beetle taxonomy is still very much in a flux and far from complete. Based on the fact that only 25% of the estimated 220,000 weevil species (note, just weevils!) have been described today, it will take another 650 years to complete documentation of this group of beetles alone (Oberprieler *et al.*, 2007)!

Weevils and cycads form obligate mutualistic symbioses. The insects complete their entire lifecycles in the male cones and some species are known to undergo a period of dormancy (diapause) in the soil that likely coincides with periods of reproductive dormancy in the cycad. Sporadic visitation to fertile female plants, aided by sophisticated biochemical communication, is a prerequisite for cycad pollination. The low reproductive rate of cycads precludes regular coning of individual plants. In decimated populations, a paucity of male plants may adversely affect the continued presence and the number of weevils. This in turn may impede the ability of female plants to 'reach' weevil pollinators via biochemical signals thereby adversely affecting pollination rates of female plants, and further compromising the extremely low recruitment rate common to cycads. The cycad-weevil relationship once again reminds us of the potentially dire consequences when and where anthropogenic actions, in this case intensive commercial harvesting to feed the international trade in ornamental plants, compromises the ecological balance present in a given habitat.

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# Rare Monotypic Limestone Genera in Pahang and Kelantan

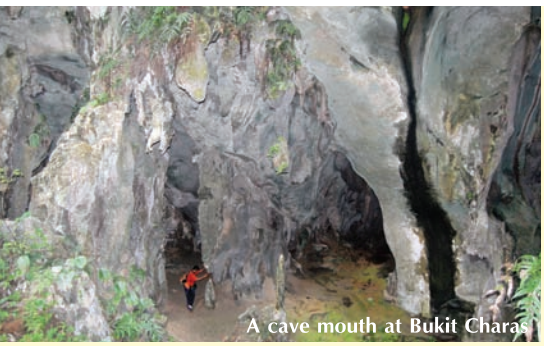
By Rafidah, A.R. (rafidahar@frim.gov.my), Kiew, R. & Mohd. Hairul, M.A.

In Peninsular Malaysia, there are more than 300 scattered limestone hills that harbour about 1,216 vascular plant species in 582 genera and 124 families. Two hundred and sixty-one species are endemic to the peninsula of which 130 are restricted to limestone habitats. Many of these endemics are rare and some are found only on a particular hill or group of hills and nowhere else.

Of special conservation importance are monotypic genera, i.e., genera that have only one species, because if the species becomes extinct, the genus goes extinct with it. Here we highlight three such genera that are restricted to limestone hills, all belonging to the African violet family, Gesneriaceae. In addition, they have restricted distributions. *Emarhendia bettiana* is known only from Bukit Charas and Bukit Panching, Pahang. *Senyumia minutiflora* grows only on Gunung Senyum and the adjacent Gunung Jebak Puyuh, Pahang, while *Spelaeanthus chinii* is known from several hills in southern Kelantan as well as from limestone hills in Taman Negara, Pahang.

All three species are confined to shady niches and have a similar appearance in their rosette habit with thin, pale green, very soft leaves with sticky hairs. The function of the sticky hairs is not known but they may make the leaves unpalatable to herbivores.


The thin sticky leaves of *Emarhendia bettiana* (A), *Senyumia minutiflora* (B) and *Spelaeanthus chinii* (C).



A cave mouth at Bukit Charas

Flowers of *Emarhendia bettiana*

## *Emarhendia bettiana*

Bukit Charas, known as Bukit Cheras in older literature, is approximately 24 km north-west of Kuantan, Pahang. A recent study enumerated a total of 249 plant species in 175 genera and 82 families, of which 30 species are Peninsular Malaysian endemics. There is a temple with a large reclining Buddha in one of the caves so it is frequently visited by tourists. The presence of the temple offers some form of protection, albeit temporary, but the threat to the population still exists because there are stairs that allow visitors to climb up the hill. This outcrop reaches about 237 m high.

*Emarhendia bettiana* is a very fragile, soft perennial herb with stems up to 45 cm long. It grows adpressed to rock surfaces clinging by fine, fibrous roots. The lower part of the stem is bare of leaves but sometimes bears side rosettes. The leaves are membranous, very thin and delicate, arranged in opposite pairs that form rosettes. A unique feature is a patch of glands on the upper lip of the corolla. Populations of mature individuals can be found on shaded moist cave walls and ledges. This species is Critically Endangered because it grows only on Bukit Charas and Bukit Panching. Bukit Panching is mined for cement while Bukit Charas is heavily visited and not legally protected. There is therefore a need for a management plan to conserve this species at Bukit Charas. Bukit Panching cannot be conserved as it already has a license for mining.


Senyumia minutiflora

## *Senyumia minutiflora*

This species derives its generic name from Gunung Senyum which is located about 68 km from Temerloh, Pahang. The hill rises to about 1,549 m asl and is an archaeological site. There are 19 fascinating caves which are heavily visited by tourists and study groups alike. Gunung Senyum is partially surrounded by oil palm estates while the adjacent Gunung Jebak Puyuh is surrounded by lowland forest.

*Senyumia minutiflora* is a perennial herb with a decumbent, rather stout, somewhat woody stem covered with long, soft white hairs. The membranous leaves are opposite and arranged in a dense, many-leaved tuft or rosette at the top of the stem. It grows in shade on rock faces. It was previously quite common within the large cave, and existing populations are found on more remote rock faces away from visitor pressure. The species is Critically Endangered because of its narrow distribution and the potential mining threat to the limestone hill. This species is currently under long-term monitoring, an activity jointly undertaken by FRIM and the Pahang State Forest Department.


Gunung Senyum


Spelaeanthus chinii

## *Spelaeanthus chinii*

*Spelaeanthus chinii* grows at Gua Bama, situated some 500 m from the main Kuala Lipis-Gua Musang road in Kuala Lipis, Pahang.

The stem of *Spelaeanthus chinii* has purplish soft, sticky hairs and is rhizomatous at the base. The leaves, in shades of grey to green, are crowded at the top. Its purplish petiole is also covered with sticky hairs. The inflorescences are light brown with soft hairs. Plants of all ages and sizes can be observed at Gua Bama indicating a viable population. The species also grows at Batu Luas in Taman Negara where it is totally protected. From a conservation viewpoint, this species is vulnerable.


Gua Bama

## Conclusion

Limestone hills in the peninsula suffer from a lack of protection and haphazard use for development purposes. These hills have traditionally and up till today been viewed only as areas important for mining. The ignorance about their unique plant diversity has persisted and led to more hills being licensed for quarrying activities. There is a need to develop a long-term strategy for the utilisation of limestone hills with a view to conserving their biodiversity, cultural, geological and archaeological values. There is also a need to develop management plans to ensure that recreational activities do not impact on biodiversity. To support the conservation of these limestone hills and their denizens, there is a need to create more awareness among the public and relevant stakeholders.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(*Continue from page 3)*


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Oberprieler, R.G. 2004. “Evil weevils” – the key to cycad survival and diversification? Lindstrom, J.A. (ed.) The Biology, Structure and Systematics of the Cycadales. Proc. 6th Int. Conf. on Cycad Biology, Thailand. Pp.170-194.

Oberprieler, R.G., Marvaldi, A.E. & Anderson, R.S. 2007. Weevils, weevils, weevils everywhere. Zootaxa 1668: 491-520.

# Macrofungi of Fra

Macrofungi, more commonly known as mushrooms, are fungi with large fruiting bodies that are visible to the naked eye. There are many different kinds of macrofungi such as agarics, brackets, puffballs, cup fungi, jelly fungi, coral fungi, stinkhorns, etc.

Fungi play important roles in the forest ecosystem. Many are involved in litter decomposition, nutrient cycling and symbiotic mycorrhizal associations with higher plants, while others are pathogens causing diseases and death of other organisms. Yet others are important sources of food for forest inhabitants such as small mammals and arthropods. In Malaysia, only about 3,000 species of fungi have been documented, most of them consisting of microscopic fungi. Information on Malaysian mycodiveristy, i.e., the diversity of fungi, is lacking and it is estimated that up to 70% of the fungi in Malaysia have yet to be discovered and described.

Fraser's Hill, at 1,500 m above sea level and located on the Titiwangsa Range in Pahang, is rich in macrofungi. Many species are found in the upper hill dipterocarp and montane oak forests of the area with the latter ecosystem believed to harbour a high diversity. The cool and humid climate with temperatures of between 17 and 25$^{0}$C and the natural vegetation appear to create optimal conditions for fungal growth.

Both agaric (soft fleshy fungi with gills) and polypore fungi (woody fungi generally with pores on the underside) can be found at Fraser's Hill. In this article, we illustrate 19 common macrofungi that are frequently encountered while the less common macrofungi will be illustrated in a forthcoming issue.

**Surveys of macrofungi at Fraser's Hill were carried out as part of a larger study on the diversity of macrofungi of Peninsular Malaysia entitled "Survey, Inventory and Documentation of the Flora and Fauna Biological Diversity of Malaysia". Collections of macrofungi were made twice in 2007, almost monthly in 2008 and monthly in 2009 with surveys still on-going. Collections were made along the road banks and several forest trails in Fraser's Hill, and at Jeriau Waterfall.**

## Division Ascomycota

*Xylaria* sp. (Xylariaceae), commonly known as "Dead Man's Fingers" because of its club-shaped to finger-like fruiting bodies, grows in clusters along mossy road banks.

*Leotia* sp. (Leotiaceae), commonly called "Jelly Baby", is fairly common at Fraser's Hill and grows among the mosses and liverworts along the roadbanks. It has a jelly-like fruitbody with olive yellow cap and stalk.

## Division Basidiomycota, Order Boletales, Family Sclerodermataceae

*Scleroderma* spp., known as earth balls, split open when mature to expose the spores. Several species are found at Fraser's Hill, of which one of the more common ones is shown here.

# aser's Hill (Part 1)

By Thi, B.K. (thibeekin@frim.gov.my) & Lee, S.S.

## Division Basidiomycota, Order Agaricales, various families

The Agaricales is a very large order consisting of many diverse families of mushrooms. Members of six families are illustrated here.

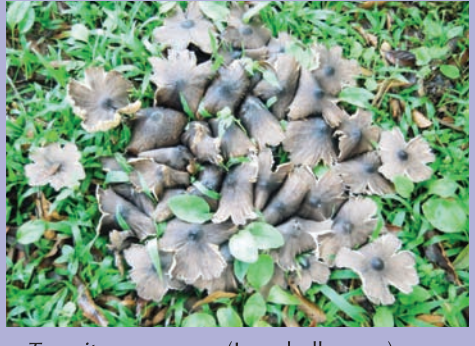
*Amanita angustilamellata* (Amanitaceae) is recognised by its shiny dark brown cap, a striate margin, a cup-shaped volva at the base of its stem, and lacks a ring on its stem. This fungus has a white spore print.

This unidentified *Entoloma* sp. (Entolomataceae) has a conical, pointed cap and pinkish gills. The spores are pink and cuboid in shape.

This unknown *Lepiota* sp. (Agaricaceae) also has white spores but they are different microscopically from those of the Amanitaceae. It has a ring on its stipe like many species of *Amanita* but it does not have a volva at the base of the stem.

Species of *Hygrocybe* (Hygrophoraceae) are called 'wax caps' because of the waxy feel of the cap. They are brightly coloured yellow, orange or red and have white spores. This tiny red-capped *Hygrocybe* grows on mossy banks along the main roads at Fraser's Hill.

*Coprinellus disseminatus* (Psathyrellaceae). These tiny 'ink-caps' autodigest into an inky mess as they mature. They have a black spore print and grow in large numbers on dead logs.



*Termitomyces* sp. (Lyophyllaceae) grows gregariously among the grass along the roadside. This fungus is one of several species of the edible *Termitomyces* which are associated with termites.

## Division Basidiomycota, Order Boletales, Family Boletaceae

Members of the family Boletaceae have pores on the underside of the cap. Many members are ectomycorrhizal, i.e., forming symbiotic associations with trees in the families Dipterocarpaceae, Fagaceae and several others.

*Tylopilus nigropurpureus* which is frequently encountered at Fraser's Hill has a dark brown to black, finely velvety and cracking cap. The stem has a network of ridges (reticulate) and the pore surface changes from pale pink to black when injured (see the dark line on the left mushroom above).

This unidentified species of *Boletus* also grows on the mossy banks. It has a brown cracking cap and the pore surface bruises light blue.

A common bolete at Fraser's Hill, *Pulveroboletus ravenelii* is bright yellow. When in season, it grows gregariously all over the forest floor and can be easily spotted among the dark brown litter and soil.

# Division Basidiomycota, Order Russulales, Family Russulaceae

In Malaysia, these fungi form ectomycorrhizal associations with trees in the Dipterocarpaceae and Fagaceae. The genera often encountered are *Russula* and *Lactarius* and many species, especially of the former can be found. However, due to a lack of taxonomical studies of tropical Russulaceae, many have yet to be identified.

◀ *Russula* has a convex to depressed cap in a wide range of colours, white to cream-coloured gills and a white to ochraceous spore print.

*Lactarius*, commoly called the milk cap, produces droplets of milky fluid when injured. The colour of the milk and whether it changes colour after exposure to air are useful characters used for identification. When damaged this specimen produces white milk which turns pinkish brown (see mushroom on the right). ▶

# Division Basidiomycota, Order Russulales, Family Stereaceae

*Stereum ostrea* grows on fallen tree trunks. The sporocarp has concentric zones and a smooth to velvety upper surface. This thin and flexible bracket-like fungus is characterised by a smooth undersurface.

# Division Basidiomycota, Order Geastrales, Family Geastraceae

The genus *Geastrum* has a star-like appearance hence its common name, the earth star. A small opening at the center of the spherical structure releases puffs of spores when hit by raindrops.

# Division Basidiomycota, Order Polyporales, Families Polyporaceae, Hymenochaetaceae

▲ *Perenniporia* sp. (Polyporaceae) has a smoky grey resupinate sporocarp and minute pores. It causes white rot in

▲ *Phellinus* sp. (Hymenochaetaceae) has a brown context, grows in layers and is effused-reflexed. It causes a distinctive pocket rot.

Many bracket or shelf-like fungi of the order Polyporales grow on tree stumps, trunks, dead branches and twigs at Fraser's Hill.

Members of the Polyporaceae have diverse forms—they can be resupinate, i.e., forming a skin-like layer, or corky to woody, forming annual to perennial shelf-like to bracket-like fruiting bodies. The fertile layer or hymenium is poroid consisting of many tiny pores where the spores are borne.

Hymenochaetaceae is widespread and has many important plant pathogens and wood-decay fungi. Their fruit bodies are generally cinnamon to brown becoming black with potassium hydroxide (KOH).

The Editor: Conservation Malaysia Bulletin, Forest Research Institute Malaysia, 52109 Kepong, Selangor D.E. (attn: Dr. Lillian Chua lilian@frim.gov.my or Dr. Saw Leng Guan sawlg@frim.gov.my). Conservation Malaysia is distributed free upon request. We welcome any contribution or feedback. Send contributions or address comments and queries to the editor. Past issues are available at http://www.tfbc.frim.gov.my. Funded by the Ministry of Plantation Industries and Commodities. Design by: Aslina Baharum (FRIM). Editorial team: Dr. Lee Su See, Dr. Laurence G. Kirton, Dr. L.G. Saw and Dr. Lillian Chua.