

Sabah Ficus Germplasm Centre (SFGC), Tabin Wildlife Reserve, Sabah

ZAINAL ZAHARI ZAINUDDIN & JOHN PAYNE*

Abstract: Sabah Ficus Germplasm Centre (SFGC) is a programme that collects and propagates the genetic diversity of native *Ficus* species of Borneo. The facility is situated in Tabin Wildlife Reserve, Sabah and is a resource worthy of description and explanation. The background leading to its establishment sheds light on the kinds of thinking needed nowadays in nature conservation programmes. The development and current management of SFGC are described in this paper.

Keywords: *Ficus*, propagation, *ex-situ*, Sabah

INTRODUCTION

Ficus (Fig)

Ficus (family Moraceae) is a genus of woody plants containing trees, shrubs, climbers, epiphytes as well as hemi-epiphytes, commonly known as strangler figs. There are about 150 species that occur in Borneo (Kochumen and Go, 2000; Berg and Corner, 2005). The *Ficus* genus is collectively known in English as ‘fig’, and in Malay and Indonesian as ‘ara’. These terms are often used to refer to both the genus *Ficus* and its fruit.

The ‘fruit’ is actually an inflorescence in an enclosed receptacle, known technically as a syconium (plural syconia). The syconium contains numerous small flowers that are closely-packed, a feature that is immediately apparent when the fruit is cut open. Each syconium has a very small, natural opening, known as the ostiole, that allows tiny female wasps (family Agaonidae) to enter and lay their eggs. These wasps also pollinate the flowers inside. About 35% of all *Ficus* species are monoecious, in which each syconium contains both female and male flowers, while the remaining species are dioecious – separate female and male plants.

Ficus syconia are a significant component of the diet of many frugivorous birds, fish and mammal species. The genus is an important food for the Bornean orangutan, binturong and hornbills, especially the helmeted hornbill, the most endangered Bucerotidae. The wide consumption of syconia by numerous wildlife species (Corlett, 2017) can be attributed to its diverse species (Berg and Corner, 2005) and availability throughout the year, as it fruits even during off-season (Harrison *et al.*, 2003; Shanahan *et al.*, 2001). However, *Ficus* is not only less nutritious by weight, but also has few natural toxic metabolites compared to other rainforest fruits. The plant seeps out white, milky latex (in some species cream-coloured or watery-whiteish) when injured to protect against herbivores.

Strangler figs can be easily identified – the bark tends to be pale-coloured and rather smooth, and grow clinging or enclosing a host tree. Some strangler fig species can grow to a large size, with a tree-like crown, whereas some remain small and resemble climbing plants. All strangler figs, however, grow naturally from seeds dispersed by birds or mammals that had dropped onto tree branches or crevices in the trunk. In some localities, the seeds are deposited and grow on rocky outcrops. Strangler fig seed are also able to germinate on bricks or cement buildings, and continue to grow unless removed.

Borneo Rhino Alliance (BORA), c/o Faculty of Science and Natural Resources, Universiti Malaysia Sabah, Jalan UMS, 88400 Kota Kinabalu, Sabah, Malaysia

*Corresponding author: sabahpayne@gmail.com

Apart from a few prominent, distinctive and common species, many *Ficus* are difficult to identify at species level. There are many species of *Ficus* with at least 480 species in Asia-Australasia (Berg and Corner, 2005). Besides, hybridization of closely-related species and intraspecific morphological variation of some *Ficus* species complicates the identification process. Some species can grow in different forms, depending on its locality. For instance, some *Ficus* species which can climb or strangle may also grow as free-standing trees. The classification and nomenclature of the *Ficus* genus has been quite complex, with different names given to the same species. The inconsistency in nomenclature has led to some herbarium specimens being misidentified or having out-dated nomenclature.

Ficus is regarded as a 'keystone' genus for frugivores and some insectivores that feed on fig wasps (Cottee-Jones and Whitaker, 2012; Mackay *et al.*, 2018). When fruiting, *Ficus* plants are typically the busiest feeding station in the ecosystem, providing a major source of food for arboreal and flying vertebrates, and terrestrial mammals that feed on fallen syconia. Young leaves and shoots of some *Ficus* species, including *Ficus microcarpa*, are consumed by orangutans. Some species have potential for use in pharmaceutical products (e.g. *Ficus deltoidei* and *F. racemosa*); as ornamentals (e.g. *Ficus benamina*, *F. punctata*, *F. villosa*, *F. trichocarpa* and *F. dubia*); and possibly for human consumption (for example, *Ficus parietalis*, *Ficus annulata* and *F. racemosa*).

History and context

Habitat loss and fragmentation are widely recognised as the major causes for species extinctions, and a great majority of habitat loss has already occurred. The first major phase of natural habitat loss occurred at the end of the Pleistocene epoch, when sea levels rose by over 100 metres, fragmenting the Sunda shelf into islands. The second major phase occurred between 1920-2020, when almost all of the forest lowlands were converted into plantations and development areas. Opportunities to establish more Protected Areas (PAs) that could potentially help to prevent the extinction of endangered species are now slim to none. The remaining fragments of natural habitat are either too small, or consist of steep, forested hill range that are ecologically unable to sustain a healthy population of wildlife that require valleys and flat lands.

The most significant way forward in nature conservation is to restore and enrich areas that are currently outside the array of PAs, and human-dominated areas used for agriculture and other purposes as well as degraded parts of accessible lowland protected areas. There are many potential avenues for this issue. The PONGO Alliance, a partnership of oil palm growers, businesses and NGOs, advocates for the conservation of orangutans and other wildlife within oil palm landscapes. The Alliance believes that 'the palm oil industry has a great chance to show its mettle by allowing and supporting coexistence of orangutans in the Kinabatangan landscape of Sabah' (Payne and Oram, 2020).

A history of widespread and repeated logging in Sabah, followed by further extraction of smaller trees under license has left Sabah with less than 8% of the total intact forest area. The majority of residual forest are in highly damaged conditions (Bryan *et al.*, 2013; Gunggut *et al.*, 2014; Reynolds *et al.*, 2011). BORA has entered into agreements with large oil palm growers in eastern Sabah to plant orangutan food plants on 'set-aside' lands within the plantation, with fundings from WWF-Malaysia/Unilever.

A series of experimental restoration and enrichment efforts were initiated in 2020. In 2021, enrichment efforts began on a 20-hectare deforested site on the southern border of Tabin Wildlife Reserve. The initiative was supported by the Sabah Forestry Department and Kuala Lumpur Kepong Berhad (KLK). The goal of the project was to enrich the area with elephants' favourite food plants. It was proposed that a maximum of 50 ha (less than 0.05% of the total Reserve area) will be managed for large terrestrial herbivores. In both projects, *Ficus* is a major plant genus involved.

As a tropical ecologist, the author (JP) was aware from full-day monitoring of a strangler fig in Krau Wildlife Reserve in 1975 that *Ficus* provides food (*syconia*) for numerous mammal and bird species in the Malaysian rainforests. As an adviser to WWF-Malaysia in Sabah in 2007, the author proposed the planting of strangler figs to enrich degraded sites in Kinabatangan Wildlife Sanctuary and Bukit Piton Forest Reserve. Apart boosting wildlife food sources, *Ficus* plants can be propagated vegetatively, which eliminates the need for fruiting to permit extraction, treatment and propagation of the seeds. However, the idea did not gain traction. The main reasons being the absence of an existing large-scale vegetative or seed propagation capacity in Sabah. Malaysian foresters also typically favour dipterocarps and fast-growing species for wood growth. Even naturalists tend to favour 'fruit trees' (durians, rambutans, langsat, mangosteen, etc.), and do not always realise that these fruits tend to be produced abundantly 'en masse'. This leads to periods of little or no fruiting in the forest, limiting the diets of frugivorous wildlife. The lack of interest in the idea of propagating and growing *Ficus* was compounded by the failure of the initial small-scale trials by WWF-Malaysia in Kinabatangan. These trials involved harvesting strangler fig seedlings from old oil palm trunks and attaching them to the trunks of small trees; and planting two-metre PVC pipes into the ground in Bukit Piton, with a *Ficus* seedling and organic matter attached to the upper end. However, the seedlings did not survive, likely due to insufficient light, nutrient and water during dry periods.

MATERIALS AND METHODS

As a wildlife veterinarian, the author (ZZZ) initiated the development of a 'rhino food garden' in Tabin Wildlife Reserve in 2011, following his move in 2010 from the Department of Wildlife and National Parks Peninsular Malaysia to Sabah. The intention was to provide the captive Sumatran rhinoceros in the Borneo Rhino Sanctuary with fresh, readily available browse to feed on by planting fast-growing food plant species. It was already known that leaves and twigs of Moraceae plant family are some favourite food plant of the Sumatran rhinoceros – from experiences in the Sumatran Rhino Conservation Centre in Peninsular Malaysia in the 1980s and US zoos that had maintained Sumatran rhinos during the 1980s–2000s. It is essential that captive Sumatran rhinos are provided with a minimum of 30 kg of fresh leafy twigs of favoured food plants daily to maintain their health.

Initially, wildings – wild seedlings taken from old oil palms or other substrates, were used to increase the number and variety of *Ficus* plants maintained in the garden. BORA staffs at Tabin Wildlife Reserve developed a detailed propagation techniques for *Ficus* plants through formal training and on-the-job experimentation. The number of *Ficus* plantings and species at Tabin Wildlife Reserve has gradually increased since 2012, using primarily vegetative propagation from wild plants found in the area. Cuttings and marcots of wild *Ficus* were planted into the soil and more experimentally, onto tree trunks. The planted *Ficus* species was focused on the species that rhinos were found to prefer. By 2019, the number of *Ficus* species in the garden has increased to more than 60 species, represented by more than 500 living plants. The death of the last native rhinoceros at Tabin Wildlife Reserve (and in Malaysia) in November 2019 has led to the temporary cessation of efforts to propagate rhino food plants. As a founder partner of PONGO Alliance, BORA decided to redevelop the garden into a component of a nursery to mass-produce *Ficus* planting material that can be used for restoration and enrichment efforts in oil palm plantations and in forest reserves. In tandem, actions were taken to actively boost the number of *Ficus* species present in the forest reserve.

In 2020, the Sabah Ficus Germplasm Centre (SFGC) was proposed as a collection of living *Ficus* plants in Tabin Wildlife Reserve by BORA. The name and concept were approved by the Sabah Forestry Department. In January 2021, Malaysia Book of Records has endorsed SFGC as the largest living collection of native Malaysian *Ficus* species.

RESULTS

The SFGC now has the largest collection of living specimens of native *Ficus* species in Malaysia, and the numbers are still increasing. As of early 2022, there were over 1,000 living *Ficus* plants made up of about 85 species in SFGC (Table 1). A few non-native *Ficus* species that were brought to Tabin Wildlife Reserve at some point over the years have since been eliminated. Due to specificity between *Ficus* species and their pollinating wasps (Kerdelhue *et al.*, 2000), there were probably some native *Ficus* species that were brought into Tabin Wildlife Reserve from other regions of Sabah that are currently unable to reproduce without human intervention.

DISCUSSION

From its beginnings as a source of rhino food, SFGC now propagates a wide variety of *Ficus* species, with a new emphasis on increasing diversity and seeking out rare native species for propagation. The methods of propagation used were guided by Hartman *et al* (1997) while Lok *et al* (2013) provided further inspiration and ideas. SFGC has become an arboretum that specialises in fig trees and all plant varieties belonging to the genus *Ficus*. BORA has been greatly aided by The Figs of Borneo (<https://borneoficus.info/>) guide by Mr Quentin Phillipps. There are many interesting rare species in SFGC, including the Bornean endemic *Ficus leptogramma*. The male trees produce extraordinarily abundant syconia on the trunks, from which ants remove the contents and form a gradually-expanding matrix of material that can be harvested as organic fertilizer for the nursery. There are also *Ficus minahassae*, a small tree confined to the Philippines, Sulawesi and east Sabah lowlands; and *Ficus xylophylla*, a spectacular specialist epiphyte with large, thick leaves, juicy syconia and can thrive on very infertile soils.

SFGC produces at least 500 marcots or cuttings per month for restoration and enrichment of set-aside zones in oil palm plantations. SFGC is operated by four full-time staff members who also participate in planting, weeding and monitoring of *Ficus* trees in oil palm plantations. The production is supervised on a part-time basis by one of the authors (ZZZ). The production of marcots can be time-consuming, and the survival rate of the cuttings is unpredictable. Hence, BORA focuses on producing seedlings at an average rate of more than 500 seedlings per month, with emphasis on *Ficus racemosa* (known locally as tangkol or nunuk ragang) and *Ficus variegata* (known locally as tandiran and nyawai). The former is a distinctive riparian zone tree, while the latter is the only *Ficus* species with known potential as a wood plantation tree.

SFGC has been providing training for government and non-governmental institutions, including HUTAN, APE Sabah, Sabah Softwoods, WWF-Malaysia, 1 Stop Borneo, Universiti Malaysia Sabah, Universiti Malaysia Terengganu, and the Department of Wildlife and National Parks Peninsular Malaysia. Several nurseries involved in habitat restoration works have been trained in *Ficus* propagation. SFGC can assist oil palm growers to embark on their own programmes to plant *Ficus* on set-aside zones within plantations, such as riparian zones, steep slopes and High Conservation Value sites. A programme to relocate bird-dispersed *Ficus* plants growing on buildings and to set-aside lands in plantations. Future research on *Ficus* plant will focus on their physical characteristics, nutritional composition, palatability of *Ficus* leaves, and their possible use as a livestock browse. SFGC is ready to engage with international experts in relation to molecular-level research as well as species identification and prospects for

bud grafting. A quarantine station to be built in Tabin Wildlife Reserve for *Ficus* plants coming into SFGC from other localities in Sabah.

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Table 1. List of *Ficus* species in the Sabah *Ficus* Germplasm Centre, February 2022 (D = dioecious, M = monoecious).

Scientific Name	Name used in SFGC	Plant form	Sex
<i>Ficus acamptophylla</i>	Ara Tudan	Climber; epiphytic	M
<i>Ficus allutacea</i>	Water fig	Climber	D
<i>Ficus annulata</i>	Ara Susu or Akar Tetikar	Strangler without hanging aerial roots	M
<i>Ficus aurata</i>	Gatal Piring	Large shrub	D
<i>Ficus beccarii</i>	Bendera Bujur	Earth fig; small tree	D
<i>Ficus benamina</i>	Ara Beringin	Strangler	M
<i>Ficus binnendijkii</i>	Ara Nunuk Merah	Strangler	M
<i>Ficus bukitrayaensis</i>	Bendera RDC	Earth fig; small tree	D
<i>Ficus callophylla</i>	Callophylla	Strangler	M
<i>Ficus callosa</i>	Paw-paw	Tree	M
<i>Ficus caulocarpa</i>	Ara Belimbing	Strangler	M
<i>Ficus cereicarpa</i>	Gatal Basah (Horned Fig)	Large shrub	D
<i>Ficus consociata</i>	Ara Abu	Strangler / hemi -epiphyte	M
<i>Ficus crassiramea</i>	Ara Manggis	Strangler; swamp -tolerant	M
<i>Ficus cucurbitina</i>	Ara Berbulu	Strangler	M
<i>Ficus cumingii</i>	Ara Kapal Kayu	Small tree	D
<i>Ficus deltoidea</i>	Ara Perawan or Mas Cotek	Epiphyte or shrub	D
<i>Ficus depressa</i>	Ara Jantung	Climber	M
<i>Ficus drupacea</i>	Ara Titingan	Strangler	M
<i>Ficus dubia</i>	Ara Batang Merah	Strangler or climber	M
<i>Ficus fistulosa</i>	Nangka Air Paya	Small tree	D
<i>Ficus forstenii</i>	Ara Sultan	Medium sized strangler	M
<i>Ficus francisci</i>	Gatal Berbulu (Franz's Fig)	Large shrub	D
<i>Ficus fulva</i>	Gatal Ranau	Small tree	D
<i>Ficus gul</i>	Gatal Gul	Medium size tree	D
<i>Ficus hemsleyana</i>	Ara Kertas Berbulu	Small tree or climber	D
<i>Ficus heteropleura</i>	Ara Kertas Kecil	Climber	D
<i>Ficus lawesii</i>	Ara Mangga	Strangler	M
<i>Ficus lepicarpa</i>	Nangka Air Maragang	Small tree	D
<i>Ficus leptogramma</i>	Nangka Air Rangup	Small tree	D
<i>Ficus magnoliifolia</i>	Ara Hitam	Large tree	D
<i>Ficus malayana</i>	Bendera Halus	Earth fig; small tree	D
<i>Ficus megaleia</i>	Bendera Besar	Earth fig; small tree	D
<i>Ficus melinocarpa</i>	Ara Kuning	Large tree	D
<i>Ficus microcarpa</i>	Ara Nunuk or Jejawi or Bonja	Strangler ; swamp-tolerant	M
<i>Ficus midotis</i>	Ara Selungkoi	Shrub or climber	D
<i>Ficus minahassae</i>	Ara Ajinomoto	Small tree	D
<i>Ficus montana</i>	Ara Kapal	Shrub	D
<i>Ficus nervosa</i>	Ara Obah (Nerved Fig)	Large tree	M
<i>Ficus nota</i>	Nangka Air Bukitor Tibig	Small tree	D
<i>Ficus parietalis</i>	Ara Kertas	Small tree or epiphyte	D
<i>Ficus pellucidopunctata</i>	Ara Mud	Strangler	M
<i>Ficus pisocarpa</i>	Ara Puncak	Strangler	M

<i>Ficus punctata</i>	Ara Dedit	Climber	D
<i>Ficus racemosa</i>	Tangkol or Nunuk Ragang	Tree	M
<i>Ficus recurva</i>	Ara Kertas Halus	Climber	D
<i>Ficus rosulata</i>	Nangka Air Pasir	Small tree	D
<i>Ficus rubrocupidata</i>	Ara Menitis	Climber	D
<i>Ficus sagittata</i>	Ara Gam	Epiphyte	D
<i>Ficus scaberrima</i>	Ara Babag or Nuratas	Shrub, epiphyte or climber	D
<i>Ficus septica</i>	Lintotobou	Small tree	D
<i>Ficus sinuata</i>	Ara Diya	Climber or bush	D
<i>Ficus stolonifera</i>	Gatal Rash	Medium size tree	D
<i>Ficus stricta</i>	Ara Tebiatu	Strangler	M
<i>Ficus stupenda</i>	Ara Unggai	Strangler	M
<i>Ficus subcordata</i>	Ara Wunut	Strangler	M
<i>Ficus subsidens</i>	Subsidens	Small shrub	D
<i>Ficus subterranea</i>	Bendera Berbulu	Earth fig; small tree	D
<i>Ficus subulata</i>	Ara Mata Ikan	Small tree or climber	D
<i>Ficus sumatrana</i>	Ara Buah Lubang	Strangler	M
<i>Ficus sunaica</i>	Ara Urit	Strangler	M
<i>Ficus tinctoria var gibbosa</i>	Ara Diamond	Small tree or epiphytic climber	D
<i>Ficus treubii</i>	Ara Tupai	Small to medium tree	D
<i>Ficus trichocarpa</i>	Ara Epal	Epiphyte with aerial roots	D
<i>Ficus uniglandulosa</i>	Common bird fig	Epiphyte	D
<i>Ficus variegata</i>	Tandiran	Tree (red and green varieties)	D
<i>Ficus villosa</i>	Ara Lipan Besar	Root climber	D
<i>Ficus virens</i>	Ara Fesada (White Fig)	Strangler; starts as epiphyte	M
<i>Ficus xylophylla</i>	Ara Giant	Strangler	M
<i>Ficus sp.</i>	Ara BRS	Strangler	
<i>Ficus sp.</i>	Ara Berhabuk	Strangler	
<i>Ficus sp.</i>	Ara Bolikatung	Strangler	
<i>Ficus sp.</i>	Ara Ebunian	Strangler	
<i>Ficus sp.</i>	Ara Kerinci	Strangler	
<i>Ficus sp.</i>	Ara Lipan	Root climber	
<i>Ficus sp.</i>	Ara Lipan Kecil	Root climber	
<i>Ficus sp.</i>	Ara Lipan Kolong	Root climber	
<i>Ficus sp.</i>	Ara Panji	Strangler	
<i>Ficus sp.</i>	Ara Pepucong	Strangler	
<i>Ficus sp.</i>	Ara Sieralaman	Strangler	
<i>Ficus sp.</i>	Ara Sundait	Strangler	
<i>Ficus sp.</i>	Ara Tangkai	Strangler; medium	
<i>Ficus sp.</i>	Ara Ungu	Climber; epiphytic	
<i>Ficus sp.</i>	Bendera Kering	Earth fig; small tree	