

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.

Acknowledgements: The authors would like to thank Sabah Forestry Department for its strong support of the work described here, the staff of BORA for their dedication, Mr Quentin Phillipps for his constant interest and inspiration, the oil palm growers and other non-governmental partners who have collaborated on experimental growing of *Ficus* on set-aside areas, and WWF-Malaysia/Unilever for financial support for the work.

REFERENCES

- Berg, C. C and Corner, E. J. H. 2005. Moraceae: *Ficus*. *Flora Malesiana* 17(2) : 1–70.
- Bryan, J. E., Shearman, P. L., Asner, G. P., Knapp, D. E., Aoro, G. and Lokes, B. 2013. Extreme differences in forest degradation in Borneo: Comparing practices in Sarawak, Sabah, and Brunei. *PLoS ONE* 8(7) : e69679.
- Corlett, R. 2017. Frugivory and seed dispersal by vertebrates in tropical and subtropical Asia: An update. *Global Ecology and Conservation* 11 : 1-22.
- Cottee-Jones, H. E. W. and Whittaker, R. 2012. The keystone species concept: A critical appraisal. *Frontiers of Biogeography* 4(3) : 117-127.
- Gunggut, H., Saufi, D. S. N. S. A. M., Zaaba, Z. and Liu, M-S. M. 2014. Where have all the forests gone? Deforestation in land below the wind. *Social and Behavioral Sciences* 153: 363-369
- Harrison, R. D., Hamid, A. A., Kenta, T., Lafrankie, J., Lee, H. S., Nagamasu, H., Nakashizuka, T. and Palmiotto, P. 2003. The diversity of hemi-epiphytic figs (*Ficus*: Moraceae) in a Bornean lowland rain forest. *Biological Journal of the Linnean Society* 78 : 439-455.
- Hartmann, H., Kester, D. E., Davies, F. T. and Geneve, R. L. 1997. *Plant propagation: Principles and practices*. New Jersey: Prentice-Hall International.
- Kerdelhue, C., Rossi, J-P. and Rasplus, J-Y. 2000. Comparative community ecology studies on Old World figs and fig wasps. *Ecology* 81(10) : 2832-2849.
- Kochumen, K. M. and Go, R. 2000. Moraceae. In *Tree Flora of Sabah and Sarawak*, eds. Soepadmo, E. and Saw, L. G. Kuala Lumpur: Forest Research Institute Malaysia, pp. 213-317.
- Lok, A. F., Ang, W. F., Ng, B. Y. Q., Leong, T. M., Yeo, C. K. and Tan, H. T. W. 2013. Native fig species as a keystone resource for the Singapore urban environment. Singapore: Raffles Museum of Biodiversity Research, National University of Singapore.
- Mackay, K. D., Gross, C. L. and Rossetto, M. 2018. Small populations of fig trees offer a keystone food resource and conservation benefits for declining insectivorous birds. *Global Ecology and Conservation*, 14 : e00403.
- Payne, J. and Oram, F. 2020. Oil palm and orangutans: A fresh look and a new idea. *The Planter* 96 (1129) : 247-253
- Payne, J., Yee, A., Fong M. S., and Zainal, Z. Z. and Oram, F. 2020. Oil palm and elephants : A review with ideas for discussion. *The Planter* 96 (1131) : 421-427.
- Reynolds, G., Payne, J., Sinun, W., Mosigil, G. and Walsh R. P. D. 2011. Changes in forest land use and management in Sabah, Malaysian Borneo, 1990 –2010, with a focus on the Danum Valley region. *Philosophical Transactions of the Royal Society B: Biological Sciences* 366(1582) : 3168–3176.
- Shanahan, M, So, S., Compton, S. G. and Corlett, R. 2001. Fig-eating by vertebrate frugivores: A global review. *Biological Reviews* 76(4) : 529–572.