NATIVE FIG SPECIES AS A KEYSTONE RESOURCE FOR THE SINGAPORE URBAN ENVIRONMENT

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Cover photograph of an Oriental pied hornbill (*Anthracoceros albirostris*) eating *Ficus kerkhovenii* figs ©Ingo Waschikies.

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INTRODUCTION

The angiosperm genus *Ficus* (commonly known as the figs) belongs to the family Moraceae and is distributed throughout the tropics and subtropics (Berg & Corner, 2005). *Ficus* is relatively large with about 735 species distributed globally (Berg & Corner, 2005), exhibiting a myriad of growth forms which include shrubs, trees, climbers, epiphytes as well as hemiepiphytic stranglers, making it the world's most diverse woody plant genus (Corner, 1988). *Ficus* species are characterised by their large quantities of latex in the bark, branches and leaves, presence of hood-like stipules covering new buds at the twig tips, ring scars on their twigs left by the stipules that have fallen off, and a specialised reproductive structure known as the syconium (plural=syconia) which are inwardly forming inflorescences with numerous florets (small flowers) that develop later into fruits (Burrows & Burrows, 2003). Fig species have two breeding systems, namely monoecy and dioecy, with male and female florets in each syconium, and separate male and female plants with unisexual florets, respectively (Shanahan et al., 2001; Harrison & Yamamura, 2003). Monoecious fig species are are considered keystone resources in the tropics because of their need to maintain a supply of its pollinator wasps, thus providing a steady supply of ripe syconia throughout the year within a population of fig plants (van Noort, 2003). In turn, many frugivores are sustained with a constant fruit supply especially during periods when no other fruits are available (Kinnaird et al., 1999; Korine et al., 2000), making these fig species good candidates for urban planting that would attract more wildlife. The high nutritional calcium levels in the syconia make them even more important to tropical frugivores especially for the egg-laying taxa (O'Brien et al., 1998). It is predicted that a cascade of extinctions would ensue if such a keystone resource was removed in the rainforest (Terborgh, 1986).

BASIC INFORMATION

Scientific name. — *Ficus* L.

Pronunciation. — FYE-kuss

Scientific family name. — Moraceae (after the genus *Morus*, the mulberries)

Common family name. — Fig or mulberry family

Natural distribution. — *Ficus* is pantropical, extending to subtropical zones (Berg & Corner, 2005). It consists of approximately 735 species, of which 120 species are found in the Americas, 105 species in Africa (including the Arabian Peninsula, Indian Ocean Islands as well as Madagascar), and the remaining 367 species occurring through the Asian–Australasian region (Berg & Corner, 2005). Others sources estimate *Ficus* species at approximately 755 species, with around 511 species occurring in the Indo-Australasian region (Asia, Malesia, Pacific Islands, and Australia), and about 132 species in the Neotropical region (Central and South America). In the Afrotropical region (Africa south of the Sahara, including Madagascar), there are currently 112 identified species, 36 of which are endemic to southern Africa (van Noort & Rasplus, 2004–2012).

National conservation status. — Forty-six native species have been recorded in Singapore, with eight species (17.4%) being presumed nationally extinct (see Table 1, Appendix; Chong et al., 2009). Of the 38 extant species (82.6%), seven are common (15.2%), two are nationally vulnerable (4.3%), four are nationally endangered (8.7%), and 25 are nationally critically endangered (54.3%). For a detailed breakdown of the national conservation status categories for each of the species, please refer to Table 1 of the Appendix.

Usage of the word "fig". — The word "fig" is used to mean any of the following: (1) fig species (= *Ficus* species); (2) fig plant (= fig individual, fig specimen, fig tree, fig treelet, fig shrub, fig climber); (3) syconium, the modified inflorescence or infructescence that fig species develop; (4) as an adjective to qualify a noun, e.g., fig wasp, fig species, fig plant, fig specialist, etc., and the context indicates the meaning. However, to avoid confusion in this book, whenever the word —fig" is used, it will be used only as a qualifier so that the reader is clear whether a fig species, fig individual, or plant is referred to, or in a common name of a *Ficus* species, e.g., sandy leafed fig. To avoid further confusion, the word fig will not be used for syconium.

PLANT MORPHOLOGY, BIOLOGY, AND ECOLOGY

Habit. — It is postulated that the diversity of habitats and climates that different fig species thrive in has caused the genus to evolve a myriad of growth forms, giving the genus an extremely large ecological amplitude to adapt to its surroundings (Berg & Corner, 2005).

Shrubs and trees. — Native *Ficus* species in Singapore that are small shrubs (with more than a single, woody stem arising from the ground) and trees (with only a single, woody trunk arising from the ground) attain heights of no more than 10 m in the extant native species of Singapore (Berg & Corner, 2005). All members in this group are dioecious, with the exception of the monoecious *Ficus vasculosa*. Most of these species belong to one of the following subgenera: *Eriosycea* (Fig. 1), *Ficus*, *Pharmacosycea*, *Sycidium*, or *Sycomorus*. Certain fig tree species are known to attain heights of up to 45 m and have large buttresses. In Singapore this was represented by a single species, *Ficus albipila* (subgenus *Pharmacosycea*) which is now presumed nationally extinct.

Hemiepiphytes (stranglers). — This growth habit is probably the most recognisable amongst tropical fig species (Fig. 2) and is the characteristic growth form of most species of the subgenera *Sycidium* and *Urostigma* (Berg & Corner, 2005). These species usually start life in the mid-canopy, when a fig seed germinates on a branch or in a crevice of the trunk of the host tree, deposited usually by birds or ants after consumption of the syconium (Corner, 1988). Because of the light requirements for seed germination, optimal heights in the canopy for germination are between 20–25 m above ground level. After germination, the hypocotyl swells, enabling the young plant to secure itself in the crevice. This development of the primary root is then followed by the development of the secondary adventitious roots which then form an extensive aerial root system around the host's trunk, down towards the ground. Once reaching the ground, the fig plant's root system competes for nutrients and water with the host. This uptake of nutrients then allows the plant to further its aerial growth, allowing its branches to spread past the host's branches and smother it. The lattice of the aerial root system also increases and thickens, leading to the strangulation of the host tree, eventually killing it. Hemiepiphytic fig species also occur in arid areas and on rocks in tropical regions, where their roots grow into the cracks of rocks till they reach the soil, after which growth is accelerated with the regular uptake of nutrients and water. This increase in growth of the roots eventually breaks up their supporting rocks and is hence aptly termed ―rock splitter". Aside from sending a lattice of roots around their hosts, stranglers also produce adventitious roots from their spreading branches that form stilt roots. These stilt roots allow these plants to "walk" away from its initial site of establishment, spreading radially outwards.

Climbers and scramblers. — Nearly 100 fig species are climbers and scramblers (Berg & Corner, 2005). The majority belongs to the subgenus *Synoecia* but also occur in the subgenera *Sycidium*, *Ficus*, as well as *Urostigma*. In this group, the fig plants are dependent on other plants for structural support. This is shown through the production of roots at intervals along their herbaceous stems (e.g., *Ficus villosa*, Fig. 3; and *Ficus apiocarpa*, Fig. 4), allowing them to climb up tree trunks and walls or over rocks. Other partially woody members have partially woody stems and do not fully rely on the branches and trunks of other trees and shrubs for support. These include species such as *Ficus globosa* and many others.

Holoepiphytes. — This growth habit is somewhat similar to that of a hemiepiphytic strangler, except that members of this group are able to sustain themselves totally as epiphytes or as lithophytes—not requiring their root systems to be anchored into the soil (Berg & Corner, 2005). An example is *Ficus deltoidea*, of which the only known example in Singapore grows on a tiny, rocky islet off Pulau Ubin.

Rheophytic shrubs. — These are low-growing shrubs, growing or creeping in rocky beds of fast flowing streams (Berg & Corner, 2005). Species with this growth form include members from the subgenera *Ficus* and *Pharmacosycea* from New Caledonia, *Sycidium* from Fiji, *Sycomorus* from the Sino-Himalayan region to New Caledonia and many more. This growth habit is not found in Singapore, probably owing to the lack of streams or rivers that are prone to flash flooding (spates).

Fig. 1. The white-leafed fig, *Ficus grossularoides* from the subgenus *Eriosycea*, displaying the habit of a shrub or small tree. (Photograph by: Hugh Tan Tiang Wah).

Fig. 2. A Johor fig tree, *Ficus kerkhovenii* strangling an *Artocarpus* species tree in the Singapore Botanic Gardens' Jungle (a remnant patch of primary and secondary forest). (Photograph by: Alvin Francis Lok Siew Loon).

Fig. 3. *Ficus villosa* climbing up a *Shorea* sp. in the Central Catchment Nature Reserve. (Photograph by: Alvin Francis Lok Siew Loon).

Fig. 4. *Ficus apiocarpa* seen scrambling amongst tree branches near the National Park Boards office at Venus Drive. (Photograph by: Alvin Francis Lok Siew Loon).

***Leaves.* —** Leaf arrangement in *Ficus* species varies from spiral, sub-opposite to distichous (Berg & Corner, 2005). The leaf blade shapes show a wide array from suborbicular, elliptic, oblong, lanceolate to linear, from obovate, obtriangular, spatulate to oblanceolate, or from cordiform, ovate to subovate. The size of the leaf blades also range from very small, 0.5–2 cm long to large leaves of more than 40 cm long. The margins of fig leaf blades also vary tremendously, taking the form of palmately or pinnately incised leaf blades in juveniles of subgenera *Ficus* and *Sycidium* but absent in *Urostigma* and *Synoecia* and rare in *Pharmacosycea*. The leaf blade margins in subgenera *Ficus*, *Sycidium*, and *Sycomorus* are very often toothed. Leaf blade venation and texture are also very diverse among species.

***Inflorescences and fig wasps.* —** The modification of the inflorescence is what gives fig species their name. The syconium is in fact an inwardly formed inflorescence, which gives rise to a fruit-like structure (Corner, 1988; Berg & Corner, 2005). Each syconium has a narrow circular or slit-shaped opening at the wide basal end known as an ostiole. In terms of sexual reproduction, fig species are generally classified into functionally dioecious species (those that only produce either the male or female gametes in an individual) and functionally monoecious species (those that can produce both male and female gametes in the same individual). In monoecious species, syconia contain both male florets or tiny flowers (stamen-bearing florets that produce the male gametes) and female florets (pistil-bearing florets that produce the female gametes) with styles of different lengths, and also gall florets (non-seed-producing short-styled pistillate florets in which female wasps can lay their eggs). In dioecious species, functionally male plants bear syconia with male florets and gall florets, while functionally female plants bear syconia with neuter florets (in place of male florets) and seed-producing female florets (usually long-styled).

Unlike normal flowers that are borne externally, thus exposed to either physical (e.g., wind) or biological (e.g., bees) pollination agents, fig florets are borne internally in the syconium (Corner, 1988; Berg & Corner, 2005). The genus *Ficus* is species rich and has coevolved with species-specific pollinating fig wasps in one of the most complex interactions found in nature. An obligate mutualism exists between a *Ficus* species and its fig wasp species, such that neither party can survive without the other. This relationship is demonstrated in the pollination process whereby both fig wasp and fig plant are obligatorily dependent on each other for their reproductive cycle.

In monoecious fig species, pollen-carrying female fig wasps (called foundresses) emerge from their natal (birth) syconium and search for a receptive syconium either on the same tree or on a conspecific individual (Corner, 1988; Berg & Corner, 2005). These foundresses then enter the syconium via the ostiole, losing their wings and, often, parts of their antennae in the process because of the tight squeeze. Once inside the syconium, the foundresses begin moving around in search of suitable florets to oviposit their eggs. During this process, pollen grains are removed from their bodies and the male florets, and deposited on the female florets. The foundresses oviposit in the gall florets inside the syconium, and finally die within. As the eggs develop, the male wasps emerge from the gall florets before the females and fertilise the pre-emerging female wasps. When the females emerge, they move around the fig cavity, loading pollen grains into their pollen sacks or onto their bodies. The wingless male fig wasps make a tunnel (sometimes more than one) through the receptacle wall of the syconium with their elaborate mouth parts, creating an exit for the females to leave (Compton & McLaren, 1989). The male wasps eventually die within the syconia, while the fertilised females leave, carrying pollen in search of another syconium to carry on the reproductive cycle of both species.

The situation is slightly different in dioecious fig species (Corner, 1988; Berg & Corner, 2005). The pollen-carrying foundresses emerge from functionally male syconia in search of other syconia. They may enter either functionally female or male syconia. If a foundress enters a functionally female syconium, it would only serve to carry on the reproductive cycle of the fig host by pollinating the female florets as it would not be able find suitable egg-laying sites and eventually die inside without contributing to its own reproduction. On the other hand, if it enters a functionally male syconium, it would be able carry on its own reproductive cycle by laying eggs in the gall florets. Once the eggs hatch, the female wasps will carry the fig pollen and emerge from the syconium to search for other syconia. Male fig trees are known to produce syconia year-round as it is important for sustaining a steady population of their short-lived fig wasp pollinators.

Such pollen dispersals carried out by short-lived wasps are known to occur over vast distances, particularly in monoecious fig species (Harrison, 2003; Harrison & Rasplus, 2006; Nason et al., 1998; Zavodna et al., 2005). This can result in the longest distance gene flow known in plants, especially if the population density is high for the fig species within its fig wasp's range.

Adult fig wasps survive only for a few days (Berg & Corner, 2005). Therefore, once they emerge from their natal syconia, it is important for them to mate, and for the females, to find a receptive syconium for oviposition as time is a limiting factor. Likewise, it is essential for the female florets in the syconia to be pollinated to sustain this mutualism. There are a few ways as to how this mutualism is sustained. The first is the asynchrony in crop development among fig plants in the tropics, which ensures fruiting all year round of at least one individual in a population, therefore, providing a continual supply of receptive syconia for the reproduction of wasps. The second is in the location of receptive syconia for pollination and oviposition. This is done using species-specific volatile cues, where wasps home in on host plant-specific chemical signals (van Noort, 2003; van Noort et al., 1989). When syconia are receptive to pollination, they release a highly volatile chemical signal, which is probably detected by receptors on the antennae of species-specific pollinating fig wasps. Such specificity is possible as each fig species has its own signature chemical cue that can only be detected by the associated fig wasp species (Ware et al., 1993). This also helps to ensure specificity of pollination within conspecifics and prevent species hybridisation (van Noort, 2003). And lastly, this mutualism is also maintained through the morphology of the fig wasp ovipositor and the style of the female floret. In monoecious species, any incompatibility between style length and ovipositor length would result in the failure of wasps to oviposit. Seeds instead of wasp larvae may then develop in the fertilised stigmas. In dioecious species, the female florets in female trees (which contain functional female florets and neuter florets) usually have styles longer than the wasp's ovipositor, thereby ensuring pollination without oviposition. This produces a higher seed yield than syconia of monoecious species. Other than the functional male florets, male trees on the other hand have non-functional female florets with short styles (gall florets), enabling higher chances for wasp oviposition (van Noort, 2003).

In dioecious fig species, syconia with gall florets often do not share the colours of seed-producing syconia at full maturity, that is, they remain greenish or paler (Berg & Corner, 2005), hence are generally less attractive to frugivorous animals. Colour dimorphy occurs in some species, such as *Ficus variegata*. Such colour differentiation is probably associated with the evolution of primate colour vision (Dominy et al., 2003). Perhaps the unattractive colours of the gall syconia ensure that they will not be consumed by frugivores, so as to protect the developing fig wasps within.

As a result of the continual supply of syconia year round, fig plants can be a source of food supply for frugivores or even some non-frugivores when there is a seasonal shortage of other fruits. As such, fig species are considered keystone species in many tropical and subtropical ecosystems (Kalko et al., 1996; Korine et al., 2000; Shanahan et al., 2001; Harrison, 2005).

Fruits. — The syconia of monoecious fig plants and female dioecious fig plants bear several hundred female florets, which develop after pollination to form ripe syconia (Borges et al., 2008). Ecologically, the syconium can be considered a fruit, as the genus has merely readapted the multiple-ovuled ovary and many-seeded fruit (Janzen, 1979). The mature syconia of different fig species can be red, yellow, green or purple, which attract a wide range of frugivores by visual signalling (Shanahan et al., 2001). Syconium sizes also vary considerably, from pea- to peach-sized structures, or sometimes even larger (Herre et al., 2008).

The general morphology of the syconium fruitlet (individual, tiny fruit developed from each female floret within the syconium) in the six subgenera are distinct (Berg & Corner, 2005; Berg, 2006). In the subgenus *Ficus*, the fruitlets are either smooth (in section *Ficus*) or tuberculate (in section *Eriosycea*). They are usually small, 1–2 mm long, but exceptions have been noted in *Ficus deltoidea* and *Ficus oleifolia* (both 3–4 mm long). Most species in the subgenus *Sycidium* have fruitlets which are achenes, lens-shaped to slightly bean-shaped, clearly to faintly keeled and smooth, or sometimes slightly tuberculate or finely punctuate. They are mostly pale yellow to whitish, but also red(dish) in some species (*Ficus elemeri* and *Ficus odorata*). In other species (*Ficus montana*, *Ficus sandanakana*, and *Ficus subsidens*), the fruits are drupaceous, with a white exocarp and a whitish tuberculate or smooth endocarp body, which is released from the exocarp when ripe. It is difficult to identify these drupaceous fruitlets when dried owing to shrinkage of the exocarp. Fruitlets from the subgenus *Sycomorous* are auriculiform to lenticular achenes, with or without a (double) keel and prominent ―pseudohilum", and with a smooth or more or less tuberculate surface. These features are mostly consistent or predominant in the sections too. Fruitlets from the subgenus *Synoecia* are commonly compressed with a keel all around, but in some species, for example, *Ficus gymnorygma*, *Ficus pubigera*, and *Ficus scratchleyana*, the fruitlet is not compressed and the keel is absent or faintly developed. The fruitlets from the subgenus *Urostigma* are smooth, reddish, partly reddish, or whitish. In subsection *Malvanthera*, they are often partly to completely embedded in the wall of the syconium. However, fruitlets found in section *Galoglychia* show similarities to the dehiscent drupe instead. No information was available for fruits found in subgenus *Pharmacosycea.*

Habitats. — Globally, fig species occupy a variety of habitats such as rainforest understories and canopies, savannahs, riversides, and xeric cliff faces (Hill, 1967; Janzen, 1979; Corner, 1988; Burrows & Burrows, 2003; Berg & Corner, 2005). In Malesia, *Ficus* species are observed to be found in almost all terrestrial vegetation types, and play an important role of food supply for animals (Berg & Corner, 2005). Mature trees are most common in moderately disturbed sites such as riparian edges, tree crowns (as epiphytes), tree falls, secondary agricultural regeneration, and old land slides (Janzen, 1979). Large terrestrial fig species whose seeds germinate on the ground are found mostly in secondary growth, by the forest edge, or in swampy open forest areas. In contrast, exclusively hemiepiphytic species germinate on trees in primary mainland habitat (Gautier-Hon & Michaloud, 1989).

General observations of the habitats of the six subgenera were also described. Firstly, in the subgenus *Sycidium*, most of the species are components of various, mostly humid types of forest (Berg & Corner, 2005). However, many of them are also frequently found in secondary growth and in riverine vegetation. A small number of species are also associated with more open types of vegetation such as grasslands, coastal habitats, and rocks. Next, approximately two-thirds of the fig species from *Synoecia* grow in lowland regions. The remainder is found in montane or submontane areas, and a few occurring at both high and low elevations. In the subgenus *Urostigma*, majority of the species establish themselves on rocky surfaces or walls and in open vegetations (including secondary vegetations and tree plantations). They are also found in exposed places such as sea-shore rocks or hill-tops or seen sprawling through forest-canopy or festooning forest edges. Members from the subgenera *Ficus* and *Sycomorus* are observed to be terrestrial, with some rheophytic species occurring in habitats with fast flowing waters. Lastly, *Pharmacosycea* species are only known to be generally terrestrial (Berg & Corner, 2005).

In Singapore, native and exotic *Ficus* species are observed to occur in a variety of habitats in the wild and in the urban environment. For example, *Ficus grossularioides* is common in secondary scrub and forest margins in Singapore (Corlett, 1993), *Ficus microcarpa*, a species primarily of coastal habitats is frequently observed growing on trees in and around the grounds of the National Institute of Education and along streets; *Ficus religiosa* is very common on walls and other suitable substrates in urban areas (Corlett, 2006).

Phenology. — Phenology is the study of cyclical biological events, such as flowering, fruiting, and leaf production in relation to climatic conditions. Abiotic factors such as rainfall, temperature and photoperiod can trigger flowering, and/or fruiting activities in plants (Rathcke & Lacey, 1985). For most tropical Asia, rainfall seasonality is the main factor in determining fruiting cycles. Phenological patterns occur at different levels—individual (within the same plant) and population (among conspecifics within the vicinity).

In the context of fig species, the species-specific mutualism between fig plants and their short-lived wasp pollinators necessitates the year-round fruiting of fig plants, with short interval times in order to sustain a population of its pollinators so as to achieve reproductive success for both taxa (Kjellberg & Maurice, 1989; Patel, 1997; Berg & Corner, 2005). Although asynchrony of syconium production among species and populations is generally observed in the paleotropics and neotropics (Newton & Lomo, 1979; Milton et al., 1982; Corlett, 1987; Windsor et al., 1989; Patel, 1997; Harrison et al., 2000), some general types of phenological patterns can be distinguished.

In the two monoecious species subgenera *Pharmacosycea* and *Urostigma*, synchrony of syconium production exists in individuals, but is asynchronous in populations (Berg & Corner, 2005). Therefore, production of seeds may occur during unfavourable periods for dispersal and germination (as fruiting is not synchronous at the population level). This also prevents self pollination as the blooming of pistillate (female) and staminate (male) florets occur at different times within the same fig plant, and all syconia (each bearing both florets in it since the species is monoecious) on an individual are at the same development phase. This theory of individual selection whereby trees attracting female pollen-carrying wasps while conspecific neighbours are releasing them, and vice versa, should thus allow individuals in reproductive asynchrony with each other to experience higher cross pollination success than individuals in synchrony with their neighbours (Janzen, 1979; Windsor et al., 1989; Bronstein et al., 1990). Continuous syconia production is observed in the subgenus *Sycomorus* and this suggests that syconia of different development phases seem to occur within the same individual or within the same population.

In dioecious species, the production of fig wasps and seeds are spatially separated in the male and female fig plants, respectively. To ensure a constant supply of fig wasp pollinators, only the production of male syconia (those bearing short-styled pistillate florets with staminate florets) is continuous (Berg & Corner, 2005). The production of female and male syconia is also not necessarily synchronous and is rarely so. For example, *Ficus carica* can have three or more crops of male syconia and one crop of female syconia annually. In a rare example, a study in Cape Tribulation, Australia on *Ficus variegata* showed some form of synchrony in syconium production between male and female fig plants (Spencer et al., 1996). Female syconium production is largely confined to the wet season. On the other hand, while male syconium production occurs year-round and is less synchronised among one another, male plants still produce a peak crop during the period just before female syconium production.

Little reproductive synchronisation was observed between *Ficus fistulosa* trees in Singapore, but they displayed synchrony in male fig production within an individual (Corlett, 1987). This strategy is thought to select against emerging wasps from reentering the male syconia on the same tree, which wastes the fig plant’s pollen. In another example, male syconium production of *Ficus grossularioides* in Singapore is synchronous within an individual while female syconium production is asynchronous at the same level (Corlett, 1993). Male syconium production at the population level is also observed to be greatest just after dry periods and onset of heavy rains. However, the absence of a regular, pronounced dry or cold season in most of Peninsular Malaysia, Sumartra, and Borneo results in the lack of large scale synchronous phenological events or, at best, weak and irregular annual cycles at the community level (Lambert & Marshall, 1991; Ng, 1998; Corlett & LaFrankie, 1998). This asynchrony of syconium production in populations and species is one of the factors that contribute to the importance of fig species as a keystone resource in the tropical rainforests of Southeast Asia.

Keystone resource and nutrition. — Fig species are widely reputed as a keystone resource in the tropical rainforests of Southeast Asia (Leighton & Leighton, 1983; Terborgh, 1986; Lambert & Marshall, 1991; Kalko et al., 1996; Korine et al., 2000; Shanahan et al., 2001; Harrison, 2005; Sreekar et al., 2010). Keystone resources are important plants that other animals in the community depend heavily on. These species are so crucial that their removal from the community is likely to cause the extirpation of dependent animals such as pollinators and seed dispersers (Mills et al., 1993). In fact, it was predicted that the removal of palm fruits, syconia, and nectar in the tropics will result in the displacement of a third to three quarters of the total bird and mammal biomass (Terborgh, 1986).

Syconia are rich in calcium, containing over three times as much as compared to other forest fruits (O'Brien et al., 1998). Dietary calcium is important for bone growth and development in birds and animals and eggshell deposition in birds. However, the nutritional quality of syconia is widely debated (Conklin & Wrangham, 1994), with different sources reporting syconia to be of low nutrient value owing to the low protein content (Milton et al., 1982; Jordano, 1983; Herbst, 1986; Bronstein & Hoffmann, 1987; Lambert, 1989) and high nutrient value (Janzen, 1979; Kalina, 1988; O'Brien et al., 1998; Wendeln et al., 2000) as compared to other forest fruits. However, what syconia may lack in terms of nutritional quality is compensated for by the large crops produced and the year-round availability (especially during times when other fruit resources are rare). The asynchrony of syconium production and development within an individual probably contribute to the large fruit crops it produces. Syconium crops are generally large (Lambert & Marshall, 1991; Leighton, 1993), with a reported crop size of up to over a million syconia on a single individual (Sreekar et al., 2010). These large crops usually attract a correspondingly large number of birds and animals to feed on the ripe syconia.

Ficus is also one of the highly speciose genera in tropical rainforests (Harrison, 2005), exhibiting a myriad of life forms, thus allowing them to occupy a diversity of habitats (Berg & Corner, 2005). The asynchrony of syconium production and development among populations and different species ensures that there are always individuals producing ripe syconia at different times of the year across different tropical terrestrial vegetation types (Harrison, 2005). This is especially important during lean times when other forest fruits are scarce and fruit-eating animals would have to rely on syconia to sustain them through (Lambert & Marshall, 1991; Shanahan et al., 2001).

Locally, 46 species of *Ficus* have been recorded (Table 1), seven of which are common (15.2%), 25 critically endangered (54.3%), four endangered (8.7%), two vulnerable (4.3%) and eight presumed nationally extinct (17.4%) species (Fig. 15, Table 1). Of these 46 *Ficus* species, 22 are dioecious and 24 are monoecious (Table 1). With an alarming 85% of these keystone fig species being of conservation concern or already presumed nationally extinct, this shortfall in fig species and their syconia has certainly taken a heavy toll on the native animal diversity, especially frugivores which rely heavily on them.

Hence, the use of more fig species in the urban setting will provide a reliable food source for many native birds and other animals. This could possibly promote and aid in the recruitment and population growth of native frugivores from neighbouring forest reserves, as well as those that are already found in the urban environment.

Frugivory. — Although syconia are consumed by a large group of birds and mammals globally, this book will focus on the taxa found in Southeast Asia, narrowing it down to taxa found in Peninsular Malaysia and especially those found in the Republic of Singapore.

With the nutritional benefits afforded by fig plants (e.g., calcium) together with the large crops and year-round supply of syconia, it is no surprise that a total of 1,274 bird and mammal species have been observed eating syconia globally, along with a few fish and reptile species (Shanahan et al., 2001). These are comprised of 10% of the world's bird species (990 species) in 18% of the genera (374 genera) of 54 families, and over 6% of the world's mammal species (284 species) in 14% of the genera (153 genera) of 38 families (Shanahan et al., 2001). Avian families that seem to have the strongest ecological and evolutionary interactions with syconia globally are the parrots (Psittacidae), pigeons (Columbidae), starlings (Sturnidae), and the crow and its allies (Corvidae). On looking at fig plant-animal interactions in the Indo-Australian region, bulbuls (Pycnonotidae; Figs. 5, 6), starlings (Sturnidae; Fig. 7), hornbills (Bucerotidae; Fig. 8), old world fruit bats (Pteropodidae), old world monkeys (Cercopithecidae), Asian barbets (Megaliaimidae; Figs. 9–11), and squirrels (Sciuridae) seem to be the most obvious.

Fig. 5. The common urban yellow-vented bulbul (*Pycnonotus goiavier*) visiting a *Ficus religiosa* plant at the Chinese Garden. (Photograph by: Tan Ghim Cheong).

Fig. 6. Buffed-vented bulbul (*Iole olivacea*) feeding on a *Ficus consociata* individual. (Photograph by: Mark Chua).

Fig. 7. Asian glossy starling (*Aplonis panayensis*) feeding on *Ficus* sp. (Photograph by: Chris Li).

Fig. 8. The great hornbill (*Buceros bicornis*) visiting a fig tree at Khao Yai National Park, Thailand. (Photograph by: Tan Ghim Cheong).

Fig. 9. A gold-whiskered barbet (*Megalaima chrysopogon*) visiting the same fig tree at Bukit Tinggi, Peninsular Malaysia. (Photograph by: Chris Li).

Fig. 10. A brown barbet (*Calorhamphus fuliginosus*) visiting a fig tree at Bukit Tinggi, Peninsular Malaysia. (Photograph by: Adrian Lim).

Fig. 11. A female red-throated barbet (*Megalaima mystacophanos*) visiting a fig tree at Bukit Tinggi, Peninsular Malaysia. (Photograph by: Adrian Lim).

Generally, these animals can be broadly categorised as fig specialists, generalists or casual consumers (Shanahan et al., 2001). Fig specialists are totally, if not highly, reliant on syconia year round with a certain degree of specialisation. Some of such specialists are hornbills (family Bucerotidae), leafbirds (*Chloropsis* species; Fig. 12), the fairy bluebird (*Irena puella*), pigeons (of the genera *Treron* [Fig. 13], *Ducula*, and *Ptilinopus*), barbets (family Megalaimidae), gibbons (family Hylobatidae), binturong (*Arctictis binturong*), and fruit bats (*Cynopterus*, Fig. 14; and *Pteropus* species). Generalist syconia-eaters include woodpeckers (family Picidae), cuckoos (family Cuculidae), pheasants (family Phasianidae) as well as many families of passerine birds (order Passeriformes). In comparison to specialists, generalists consume syconia to supplement their diet of fruits, nectar or leaves, although they may rely heavily on them during lean periods of the year where other foods are scarce. Casual syconium-eaters, in contrast to the above two categories, are generally not even frugivores and only feed on syconia opportunistically. These include species such as shrikes (family Laniidae), kingfishers (suborder Alcedines), and rollers (family Coraciidae).

In Southeast Asia, many bird orders are known to rely on syconia for food. These include the Galliformes (fowls), Piciformes (woodpeckers and allies), Bucerotiformes (hornbills), Cuculiformes (cuckoos and allies), Psittaciformes (parrots and allies), Columbiformes (pigeons and doves), Gruiformes (cranes and allies), Ciconiiformes (herons and allies), and Passeriformes (passerine birds; see Shanahan et al., 2001). Some syconium-eating bird orders were however intentionally excluded as they are not represented in the Republic of Singapore. All birds native to Singapore that had been recorded feeding on syconia with their fig species reliance have been listed in Table 2 for easy reference.

From the order Galliformes, only the pheasant family (Phasianidae) has been observed consuming syconia (Shanahan et al., 2001). Because members of this order are omnivourous, terrestrial feeders, they feed only opportunistically and primarily on fallen syconia in the undergrowth. In Singapore, syconium feeding in this order is only represented by the red junglefowl (*Gallus gallus*).

The woodpecker family (Picidae) and the Asian barbet family (Megalaimidae) in the order Piciformes are well represented in Southeast Asia and Singapore. The family Picidae in Singapore is only represented by two genera that have been recorded consuming syconia, and these are *Celeus* as well as *Dinopium* (Shanahan et al., 2001). This family is however mainly insectivorous, only consuming syconia opportunistically (Shanahan et al., 2001). Some members of the family Megalaimidae, in contrast, are syconium specialists, with 20 out of 26 species recorded feeding on syconia (Shanahan et al., 2001). In Singapore, this family is represented by only five species in the genera *Calorhamphus* and *Megalima* (Wang & Hails, 2007). Out of the five species, four are native except for the lineated barbet (*Megalaima lineata hodgsoni*) which was introduced in 1996 (Lok et al., 2009). Of the four native barbets, the blue-eared barbet (*Megalaima australis duvauceli*) and the brown barbet (*Calorhamphus fuliginosus*; Fig. 10) are both now presumed nationally extinct. The two remaining native barbets—the coppersmith barbet (*Megalaima haemacephala indica*; Fig. 16) and the red-crowned barbet (*Megalaima rafflesii*)—are still regularly seen, with the former inhabiting parks and urban areas, congregating in large numbers especially in cultivated fig trees such as *Ficus benjamina*, *Ficus microcarpa*, and *Ficus religiosa*, where they can be easily observed. This is especially true for a particular *Ficus religiosa* specimen at the entrance of the Japanese Garden, which attracts many coppersmith barbets when in fruit (Lok & Lee, 2009). The coppersmith barbet has a rather short gut passage time of about 20–35 minutes, implying short dispersal distances and very often defaecate while still feeding in the same tree (Lambert, 1989). Although a rather small bird with an equally small gape, the coppersmith barbet has been able to utilise syconia of a larger diameter, by only taking the ripest ones, which it then crushes before ingesting. In contrast, the red-crowned barbet is a strictly forest species, only venturing to the periphery of Singapore's nature reserves in search of food (Lok & Lee, 2009). The red-crowned barbet is often seen feeding on syconia of *Ficus microcarpa* at the summit of the Bukit Timah

Fig. 12. A greater leafbird (*Chloropsis sonnerati*) visiting a fig tree in Peninsular Malaysia. (Photograph by: Chris Li).

Fig. 13. (Above) Pinked-necked pigeon (*Treron vernans*) feeding on a syconium of a *Ficus benjamina* plant (Photograph by: Chris Li).

Fig. 14. (Right) The common fruit bat (*Cynopterus brachyotis*) roosting under a banana leaf. (Photograph by: Alvin Francis Lok Siew Loon).

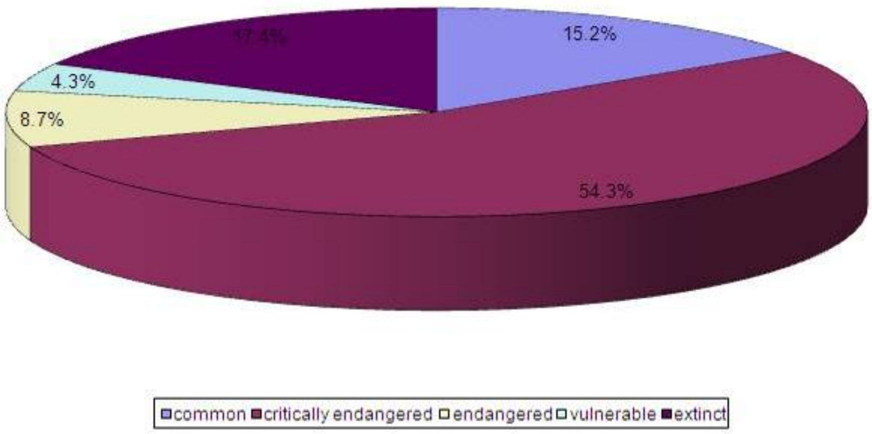

Fig. 15. Pie chart showing the local status distribution of our native *Ficus* species.

Fig. 16. An coppersmith barbet (*Megalaima haemacephala*), here seen feeding on figs of a cultivated *Ficus religiosa*. (Photograph by: Alvin Francis Lok Siew Loon).

Nature Reserve along with numerous hill mynahs (*Gracula religiosa*) and fairy blue birds (*Irena puella*) when the tree is fully laden with syconia. In all, barbets seem to be highly reliant on *Ficus* species, with 43 fig species known to be consumed by them (Shanahan et al., 2001).

The other order of important *Ficus* frugivores is the Bucerotiformes, which includes the hornbill family (Bucerotidae; Shanahan et al., 2001). Two species of hornbills have been recorded in Singapore—the Oriental pied hornbill (*Anthracoceros albirostris convexus*) and the rhinoceros hornbill (*Buceros rhinoceros rhinoceros*). While the rhinoceros hornbill is presumed nationally extinct, the Oriental pied hornbill has seemed, in recent years, to be re-establishing itself after being absent from the Republic for a number of years, probably with founder populations from the neighbouring Johor state of Peninsular Malaysia. Owing to the hornbill's large size and equally large gape, they require and are able to consume many syconia and other fruits of various sizes in order to sustain themselves. Rhinoceros hornbills were reported to be able to consume 27 *Ficus binnendykii* syconia a minute (Shanahan et al., 2001, after Leighton, 1982) while nesting females are reported to have as much as 93% of their diet comprised of syconia (Johns, 1987). The dire statuses of fig species in Singapore today could possibly provide an explanation for the extirpation of this magnificent species of hornbill from Singapore. Dependence on syconium consumption is reported at 24.5% (Tsuji, 1996) and 35.3% (Poonswad et al., 1988) of the diet for the Oriental pied hornbill which with its lower reliance on syconia has managed to re-establish itself, by utilising other cultivated fruit resources available in Singapore's urban areas. Two pairs of the Oriental pied hornbills at Changi Point and Upper Seletar Reservoir Park, besides consuming syconia, have been regularly observed to visit cultivated exotic palms such as the MacArthur palm (*Ptychosperma macarthurii*) as well as the butterfly palm (*Dypsis lutescens*) for their fruits (Fig. 17) at Changi Point (AFSLL, pers. obs.).

While cuckoos are predominantly insectivorous, the locally plentiful Asiatic koel (*Eudynamis scolopacea*; Fig. 18) is highly frugivorous with an individual observed to have eaten 68 *Ficus virens* syconia before regurgitating a pellet containing its seeds (Shanahan et al., 2001, after So, 1991). Other native cuckoos from the genera *Cacomantis*, *Cuculus*, *Phaenicophaeus*, and *Surniculus* have also been recorded feeding on syconia. The banded bay cuckoo (*Cacomantis sonneratii*), plaintive cuckoo (*Cacomantis merulinus*), Indian cuckoo (*Cuculus micropteris*), Oriental cuckoo (*Cuculus saturatus*), and drongo cuckoo (*Sturniculus lugubris*) have all been observed to opportunistically feed on the syconia of the native *Ficus microcarpa* in wasteland vegetation as well as the cultivated trees of *Ficus benjamina* and *Ficus religiosa*, while the chestnut-bellied malkoha (*Phaenicophaeus sumatranus*) has been observed feeding on the syconia of a *Ficus consociata* tree near Venus Drive (AFSLL, pers. obs.).

Although under-represented in Singapore, the order Psittaciformes has global records of 122 species in 42 genera known to eat syconia (Shanahan et al., 2001). Species of *Cyclopsitta*, *Psittaculirostris*, *Agapornis*, *Amazona finschii*, *Loriculus*, and *Psittacula columboides* have some degree of specialisation on syconia (Corlett, 1998; Juniper & Parr, 1998). In Singapore, all three native species of this order have been observed feeding on the syconia of *Ficus* species. The blue-crowned hanging parrot (*Loriculus galgulus galgulus*; Fig. 19) is the most commonly observed syconium feeder, while the blue-rumped parrot (*Psittinus cyanurus cyanurus*) has been observed as a casual feeder on the syconia of *Ficus consociata* in the Central Catchment Nature Reserve, and the long-tailed parakeet (*Psittacula longicauda longicauda*) has occasionally been observed feeding on the syconia of *Ficus microcarpa* (AFSLL, pers. obs.). The blue-crowned hanging parrot has been observed to feed on *Ficus caulocarpa*, *Ficus crassiramea*, *Ficus delosyce*, *Ficus kerkhovenii*, *Ficus pisocarpa*, *Ficus stupenda*, and *Ficus virens* (Wells, 1999). However, even with a high degree of specialisation for syconia, the blue-crowned hanging parrot together with the two other species are all known to feed on a wide range of fruits and flowers from many tree species including the oil palm (*Elaeis guineensis*; Fig. 19), mango (*Mangifera indica*), the golden shower tree (*Cassia fistula*), various species of *Macaranga*, and petai (*Parkia speciosa*; AFSLL, pers. obs.).

Pigeons and doves are by far the most commonly encountered birds in urban Singapore feeding on syconia, with members of the genus *Treron* suggested as syconium specialists (Leighton & Leighton, 1983; Lambert, 1991). Seven species of native pigeons have been recorded to feed on syconia. *Treron curvirostra curvirostra*, *Treron fulvicollis fulvicollis*, *Treron olax olax*, and *Treron vernans griseicapilla* are regularly observed feeding on syconia, especially from the commonly encountered *Ficus benjamina* and *Ficus microcarpa* trees in parks as well as wasteland vegetation (Figs. 13, 20). The green imperial pigeon (*Ducula aenea polia*) and the pied imperial pigeon

Fig. 17. An oriental pied hornbill (*Anthracoceros albirostris convexus*) feeding on an alternative food source (fruits of the butterfly palm) at Changi Point. (Photograph by: Alvin Francis Lok Siew Loon).

Fig. 18. A male Asiatic koel (*Eudynamis scolopacea*) feeding on ripe synconia. (Photograph by: Tan Ghim Cheong).

Fig. 19. The blue crowned hanging parrot (*Loriculus galgulus galgulus*) feeding on oil palm fruits (*Elaeis guineensis*), an alternative food source. (Photograph by: Mark Chua).

Fig. 20. The thick-billed pigeon (*Treron curvirostra*) on a *Ficus benjamina* plant. (Photograph by: Ingo Waschikies).

(*Ducula bicolor bicolour*) are both reported to feed on syconia (Wells, 1999), although they often feed on a variety of other fruits including the regularly available fruits of the *Livistonia* palm (Fig. 21) as well as the MacArthur palm. The pied imperial pigeon can often be observed feeding on syconia of a *Ficus superba* tree at Nanyang Drive when it is fruiting (AFSLL, pers. obs.). In Singapore, the jambu fruit dove (*Ptilinopus jambu*) has been observed feeding on a variety of fruits, especially on *Syzygium* species as well as syconia of *Ficus microcarpa* and *Ficus benjamina* at the Japanese Garden entrance (AFSLL, pers. obs.).

The passerine birds account for 57.5% of the genera and 54.8% of the bird species recorded eating syconia (Shanahan et al., 2001). Within the Passeriformes, families such as the Corvidae (crow family), Sturnidae (starling and mynah family), Pycnontodae (bulbul family), Irenidae (leafbirds and fairy bluebird family), Muscicapidae; subfamily turnidae (thrushes), Sylviidae; subfamily Sylviinae (babblers and warblers), Nectariinidae (flowerpecker, sunbird, and spinderhunter family), and Eurylaimidae (broadbill family) have all been recorded feeding on syconia (Table 2).

Amongst the corvids that have been recorded feeding on syconia are cuckoo-shrikes (*Pericrocotus* species), drongos (*Dicrurus* species), ioras (*Aegithina* species), minivets (*Pericrocotus* species), and orioles (*Oriolus* species; see Shanahan et al., 2001). Although these are predominantly insectivorous, they are also opportunistic syconium feeders. Sturnids such as starlings and hill mynahs (*Gracula religiosa*) are rather specialised frugivores and have been recorded feeding on syconia of 19 hemiepiphytic species and can sometimes account for up to 50% of the food tree visitations (Lambert, 1989). Common starlings such as the glossy starlings (*Aplonis panayensis*; Fig. 3) and the purple-backed starling (*Sturnus sturninus*) are regular visitors to *Ficus microcarpa* and *Ficus benjamina* trees in parks, housing estates, cemeteries, wasteland sites, and other urban areas, sometimes feeding in mixed flocks. Other species such as hill mynahs, on the other hand, are usually forest-dwelling species, occasionally venturing out to well-vegetated parks.

Bulbuls (family Pycnontidae) are amongst the most important small frugivores and have been recorded feeding on 63 species of *Ficus* (Shanahan et al., 2001). The buff-vented bulbul (*Iole olivacea*) is a common species in the nature reserves and can be seen feeding on a variety of fig species including the common, urban *Ficus microcarpa*, and the common, forest edge *Ficus grossularoides*. These birds can also be seen feeding on syconia of a larger diameter like those of the critically endangered *Ficus consociata* (Fig. 6), of which ripe syconia are taken and crushed before swallowing. Other common urban-dwelling bulbuls such as the yellow-vented bulbul (*Pycnonotus goiavier*; Fig. 5) usually feed on forest edge and urban fig species such as *Ficus benjamina*, *Ficus grossularoides*, *Ficus heteropleura*, *Ficus microcarpa*, and *Ficus religiosa*.

The other bird family in Singapore that seems to be highly restricted to the forest is the Irenidae, which includes the leafbirds (*Chloropsis* species) and the Asian fairy bluebirds (*Irene puella*). These birds are common in Malaysian forests, but for some reason have become rather scarce in Singapore forests in recent years. The slow disappearance of these birds could be attributed to dwindling forest health and fast declining numbers and species richness of *Ficus* species in the forests, which probably provided a stable supply of food. These birds can however be seen with other rare forest species during fruiting of the *Ficus microcarpa* tree at the summit of Bukit Timah, although numbers seem to be in a steady state of decline. Three species of leafbirds are recorded for Singapore—the greater green leafbird (*Chloropsis sonnerati zosterops*; Fig. 12) and lesser green leafbird (*Chloropsis cyanopogon cyanopogon*) are both critically endangered (Lim et al., 2008), while the blue-winged leafbird (*Chloropsis cochichinensis cochichinensis*) is a rare resident (although erroneously considered a common resident by Wang & Hails [2007]). The Asian fairy bluebird is also very likely to be incorrectly listed as a common resident by Wang & Hails (2007), as it is seldom encountered unless a fig tree in the forest is heavily fruiting. Another possible reason is that this species may be a main canopy statum dweller, so it escapes observation.

Although most thrushes (Muscicapidae) are mainly insectivorous, members in the subfamily Turdinae are highly frugivorous (Lambert, 1989). In Singapore three genera—*Zoothera*, *Turdus*, and *Monticola*—have been recorded feeding on syconia (AFSLL, pers. obs.). Whilst some *Zoothera* species are terrestrial foragers feeding on fallen syconia, others feed on syconia directly from the trees (Lambert, 1989). The orange-headed thrush (*Zoothera citrina citrina*; Fig. 22), which is a winter visitor, and the Siberian thrush (*Zoothera sibirica*; Fig. 23), which is a passage migrant, are recorded to occur in Singapore (Wang & Hails, 2007). The orange-headed thrush usually feeds on the forest floor and has been recorded at Hinhede Park at the Bukit Timah Nature Reserve feeding on fallen syconia, while the Siberian thrush has been observed feeding on syconia of *Ficus benjamina* as well as a *Ficus microcarpa* (AFSLL, pers. obs.). The uncommon passage migrant, the eye-browed thrush (*Turdus obscures obscurus*), is also a regular syconium feeder, usually feeding in small flocks in trees of *Ficus benjamina* and *Ficus microcarpa* especially in wastelands, abandoned farms, as well as in the Western Catchment Area (AFSLL, pers. obs.). The rare passage migrant, the blue rock thrush (*Monticola solitaries pandoo*), is also generally frugivorous, with syconia reported in its diet (Lambert, 1989).

Babblers and warblers of the Sylviidae family have both been recorded to feed on syconia (Lambert, 1989). The brown fulvetta (*Alcippe brunneicauda*) was reported to be frequently feeding on syconia in Malaysia (Lambert, 1989) and the chestnut-backed scimitar babbler (*Pomatorhinus montanus*) has also been reported to consume *Ficus sumatranus* syconia exclusively (McClure, 1966). However there are no field observations of these birds feeding on syconia in Singapore.

In the Nectariinidae family, only the flowerpeckers are true frugivores, with spiderhunters and sunbirds being predominantly insectivorous and nectivorous, respectively (Lambert, 1989). Six species of flowerpeckers in two genera have been recorded for Singapore, five belonging to the genus *Dicaeum* and the last being the locally extinct yellow-breasted flowerpecker (*Prionochilus maculates maculatus*; Table 2; Wang & Hails, 2007). All six species of flowerpeckers have been recorded feeding on syconia, although a wide range of other fruits are taken. These birds seem to have a preference for syconia of hemiepiphytic species with syconia below 1 cm across, such as those of *Ficus benjamina* (Fig. 24), *Ficus caulocarpa*, *Ficus pellucidopunctata*, *Ficus pisocarpa*, and *Ficus stupenda* (see Wells, 1999). However, the orange-bellied flowerpecker (*Dicaeum trigonostigma trigonsostigmum*) has been recorded feeding on syconia as large as 1.5 cm in diameter (*Ficus consociata*; Fig. 25; Wells, 1999).

The last family of birds that have been recorded feeding on syconia is that of Eurylaimidae (broadbill family; Shanahan et al., 2001). It should be noted that all members of this family are presumed nationally extinct in Singapore. In all, Singapore had five species of broadbills in the genera *Calyptomena*, *Corydon*, *Cymbirhynchus*, and *Eurylaimus* (Wang & Hails, 2007). Of these only the green broadbill (*Calyptomera viridis*) is highly frugivorous while the others are predominantly insectivorous, although *Cymbirhynchus* and *Eurylaimus* species have also been recorded opportunistically feeding on syconia. The green broadbill has been recorded feeding on 21 *Ficus* species in Malaysia, spending as much as 31–62% of their time in fig trees (Lambert, 1989, 1991). The wide gape size of this group of birds allows them to swallow syconia whole.

Birds in the Gruiformes, such as the purple swamphen (*Porphyrio porphyrio*) and white-breasted waterhen (*Amaurornis phoenicurus*) as well as the Ciconiiformes such as cattle egrets (*Bubulcus ibis*; Shanahan et al., 2001) have also been recorded eating syconia, although based on their habitats and diets, are very unlikely to feed on syconia frequently. These reported observations could have just been once-off sightings.

Besides birds, many mammals in Singapore also depend on syconia for food (see Table 3, Appendix). In general, primates (family Cercopithecidae), civets (family Viverridae; Fig. 26), tree

Fig. 21. Pied imperial pigeons (*Ducula bicolor bicolour*) here seen feeding on the fruits of a *Livistonia* sp. (Photograph by: Mark Chua).

Fig. 22. A orange-headed thrush (*Zoothera citrina citrina*), often seen feeding on fallen syconia on the forest floor. (Photograph by: Mark Chua).

Fig. 23. The Siberian thrush (*Zoothera sibirica*) feeding in a *Ficus benjamina* tree. (Photograph by: Mark Chua).

Fig. 24. The scarlet-backed flowerpecker (*Dicaeum cruentatum*) feeding on a *Ficus benjamina* synconium. (Photograph by: Tan Gim Cheong).

Fig. 25. An orange-bellied flowerpecker (*Dicaeum trigonostigma trigonsostigmum*) feeding on *Ficus consociata*. (Photograph by: Mark Chua).

shrews (family Tupaiidae), pigs (family Suidae), mousedeers (family Tragulidae), bats (family Pteropodidae) and many rodents like squirrels (family Sciuridae; Fig. 27), rats (family Muridae), as well as porcupines (family Hystricidae) have all been recorded eating syconia (Shanahan et al., 2001). Most of these, however, are restricted to forest areas, except for the plantain squirrel (*Callosciurus notatus*) and the common fruit bat (*Cynopterus brachyotis*) being commonly found in urban areas (Baker et al., 2008).

Fig. 26. A civet feeding in a fig tree at Khao Yai National Park, Thailand. (Photograph by: Tan Gim Cheong).

Fig. 27. The plaintain squirrel (*Callosciurus notatus*) feeding on syconia. (Photograph by: Johnny Wee).

Folivory. — Although not as commonly consumed as the fruits, fig leaves do provide food sources for several species of native fauna. Please see Table 4 for the species associated with *Ficus* species folivory. Fig individuals are also food plants to several species of native Lepidoptera (butterflies and moths). Of the native butterfly species, only two members of the Nymphalidae are known to rely on *Ficus* species as host plants for their early life stages. The little maplet (*Chersonesia peraka peraka*; Fig. 28), a locally rare species confined to the forests, is known to feed on the leaves of *Ficus punctata*, while the striped blue crow (*Euploea mulciber mulciber*; Fig. 29), a locally common species found in urban parks, gardens, forests and mangroves, feeds on the leaves of *Ficus globosa* and *Ficus microcarpa* (Khew, 2010).

The early life histories of moths were said to be generally understudied (Barlow, 1982), and it has been so till present. Amongst the many possible species that may be able to utilise fig leaves as larval food, most members of the genus *Asota* (family Noctuidae) are more easily distinguished and are well known for feeding voraciously on fig leaves. *Asota plana* (Fig. 30) is probably the most easily recognisable and commonly encountered fig leaf-eating moth here, feeding on the white-leafed fig (*Ficus grossularioides*), Malayan banyan (*Ficus microcarpa*) and other congeners (WFA, pers. obs.). *Asota egens* (Fig. 31) is also occasionally encountered, and is known to feed on *Ficus xylophylla* leaves (WFA, pers. obs.), while *Asota subsimilis* has been found feeding on *Ficus fistulosa* leaves (TML, pers. obs.; Fig. 32). Other known fig leaf-eating species that occur here include *Mecodina lanceola* (family Erebidae; Fig. 33; Leong, 2010), and a *Phauda* species (family Zygaenidae; Fig. 34; TML, pers. obs.).

Fig. 28. a, *Chersonesia peraka peraka* (the little maplet) caterpillar on a *Ficus punctata* leaf. b, Adult *Chersonesia peraka peraka*. (Photographs by: Horace Tan Hwee Huat).

Fig. 29. a, *Euploea mulciber mulciber* (the striped blue crow) caterpillar on a *Ficus punctata* leaf. b, Adult *Euploea mulciber mulciber*. (Photographs by: Horace Tan Hwee Huat).

Fig. 30. a, *Asota plana* final instar on a *Ficus microcarpa* leaf. b, Adult *Asota plana*. (Photographs by: Alvin Francis Lok Siew Loon [a] and Leong Tzi Ming [b]).

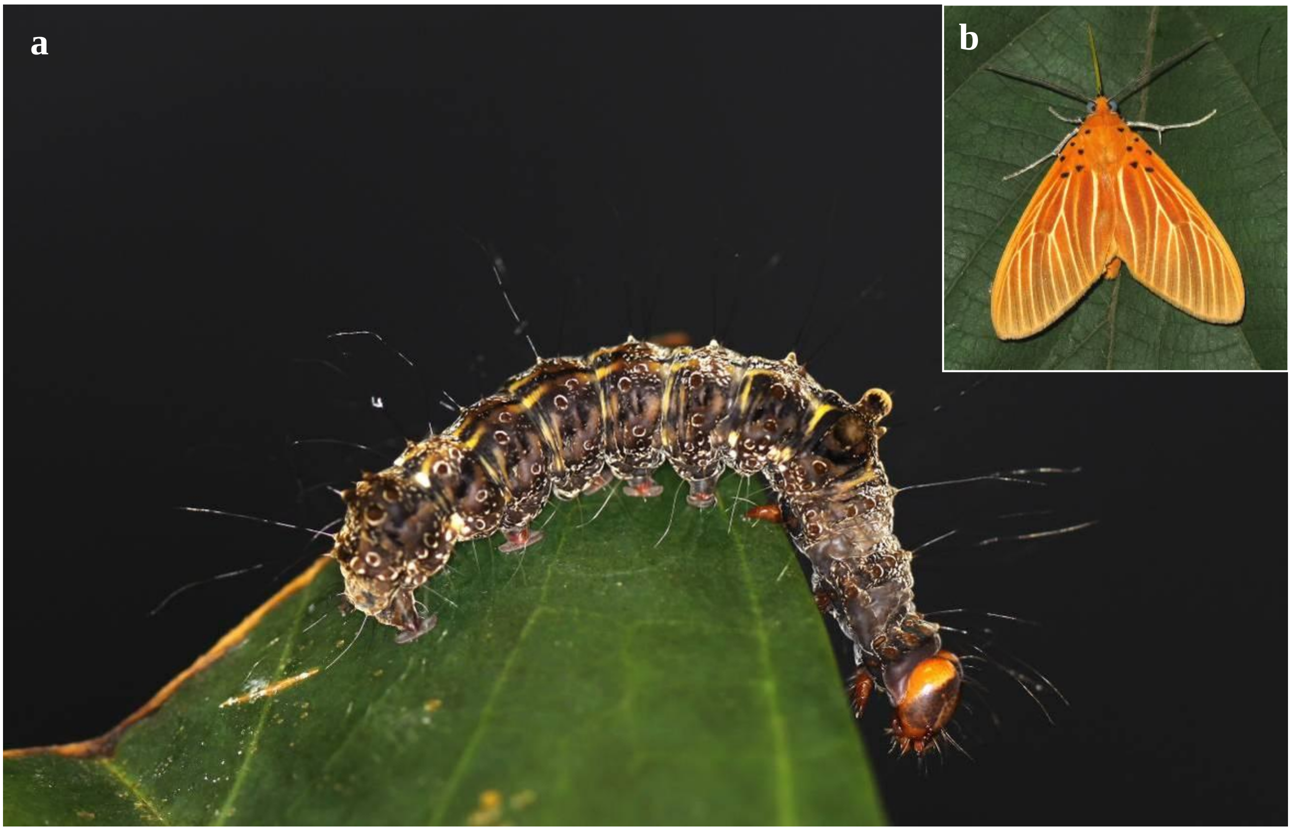

Fig. 31. a, *Asota egens* caterpillar on a *Ficus xylophylla* leaf. b, Adult *Asota egens*. (Photographs by: Alvin Francis Lok Siew Loon).

Fig. 32. a, *Asota subsimilis* final instar feeding on a *Ficus fistulosa* leaf. b, Adult *Asota subsimilis*. (Photographs by: Leong Tzi Ming).

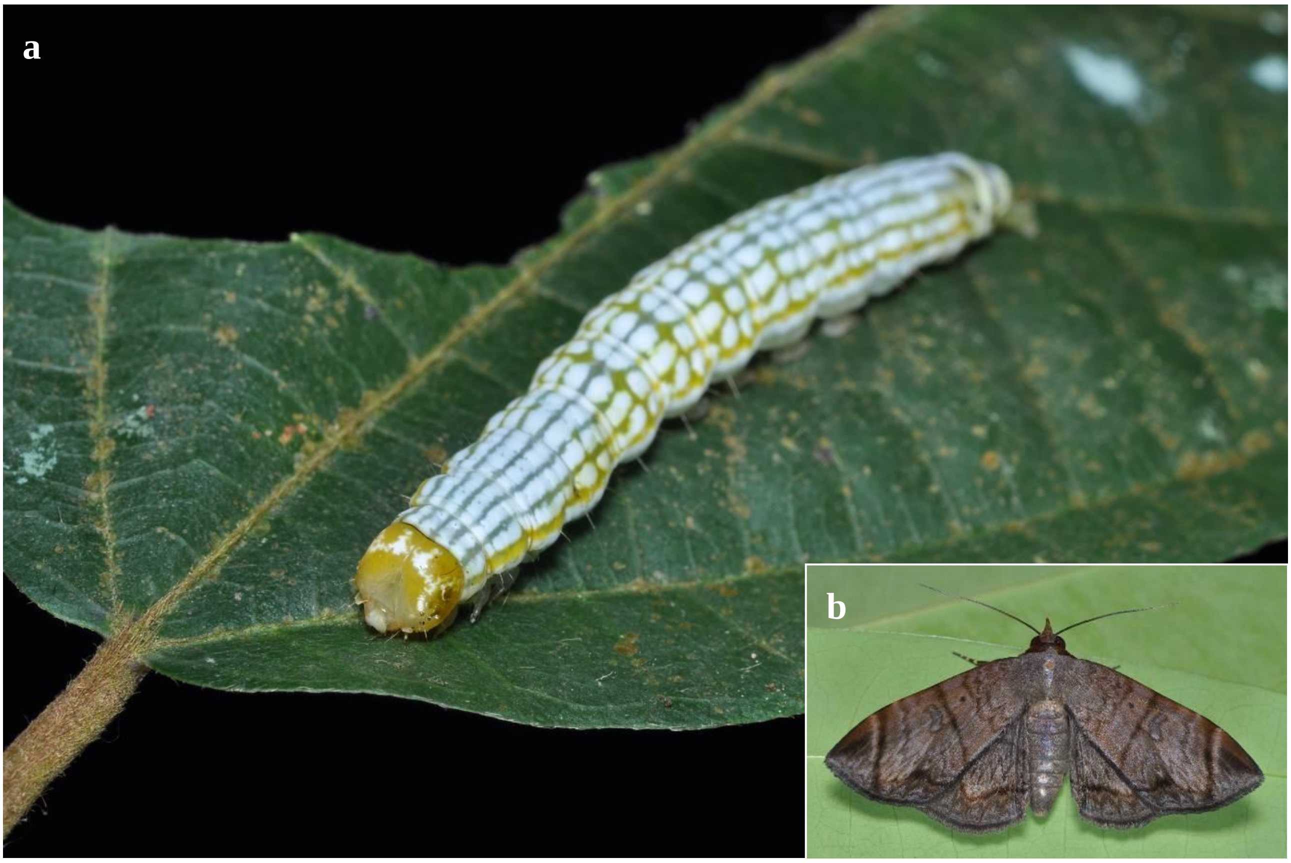

Fig. 33. a, *Mecodina lanceola* final instar feeding on a *Ficus variegata* leaf. b, Adult *Mecodina lanceola*. (Photographs by: Leong Tzi Ming).

Fig. 34. a, *Phauda* sp. final instar feeding on a *Ficus microcarpa* leaf. b, Adult *Phauda* sp. (Photographs by: Leong Tzi Ming).

HORTICULTURE

Urban usage and planting plan. — As described in the previous sections, *Ficus* species are a very diverse group of plants with many growth forms, including terrestrial shrubs or trees, hemiepiphytes (stranglers), holoepiphytes or lithophytes, climbers, rheophytic shrubs, and creeping shrubs (Berg & Corner, 2005). However, owing to the lack of certain habitats in Singapore (e.g., large rivers), the growth forms of native fig species are restricted to terrestrial shrubs or trees, hemiepiphytes, holoepiphytes, and climbers (Table 1). As the majority of our local *Ficus* species are either forest edge shrubs or trees and hemi- or holoepiphytes, they are suitable for urban planting, being able to thrive in bright, windy, and rather desiccating conditions. Of particular interest for urban planting are the hemiepiphytes, which can grow into large, ground-dwelling trees, capable of producing many syconia year-round. It is this asynchronous fruiting of many of these fig species (Herre et al., 2008) that ensure a continual supply of food to many of the native birds year round, thus increasing Singapore's urban biodiversity.

Hemiepiphytic *Ficus* species (strangler figs) have adventitious roots systems that make them suitable for shallow soil banks and road side verges compared to trees with long tap roots (Fig. 35). Their laterally spreading adventitious root systems are also useful for holding soil together, especially on gentle slopes, where these roots are useful for preventing soil erosion and overland flow, especially after heavy rains (Fig. 36; Tan et al., 2010). In general these plants also have wide-spreading crowns and thick foliage which provide shade (Fig. 35). In many species, the hanging adventitious roots from the crown can also be trained to form structures for aesthetic and civil engineering purposes. An excellent example can be found in the town of Cherrapunji of northeastern India, where the locals have creatively and cleverly woven the adventitious roots of the hemiepiphytic rubber fig (*Ficus elastica*) into an intricate and durable pedestrian bridge over rapids (Fig. 37). Thus, the same principle could be applied to hemiepiphytic fig species planted in urban areas for example, by coiling the adventitious roots around a pole or frame inserted into the ground, allowing them to be trained and grown in a certain direction over and across pathways to form an archway. Native hemiepiphytes can also be useful in replacing exotic roadside and urban landscape trees, by planting them in the forks of the large trees and allowing the fig plants to slowly overgrow their hosts to occupy their space (Fig. 38). Besides the ―replacement" method, some *Ficus* species have widely spreading crowns that provide ample shade and branches that do not break easily so are also good substitutes for roadside trees such as the angsana (*Pterocarpus indicus*) and rain tree (*Albizia saman*), both of which are exotics and which have presented their own problems such as the *Fusarium* wilt disease (Sanderson et al., 1997) and deleterious mutations such as leaf reduction, respectively. Both exotics are also prone to branch breakage and toppling during heavy wind. Although *Ficus* species are not popular street and urban landscape trees in Singapore, they have been used extensively in countries like Australia, where they effectively provide shade on roads (Fig. 39) and attract a large variety of wildlife to them.

Holoepiphytes such as the mistletoe fig (*Ficus deltoidea*) are species which start life much like hemiepiphytes up on their host tree, but do not produce leading roots down to the soil. They remain up in the crown with a complex root system, holding up the plant, much like that of an epiphytic orchid. Holoepiphytes have succulent leaves and can be used in sites that are very well drained, dry, and with little soil—in places that preclude the use of other species that easily dry up. In Singapore, the recent introduction of bioretention swales or bioswales (elongated soil beds with perforated drainage pipes below the soil, planted with vegetation to remove pollutants from stormwater runoff such as finer suspended solids and other contaminants; Public Utilities Board, 2010) at roadsides and paths requires the use of drought-tolerant species that are able to withstand full sunlight, and *Ficus deltoidea* would be a good candidate for this purpose. This species could also be utilised for skyrise greenery (e.g., rooftop gardens) where it is usually exposed to high amounts of sunlight and desiccating wind, and also shallow soil beds (owing to loading capacity on buildings). Native

Fig. 35. The sea fig (*Ficus superba*) growing in the National Technological University (NTU) campus, behind a bus stop in a small soil verge (street planting). (Photograph by: Alvin Francis Lok Siew Loon).

Fig. 36. Malayan banyan roots, seen here at Astrid Hill, can stabilise slopes because they grow vigorously over the soil surface and help to prevent soil erosion. (Photograph by: Hugh Tan Tiang Wah).

Fig. 37. A *Ficus elastica* suspension bridge in Cherrapunji, northeastern India. (Photograph by: Marcus Fornell).

hemiepiphytic species such as Malayan banyan (*Ficus microcarpa*) that grow naturally on buildings are also good candidates for the bioswale as they are also able to withstand the similarly dry conditions presented in the swales during drought periods.

As mentioned earlier, as the symbiotic fig wasps survive for a mere few days once they emerge from their natal syconia, it is important for them to find a receptive syconium for oviposition for the survival of their species. Likewise, it is essential for the florets in the syconia to be pollinated to produce seeds for the *Ficus* species. This mutualism is sustained through the asynchrony in crop development between conspecific fig trees in the tropics, which ensures fruiting by at least one individual in the population all year round, therefore, providing a continuous supply of receptive syconia for the reproduction of wasps. It is therefore important that when planting monoecious fig trees and plants in the urban environment, a specimen of the same species is planted every few blocks or streets in housing estates or at least in a minimum number of five at each planting. While this planting scheme is probably adequate to provide sufficient individuals of the same species in a given area to provide a continuous supply of pollinators and host fig plants, it has a drawback in that this does not allow for high-biodiversity planting. A possible solution to this drawback is to have *Ficus* species ―pockets" in urban areas or housing estates, where a few hemiepiphytic *Ficus* species can be planted together in open plots of land or at the edges of large fields. This mixed-species planting should also be duplicated in every neighbourhood, to allow connectivity of the fig trees and the *Ficus* species-specific pollinator wasp species. If dioecious *Ficus* species are utilised for planting along streets or landscapes, then many more individuals are required to ensure sufficient male and female plants in the area. If, however, the dioecious species can be propagated by stem cuttings (e.g., sand-leafed fig, *Ficus heteropleura*), then the exact number of male and female species can be planted at any one site using the rooted stem cuttings from specific male and female parent plants.

Fig. 38. *Ficus microcarpa* growing in the fork of a rain tree, which will eventually be overtaken and replaced by the fig (replacement planting). (Photograph by: Alvin Francis Lok Siew Loon).

Fig. 39. *Ficus* sp. planted along the roadside in Kuranda, Queensland, Australia. (Photograph by: Alvin Francis Lok Siew Loon).

Epiphytic and climbing fig species can also be used to enhance urban landscape trees that are designated to be retained and not replaced. Existing trees can be enhanced, by growing the native creeping or climbing fig species such as *Ficus globosa*, *Ficus heteropleura*, *Ficus punctata*, *Ficus sagittata*, *Ficus trichocarpa*, and *Ficus villosa* at the base of the trees and allowing the climber to grow up the tree trunk (Figs. 40, 41).

Obstacles to introduction. — In many parts of Southeast Asia, cultivating hemiepiphytes or stranglers is usually frowned upon. This is largely attributed to superstition, as many stranglers, owing to their shape and form, are quickly associated with the Benjamin fig or waringin (*Ficus benjamina*). Large waringin trees are believed to house spirits of the Pontianak (ghost of a woman who died in childbirth of Malay folklore), because of their sinister-looking form with the dark shady crown of drooping branches and hanging aerial roots, where the Pontianak is believed to swing from these hanging roots (Tan & Giam, 2009). Because of this superstition, tree cutters are wary of felling large strangler figs because they are afraid of offending the spirit residing within them, so should a tree need to be felled, the costs will be higher, assuming one can find a tree cutter willing to do this. Feng Shui belief also indicates that the waringin tree is an inauspicious plant to grow because its drooping branches signifies sorrow and the dense crown blocks the flow of qì (life force or energy), thus creating a stale state or accumulation of qì. Some Chinese however associate the banyan tree with good spirits and will ask it to adopt a sick child to improve the child’s health.

Besides superstition, *Ficus* species are not often cultivated because of the damage they may potentially cause to infrastructure. This is especially true if these plants are grown near or on buildings and are allowed to find a foothold in cracks and crevices. Stranglers can also cause much damage if they are allowed to grow near electrical conduits or water pipes, which are quickly enveloped by the plants’ contractile roots and crushed, as would a strangler its host tree. Having said that, growing any tree close to concrete structures would inadvertently result some form of damage by the roots as well as falling branches or trees. The *Ficus superba* at Nanyang Drive, (Fig. 28) despite being grown in a small earth bank and close to a drain, caused only minor damage to the drain, barely 2 m from the tree (Fig. 42). In this instance, the spreading roots of the *Ficus superba* found its way into the drain through a drainage hole, after which it spread its roots along the bottom and sides of the drain (Fig. 43). Another example of growing a strangler in a confined space with little or no damage to its surroundings are the *Ficus superba* trees planted at Universal Studios Singapore on Sentosa, where the tree sits in a relatively tiny 1.5 × 1.5 m planting bed (Fig. 44).

Another possible reason why *Ficus* species are not widely cultivated is attributed to the mess that they can cause from the fallen syconia of fruiting trees and from the droppings of the birds attracted to the syconia under and around such trees. Both reasons make these trees unpopular plants for car parks, even though they provide much shade and have branches which are unlikely to fall and cause damage to cars parked below, compared to the rain tree (*Albizia saman*), which provides less shade and has branches that sometimes break and fall, damaging cars parked below. However, rain trees are also popular roosting sites of the exotic, pest bird, the Javan mynah (*Acridotheres javanica*) whose droppings create a huge mess to the cars below them. However, *Ficus* species can be planted away from paths and roads, in parks or large gardens if they cannot be planted along streets and car parks, to minimise the inconvenience to residents.

While fig plants have the potential to attract much wildlife to urban areas to warm the hearts of nature lovers, some Singaporeans may not be prepared to cope with wildlife very close to where they live, and would prefer wildlife to be kept a comfortable distance away, in the nature reserves. Birds attracted to such fruiting fig trees not only defaecate around and below such trees as mentioned above, but also produce much noise when feeding during the peak periods which are just after dawn and before dusk, when the air is cool. Dawn feeding noise by the birds will wake residents early in the morning and has led to complaints to the Town Councils. Noise pollution as well as worries about health risks such as bird flu will lead to official complaints to the National Environmental Agency (NEA) or the Agri-food and Veterinary Authority of Singapore (AVA), appealing for such trees to be removed. To counter such complaints, it is imperative to provide effective public education to Singaporeans to minimise human–wildlife conflict.

The incorporation of *Ficus* species into planting schemes such as the Streetscape Greenery Master Plan or into Urban Redevelopment Authority (URA) development guidelines is also recommended so as to increase the urban biodiversity. Partnership amongst governmental and non-governmental agencies in planning and sorting out logistical and biodiversity conservation issues is also needed to ensure such planting could be carried out effectively and efficiently.

Commercial availability. — Sadly, many native *Ficus* species are not commercially available. Out of the 46 species of native *Ficus* species recorded for Singapore, only four (8.7%) are commercially available from nurseries, of which none were propagated from Singapore genotypes, but rather from stock obtained, grown, and imported from neighbouring countries such as Malaysia, Indonesia, and Thailand. Government agencies such as the the National Parks Board (NParks), which is the largest purchaser of nursery plants in Singapore and charged with the mission to safeguard native biodiversity (National Parks Board Act, Chapter 198A, Section 6 (1) (c)), should actively promote the propagation and cultivation of *Ficus* species of local provenance, by encouraging and educating local nurseries to propagate such plants as well as to provide stock material for propagation, thereby maintaining a healthy stock of plants with native genotypes.

Propagation. — Although native *Ficus* species are relatively easy to cultivate, plants of local provenance are seldom available for sale to the public and NParks alike, especially the rarer species owing to the lack of demand for the reasons highlighted above. To overcome this, many native *Ficus* species have been propagated from local provenance at the National University of Singapore Native Plant Nursery at Research Link. The common methods employed for propagation are from germinating seeds (Fig. 41), rooting stem cuttings (Fig. 42), and air-layering (Fig. 43).

Fig. 40. *Ficus hetropleura* planted on a rain tree along a carpark at the National Univeristy of Singapore. (Photograph by: Alvin Francis Lok Siew Loon).

Fig. 41. *Ficus heteropleura* growing wild on a large rain tree at Bukit Brown Cemetery. (Photograph by: Alvin Francis Lok Siew Loon).

Fig. 42. *Ficus superba* growing at the Nanyang Technological University, barely 2 m away from a drain and busstop. (Photograph by: Alvin Francis Lok Siew Loon).

Fig. 43. *Ficus superba* roots spreading along the periphery of the inside of the drain. (Photograph by: Alvin Francis Lok Siew Loon).

Fig. 44. *Ficus superba* growing in a confined earth bank at Universal Studios Singapore. (Photograph by: Ang Wee Foong).

Seed germination. — Although all *Ficus* species can be propagated from seeds, this method is primarily used for species that are dioecious shrubs or trees, as these are very difficult to root via stem cuttings or air layering. The seeds within the syconia are removed and placed on moist filter or tissue paper and sealed in a small plastic container under a light source for about 12 hours per day (Fig. 45).

Typically, the seeds germinate within 10–12 days or so, with varying rates of success depending on the degree of freshness or ripeness of the seeds and syconia, temperature as well as the species.

Once germinated, the fragile seedlings will sprout their first true leaves by the end of the first week. A dilute solution of liquid fertiliser (half or quarter of the recommended dose in tapwater) can be added to the plants to encourage rapid growth. Once the seedlings are of a reasonable size, they can be transplanted onto a growth medium of sandy, humus-rich soil that is well-drained and grown to planting size.

Rooting stem cuttings. — This is the easiest and most convenient way of propagating stranglers and root climbers. The crucial point of this method is the production of adventitious roots from the stem cuttings, after which the rooted cutting can be subsequently transplanted into a mixture of soil to be grown to planting size.

The selection of branches is extremely important. Usually, “softwood” or green twigs are preferred as old, “hardwood” branches are more difficult to root. Stem cuttings obtained from mature individuals should be short branches of not more than 20 cm, with about two to three nodes each. Syconia borne on the branches and excess leaves at the bottom half of the cuttings should be removed, and the remaining mature leaves having each leaf blade’s distal half removed, so as to reduce transpiration loss and hence water stress on the cutting. The processed cuttings should then be placed in tapwater immediately to prevent drying out as well as to leach out as much latex from the cuttings as possible. Change the water every day for a few days, then the cuttings can either be stuck directly in clean sand, soil or placed into water and aerated (Fig. 46). Aerating the water tends to yield a higher rate of rooting success by increasing oxygenation and discouraging the formation of fungal clots on the cut ends. When rooting stem cuttings in water, tannins are leached out into the water, giving the water a brown tinge. This tannin increases the acidity of the tapwater which may kill the cuttings, so the tapwater should also be changed regularly (once every 2–3 days) to ensure successful rooting.

Once adventitious roots have been formed, the rooted cutting should be removed from the aerated water and transplanted into a solid potting medium of well-drained soil for establishment as prolonged submergence causes root rot.

Air-layering. — This method of rooting is employed for stranglers and root climbers that are not easily rooted by stem cuttings. Air-layering is usually carried out by first scarring the stem tissue of a branch and wrapping a layer of moist rooting medium (e.g., sphagnum moss or well-drained soil) around the scars with a plastic wrap (Fig. 47). The wrap is then left on for several weeks until adventitious roots are formed from the scars and fills up the rooting medium. The rooted branch can then be removed from the parent plant below the adventitious roots and transplanted into a planting medium of well-drained soil and grown till planting size. Appropriate amounts of rooting hormone may be applied to the scars before wrapping to increase the chances of adventitious rooting.

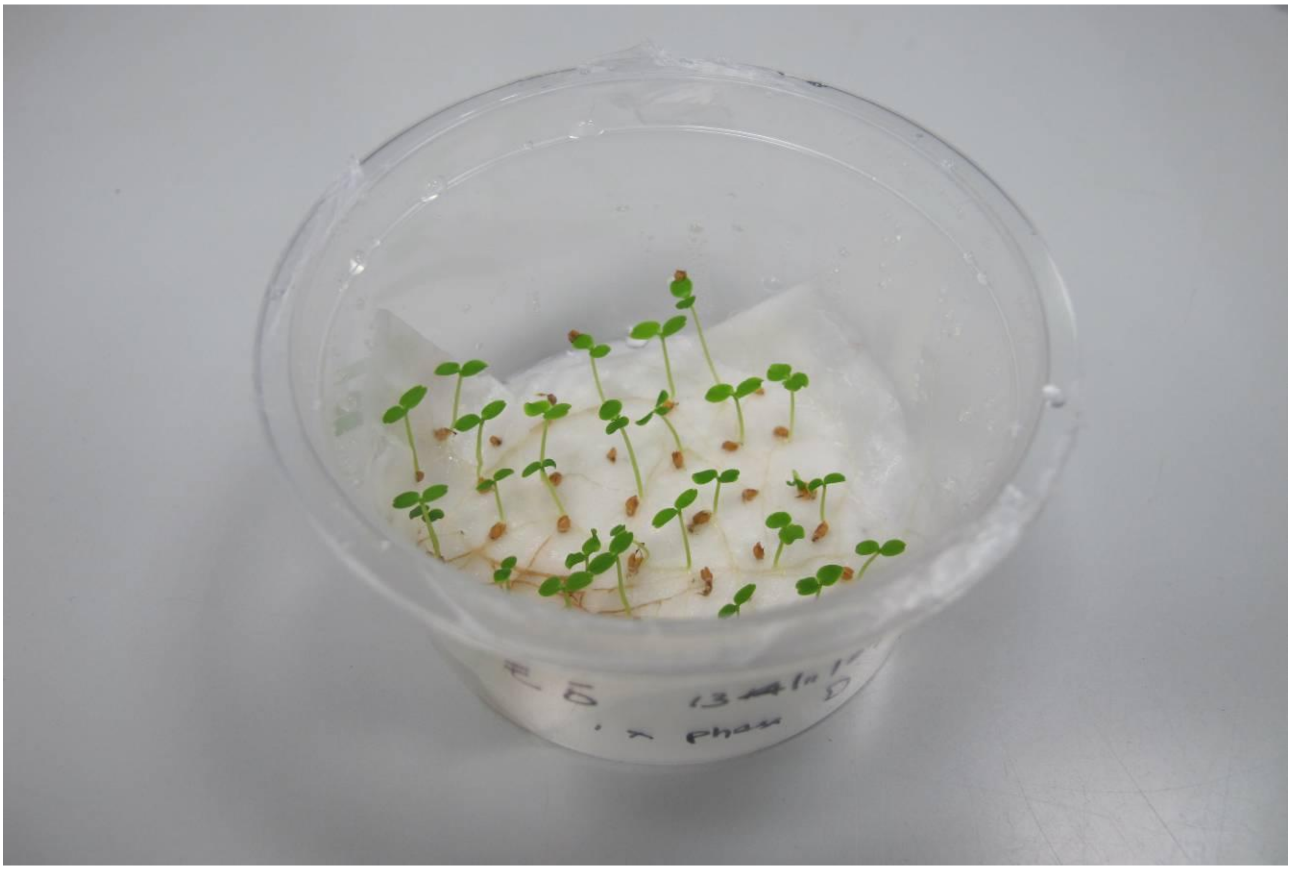

Fig. 45. *Ficus* seedlings germinating from seeds sitting on moist filter paper. (Photograph by: Alvin Francis Lok Siew Loon).

Fig. 46. *Ficus apiocarpa* cuttings being rooted. (Photograph by: Alvin Francis Lok Siew Loon).

Fig. 47. *Ficus consociata* being air-layered. (Photograph by: Alvin Francis Lok Siew Loon).

CONCLUSIONS

Ficus species provide ecosystem functions for many species of both common and threatened native animals such as birds, mammals, and insects as well as plants such as mistletoes. The propagation and cultivation of native *Ficus* species in urban areas can also potentially aid in the conservation of native genotypes and increase the abundance and recruitment of these organisms as natural forests are slowly being encroached upon by various human developments. Additionally, native *Ficus* species can be utilised in various applications such as street, park or garden trees that cool down the environment through evapotranspiration and beautify the environment. However, cultivation of *Ficus* species is not without its difficulties and problems. The concerted and committed efforts of various governmental and non-governmental stakeholders in partnership are also crucial to the successful implementation of native *Ficus* species cultivation in urban areas. As human–wildlife conflicts would inevitably arise with the recruitment of wildlife into the urban environment, public education is essential for helping Singapore's residents understand the ecological significance and value of biodiversity.

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APPENDIX

Table 1. *Ficus* species recorded from Singapore compiled from Berg & Corner (2005) and Chong et al. (2009) arranged alphabetically by scientific name.

S/No.	Scientific Name	Subgenus	Section	Subsection	Local Status	Habit	Sexual System
1.	*Ficus aurata* Miq. var. *aurata*	Ficus	Eriosycea	Auratae	Vulnerable	Shrub or tree	Dioecious
2.	*Ficus chartacea* Wall. ex King	Ficus		Eriosycea	Vulnerable	Shrub or tree	Dioecious
3.	*Ficus glandulifera* (Wall. ex Miq.) King	Ficus	Eriosycea	Eriosycea	Critically Endangered	Tree	Dioecious
4.	*Ficus grossularioides* Burm.f. var. *grossularioides* Burm.f.	Ficus	Eriosycea	Eriosycea	Common	Shrub or tree	Dioecious
5.	*Ficus lamponga* Miq.	Ficus	Eriosycea	Eriosycea	Critically Endangered	Tree	Dioecious
6.	*Ficus deltoidea* Jack	Ficus	Ficus	Frutescentiae	Critically Endangered	Shrub and epiphytic, epilithic or tree	Dioecious
7.	*Ficus heteropleura* Blume	Sycidium	Palaeomorphe	—	Common	Shrub, often lianescent and/or strangler	Dioecious
8.	*Ficus obscura* Blume var. *borneensis* (Miq.) Corner	Sycidium	Palaeomorphe	—	Critically Endangered	Shrub or tree, mostly strangler	Dioecious
9.	*Ficus sinuata* Thunb.	Sycidium	Palaeomorphe	—	Critically Endangered	Shrub or treelet, often a strangler	Dioecious
10.	*Ficus botryocarpa* Miq.	Sycomorus	Sycocarpus	Sycocarpus	Nationally Extinct	Tree	Dioecious
11.	*Ficus fistulosa* Reinw. ex Blume	Sycomorus	Sycocarpus	Sycocarpus	Common	Tree	Dioecious
12.	*Ficus scortechinii* King	Sycomorus	Sycocarpus	Sycocarpus	Critically Endangered	Tree	Dioecious
13.	*Ficus variegata* Blume	Sycomorus	Sycomorus	Neomorphe	Common	Tree	Dioecious
14.	*Ficus apiocarpa* Miq.	Synoecia	Kissosycea	—	Endangered	Root-climber	Dioecious
15.	*Ficus punctata* Thunb.	Synoecia	Kissosycea	—	Common	Root-climber	Dioecious
16.	*Ficus ruginervia* L.	Synoecia	Kissosycea	—	Nationally Extinct	Root-climber	Dioecious
17.	*Ficus laevis* Blume	Synoecia	Rhizocladus	Pogonotrophe	Critically Endangered	Root-climber	Dioecious
18.	*Ficus excavata* King	Synoecia	Rhizocladus	Punctulifoliae	Nationally Extinct	Root-climber	Dioecious
19.	*Ficus recurva* Blume var. *ribesoides* King	Synoecia	Rhizocladus	Punctulifoliae	Critically Endangered	Root-climber	Dioecious
20.	*Ficus sagittata* Vahl	Synoecia	Rhizocladus	Punctulifoliae	Critically Endangered	Root-climber	Dioecious
21.	*Ficus villosa* Blume	Synoecia	Rhizocladus	Punctulifoliae	Critically Endangered	Root-climber	Dioecious
22.	*Ficus trichocarpa* Blume	Synoecia	Rhizocladus	Trichocarpeae	Critically Endangered	Root-climber	Dioecious

S/No.	Scientific Name	Subgenus	Section	Subsection	Local Status	Habit	Sexual System
23.	*Ficus albipila* (Miq.) King	Pharmacosycea	Oreosycea	Pedunculatae	Nationally Extinct	Tree	Monoecious
24.	*Ficus vasculosa* Wall. ex Miq.	Pharmacosycea	Oreosycea	Pedunculatae	Endangered	Tree	Monoecious
25.	*Ficus binnendykii* Miq. var. *binnendykii* Miq.	Urostigma	Urostigma	Conosycea	Critically Endangered	Strangler	Monoecious
26.	*Ficus binnendykii* Miq. var. *coriacea* Corner	Urostigma	Urostigma	Conosycea	Critically Endangered	Strangler	Monoecious
27.	*Ficus bracteata* Wall. ex Miq.	Urostigma	Urostigma	Conosycea	Critically Endangered	Strangler	Monoecious
28.	*Ficus consociata* Blume var. *murtoni* King	Urostigma	Urostigma	Conosycea	Critically Endangered	Strangler	Monoecious
29.	*Ficus crassiramea* Miq.	Urostigma	Urostigma	Conosycea	Critically Endangered	Strangler	Monoecious
30.	*Ficus delosyce* Corner	Urostigma	Urostigma	Conosycea	Nationally Extinct	Strangler	Monoecious
31.	*Ficus dubia* Wall. ex King	Urostigma	Urostigma	Conosycea	Critically Endangered	Strangler	Monoecious
32.	*Ficus globosa* Blume	Urostigma	Urostigma	Conosycea	Endangered	Climber, or strangler or treelet	Monoecious
33.	*Ficus kerkhovenii* Valeton	Urostigma	Urostigma	Conosycea	Critically Endangered	Strangler	Monoecious
34.	*Ficus microcarpa* L.f.	Urostigma	Urostigma	Conosycea	Common	Strangler	Monoecious
35.	*Ficus microsyce* Ridl.	Urostigma	Urostigma	Conosycea	Critically Endangered	Strangler or climber	Monoecious
36.	*Ficus pellucidopunctata* Griff.	Urostigma	Urostigma	Conosycea	Nationally Extinct	Strangler	Monoecious
37.	*Ficus pisocarpa* Blume	Urostigma	Urostigma	Conosycea	Critically Endangered	Strangler	Monoecious
38.	*Ficus retusa* L.	Urostigma	Urostigma	Conosycea	Critically Endangered	Strangler	Monoecious
39.	*Ficus subgeideri* Corner var. *rigida* (Miq.) Corner	Urostigma	Urostigma	Conosycea	Critically Endangered	Strangler	Monoecious
40.	*Ficus subgeideri* Corner var. *subgelderi* Corner	Urostigma	Urostigma	Conosycea	Nationally Extinct	Strangler	Monoecious
41.	*Ficus sundaica* Blume var. *sundaica* Blume	Urostigma	Urostigma	Conosycea	Critically Endangered	Strangler	Monoecious
42.	*Ficus xylophylla* Wall. ex Miq.	Urostigma	Urostigma	Conosycea	Critically Endangered	Strangler	Monoecious
43.	*Ficus annulata* Blume	Urostigma	Urostigma	Urostigma	Nationally Extinct	Strangler	Monoecious
44.	*Ficus caulocarpa* Miq.	Urostigma	Urostigma	Urostigma	Common	Strangler	Monoecious
45.	*Ficus superba* Miq.	Urostigma	Urostigma	Urostigma	Endangered	Strangler	Monoecious
46.	*Ficus virens* Ait. var. *glabella* (Blume) Corner	Urostigma	Urostigma	Urostigma	Critically Endangered	Strangler	Monoecious

Table 2. Bird species that have been recorded feeding on *Ficus* species syconia in Singapore compiled from Lambert (1989, 1991) and Shanahan et al. (2001). Species are arranged alphabetically by their scientific name.

S/No.	Scientific Name	Order	Family	Common Name	Habitat	Fig Dependence	Local Status
1.	*Acridotheres tristis tristis*	Passeriformes	Sturnidae	Common mynah	Primary forest, secondary forest, forest fringes, gardens, parks, wasteland, mangroves and beach forest	Fig generalist	Common resident breeder
2.	*Aegithina tiphia singapurensis*	Passeriformes	Aegithinidae	Common iora	Secondary forest, forest fringes, gardens, parks, wasteland and abandon agricultural land	Casual fig eater	Common resident breeder or rare winter visitor
3.	*Aegithina viridissima viridissima*	Passeriformes	Aegithinidae	Green iora	Primary forest, secondary forest and freshwater swamp forest	Casual fig eater	Extinct
4.	*Alophoixus phaeocephalus phaeocephalus*	Passeriformes	Pycnonotidae	Yellow-bellied bulbul	Primary forest, secondary forest and forest fringes	Fig generalist	Extinct
5.	*Amaurornis phoenicurus chinensis*, *Amaurornis phoenicurus javanicus*, *Amaurornis phoenicurus phoenicurus*	Gruiformes	Rallidae	White-breasted waterhen	Secondary forest, forest fringes, gardens, parks, wasteland, abandon agricultural land and mangroves	Casual fig eater	Common resident breeder, uncommon winter visitor or passage migrant
6.	*Anthracoceros albirostris convexus*	Coraciiformes	Bucerotidae	Oriental pied hornbill	Edges of evergreen forest, surrounding areas of open secondary forest, woodlands	Fig specialist	Rare resident breeder
7.	*Aplonis panayensis strigatus*	Passeriformes	Sturnidae	Asian glossy starling	Primary forest, secondary forest, forest fringes, gardens, parks, wasteland, mangroves and beach forest	Fig generalist	Common resident breeder
8.	*Bubulcus ibis coromandus*	Ciconiiformes	Ardeidae	Cattle egret	Open grassy areas	Casual fig eater	Common winter visitor passage migrant
9.	*Buceros rhinoceros rhinoceros*	Coraciiformes	Bucerotidae	Rhinoceros hornbill	Primary forest and old second-growth forest	Fig specialist	Extinct
10.	*Cacomantis merulinus threnodes*	Cuculiformes	Cuculidae	Plaintive cuckoo	Primary forest, secondary forest, forest fringes, gardens, parks, wasteland, abandon agricultural land and mangroves	Fig generalist	Uncommon resident breeder

S/No.	Scientific Name	Order	Family	Common Name	Habitat	Fig Dependence	Local Status
11.	*Cacomantis sepulcralis sepulcralis*	Cuculiformes	Cuculidae	Rusty-breasted cuckoo	Primary forest, secondary forest, forest fringes, gardens, parks, wasteland, abandon agricultural land and back mangroves	Casual fig eater	Uncommon resident breeder
12.	*Cacomantis sonneratii malayanus*	Cuculiformes	Cuculidae	Banded bay cuckoo	Primary forest, secondary forest, forest fringes, gardens, parks, wasteland, abandon agricultural land and mangroves	Casual fig eater	Uncommon resident breeder
13.	*Callosciurus notatus*	Rodentia	Sciuridae	Plantain squirrel	Primary forest, secondary forest, mangroves, forest fringes and adjacent parklands	Fig generalist	Widespread and common
14.	*Calorhamphus fuliginosus hayii*	Piciformes	Capitonidae	Brown barbet	Primary forest,swampy forest and secondary forest	Fig specialist	Extinct
15.	*Calyptomena viridis viridis*	Passeriformes	Eurylamidae	Green broadbill	Primary forest, riverine forest and freshwater swamp forest	Fig specialist	Extinct
16.	*Chloropsis cochinchinensis icterocephala*	Passeriformes	Chloropseidae	Blue-winged leafbird	Primary forest and old second-growth forest	Fig specialist	Common resident, breeding not proven
17.	*Chloropsis cyanopogon cyanopogon*	Passeriformes	Chloropseidae	Lesser green leafbird	Primary forest and old second-growth forest	Fig specialist	Uncommon resident, breeding not proven
18.	*Chloropsis sonnerati zosterops*	Passeriformes	Chloropseidae	Greater green leafbird	Primary forest and old second-growth forest	Fig specialist	Rare resident, breeding not proven
19.	*Coracina fimbriata culminata*	Passeriformes	Campephagidae	Lesser cuckooshrike	Primary forest, secondary forest and freshwater swamp forest	Casual fig eater	Rare resident, breeding not proven
20.	*Coracina striata sumatrensis*	Passeriformes	Campephagidae	Bar-bellied cuckooshrike	Primary forest, secondary forest and freshwater swamp forest	Casual fig eater	Extinct
21.	*Cuculus micropterus micropterus*	Cuculiformes	Cuculidae	Indian cuckoo	Primary forest, secondary forest, forest fringes, gardens and parks	Fig generalist	Common winter visitor or passage migrant
22.	*Cuculus saturatus saturatus*	Cuculiformes	Cuculidae	Oriental cuckoo	Primary forest, secondary forest, forest fringes, gardens and parks	Casual fig eater	Rare winter visitor or passage migrant

S/No.	Scientific Name	Order	Family	Common Name	Habitat	Fig Dependence	Local Status
23.	*Cymbirhynchus macrorhynchos malaccensis*	Passeriformes	Eurylamidae	Black-and-red broadbill	Primary forest, riverine forest, freshwater swamp forest, secondary forest and mangrove forest	Fig specialist	Extinct
24.	*Dicaeum agile sordidum*	Passeriformes	Dicaeidae	Thick-billed flowerpecker	Primary forest, secondary forest and forest fringes	Fig generalist	Rare non-breeding visitor
25.	*Dicaeum chrysorrheum chrysorrheum*	Passeriformes	Dicaeidae	Yellow-vented flowerpecker	Primary forest, secondary forest and forest fringes	Fig generalist	Rare resident, breeding not proven
26.	*Dicaeum concolor borneanum*	Passeriformes	Dicaeidae	Plain flowerpecker	Primary forest and secondary forest	Fig generalist	Extinct
27.	*Dicaeum cruentatum ignitum*	Passeriformes	Dicaeidae	Scarlet-backed flowerpecker	Primary forest, secondary forest, forest fringes, parks, gardens and wasteland	Fig generalist	Common resident breeder
28.	*Dicaeum trigonostigma trigonsostigmum*	Passeriformes	Dicaeidae	Orange-bellied flowerpecker	Primary forest, secondary forest and forest fringes	Fig generalist	Common resident breeder
29.	*Dicrurus aeneus malayensis*	Passeriformes	Dicruridae	Bronzed drongo	Primary forest, secondary forest and freshwater swamp forest	Casual fig eater	Extinct
30.	*Dicrurus annectans annectans*	Passeriformes	Dicruridae	Crow-billed drongo	Secondary forest, forest fringes, gardens, parks, wasteland and abandon agricultural land	Casual fig eater	Uncommon winter visitor or passage migrant
31.	*Dicrurus leucophaeus* species *leucogenis/ salagensi/ nigrescens/ leucophaeus*	Passeriformes	Dicruridae	Ashy drongo	Secondary forest, forest fringes, gardens, parks, wasteland and abandon agricultural land	Casual fig eater	Rare winter visitor, non-breeding visitor
32.	*Dicrurus macrocercus cathoecus*	Passeriformes	Dicruridae	Black drongo	Primary forest, secondary forest, forest fringes, gardens, parks, wasteland and abandon agricultural land	Casual fig eater	Uncommon winter visitor or passage migrant
33.	*Dicrurus paradiseus platurus*	Passeriformes	Dicruridae	Greater racket-tailed drongo	Primary forest, secondary forest, forest fringes, gardens, parks, wasteland and magroves	Casual fig eaters	Common resident breeder
34.	*Ducula aenea polia*	Columbiformes	Columbidae	Green imperial pigeon	Primary forests, secondary forests, mangroves and open country with scattered trees & second growth	Fig specialist	Rare non-breeding visitor

S/No.	Scientific Name	Order	Family	Common Name	Habitat	Fig Dependence	Local Status
35.	*Ducula bicolor bicolor*	Columbiformes	Columbidae	Pied imperial pigeon	Wild populations restricted to offshore islands in Singapore in secondary forests, mangroves and open country with scattered trees and second growth with free ranging individuals from the Singapore Bird Park, found in parks, gardens and housing estates in the western part s of Singapore	Fig specialist	Rare non-breeding visitor
36.	*Eudynamys scolopacea malayana*, species *scolopacea*	Cuculiformes	Cuculidae	Asian koel	Forest edges, secondary growth, housing estates, parks, gardens and park connectors	Fig specialist	Common resident breeder or winter visitor
37.	*Eurylaimus javanicus pallidus*	Passeriformes	Eurylamidae	Banded broadbill	Primary forest, riverine forest, freshwater swamp forest, secondary forest and mangrove forest	Fig specialist	Extinct
38.	*Gallus gallus spadiceus*	Galliformes	Phasianidae	Red junglefowl	Secondary forest, forest fringes, mangroves and abandon agricultural land	Casual fig eaters	Uncommon resident breeder
39.	*Gracula religiosa javana*	Passeriformes	Sturnidae	Hill mynah	Primary forest, secondary forest, forest fringes, gardens, parks and wasteland	Fig generalist	Uncommon resident breeder
40.	*Hemixos flavala*	Passeriformes	Pycnonotidae	Ashy bulbul	Primary forest, secondary forest and forest fringes	Fig generalist	Uncommon non-breeding visitor
41.	*Hylopetes spadiceus*	Rodentia	Sciuridae	Red-cheeked flying squirrel	Primary forest and secondary forest	Fig generalist	Critically endangered
42.	*Hystrix brachyura*	Rodentia	Hystricidae	Malayan porcupine	Primary forest and secondary forest	Fig generalist	Critically Endangered
43.	*Iole olivacea olivacea*	Passeriformes	Pycnonotidae	Buff-vented bulbul	Primary forest, secondary forest and forest fringes	Fig generalist	Rare resident, breeding not proven
44.	*Iomys horsfieldii*	Rodentia	Sciuridae	Horsfield's flying squirrel	Primary forest and secondary forest	Fig generalist	Endangered
45.	*Irena puella malayensis*	Passeriformes	Irenidae	Asian fairy bluebird	Primary forest and old second-growth forest	Fig specialist	Common resident breeder? On a decline.
46.	*Ixos malaccensis malaccensis*	Passeriformes	Pycnonotidae	Streaked bulbul	Primary forest, secondary forest and forest fringes	Fig generalist	Rare non-breeding visitor

S/No.	Scientific Name	Order	Family	Common Name	Habitat	Fig Dependence	Local Status
47.	*Loriculus galgulus galgulus*	Psittaciformes	Psittacidae	Blue-crowned hanging parrot	Primary forest, secondary growth, housing estates, parks, gardens and abandon land	Fig specialist	Uncommon resident , breeding not recorded
48.	*Maxomys rajah*	Rodentia	Muridae	Brown spiny rat	Primary forest and secondary forest	Casual fig eater	Endangered
49.	*Megalaima australis duvauceli*	Piciformes	Capitonidae	Blue-eared barbet	Primary forest and old second-growth forest	Fig specialist	Extinct
50.	*Megalaima haemacephala indica*	Piciformes	Capitonidae	Coppersmith barbet	Secondary forest, parks, gardens and wasteland	Fig specialist	Common resident breeder
51.	*Megalaima rafflesii malayensis*	Piciformes	Capitonidae	Red-crowned barbet	Primary forest and old second-growth forest	Fig specialist	Uncommon resident breeder
52.	*Monticola solitarius pandoo*	Passeriformes	Turdidae	Blue rock thrush	Primary forest, secondary forest, forest fringes, gardens, parks, wasteland and magroves	Fig generalist	Rare passage migrant
53.	*Motacilla flava* species *simillima/ taivana*	Passeriformes	Motacillidae	Yellow wagtail	Open ground of all kinds, bare, sparsely vegetated or with short grass cover	Fig generalist	Common winter visitor
54.	*Oriolus chinensis maculatus*, species *diffusus*	Passeriformes	Oriolidae	Black-naped oriole	Secondary forest, forest fringes, gardens, parks, wasteland and abandon agricultural land	Fig generalist	Common resident breeder or rare winter visitor
55.	*Oriolus xanthonotus xanthonotus*	Passeriformes	Oriolidae	Dark-throated oriole	Primary forest, secondary forest and freshwater swamp forest	Fig generalist	Extinct
56.	*Pericrocotus divaricatus divaricatus*	Passeriformes	Campephagidae	Ashy minivet	Primary forest, secondary forest, forest fringes, gardens, parks, wasteland, abandon agricultural land and back mangroves	Casual fig eater	Common winter visitor or passage migrant
57.	*Pericrocotus flammeus xanthogaster*	Passeriformes	Campephagidae	Scarlet minivet	Primary forest, secondary forest and freshwater swamp forest	Casual fig eater	Very rare resident, breeding not proven
58.	*Pericrocotus igneus igneus*	Passeriformes	Campephagidae	Fiery minivet	Primary forest, secondary forest and freshwater swamp forest	Casual fig eater	Extinct
59.	*Petaurista petaurista*	Rodentia	Sciuridae	Red giant flying squirrel	Primary forest and secondary forest	Fig generalist	Critically endangered
60.	*Phaenicophaeus diardi diardi*	Cuculiformes	Cuculidae	Black-bellied malkoha	Primary forest, secondary forest and freshwater swamp forest	Casual fig eater	Extinct

S/No.	Scientific Name	Order	Family	Common Name	Habitat	Fig Dependence	Local Status
61.	*Phaenicophaeus sumatranus sumatranus*	Cuculiformes	Cuculidae	Chestnut-bellied malkoha	Primary forest, secondary forest and freshwater swamp forest	Casual fig eater	Uncommon resident breeder or winter visitor
62.	*Porphyrio porphyrio viridis*	Gruiformes	Rallidae	Purple swamphen	Fresh or brackish water marshes and back mangroves	Casual fig eater	Rare resident breeder
63.	*Prionochilus maculatus maculatus*	Passeriformes	Dicaeidae	Yellow-breasted flowerpecker	Primary forest and secondary forest	Fig generalist	Extinct
64.	*Psittacula longicauda longicauda*	Psittaciformes	Psittacidae	Long-tailed parakeet	Secondary growth/mangroves/Teak & coconut plantations/foothill & lowland areas	Fig generalist	Common resident breeder
65.	*Psittinus cyanurus cyanurus*	Psittaciformes	Psittacidae	Blue-rumped parrot	Primary forest, freshwater swamp forest and sceondary forest	Fig generalist	Rare resident, breeding not proven
66.	*Ptilinopus jambu*	Columbiformes	Columbidae	Jambu fruit dove	Forests, parks, gardens and other wooded areas including mangroves and abandon wastelands	Fig specialist	Uncommon non-breeding visitor
67.	*Pycnonotus atriceps atriceps*	Passeriformes	Pycnonotidae	Black-headed bulbul	Primary forest, secondary forest, forest fringes, gardens, parks and wasteland	Fig generalist	Rare resident breeder
68.	*Pycnonotus brunneus brunneus*	Passeriformes	Pycnonotidae	Red-eyed bulbul, Asian red-eyed bulbul	Primary forest, secondary forest and forest fringes	Fig generalist	Rare resident breeder
69.	*Pycnonotus cyaniventris cyaniventris*	Passeriformes	Pycnonotidae	Grey-bellied bulbul	Primary forest, secondary forest and forest fringes	Fig generalist	Extinct
70.	*Pycnonotus erythropthalmos erythropthalmos*	Passeriformes	Pycnonotidae	Spectacled bulbul	Primary forest, secondary forest and forest fringes	Fig generalist	Extinct
71.	*Pycnonotus goiavier personatus*	Passeriformes	Pycnonotidae	Yellow-vented bulbul	Secondary forest, forest fringes, gardens, parks and wasteland	Fig generalist	Common resident breeder
72.	*Pycnonotus plumosus plumosus*	Passeriformes	Pycnonotidae	Olive-winged bulbul	Primary forest, secondary forest and forest fringes	Fig generalist	Common resident breeder
73.	*Pycnonotus simplex simplex*	Passeriformes	Pycnonotidae	Cream-vented bulbul	Primary forest, secondary forest and forest fringes	Fig generalist	Uncommon resident breeder
74.	*Pycnonotus zeylanicus*	Passeriformes	Pycnonotidae	Straw-headed bulbul	Primary forest, secondary forest, forest fringes, gardens, parks and wasteland	Fig generalist	Uncommon resident breeder

S/No.	Scientific Name	Order	Family	Common Name	Habitat	Fig Dependence	Local Status
75.	*Rattus annandalei*	Rodentia	Muridae	Annandale's rat (singapore rat)	Primary forest and secondary forest	Casual fig eater	Restricted to a few areas but common
76.	*Rattus tiomanicus*	Rodentia	Muridae	Malaysian wood rat	Secondary forest, forest fringes, gardens, parks, wasteland and abandon agricultural land	Casual fig eater	Widespread and common
77.	*Ratufa affinis*	Rodentia	Sciuridae	Cream-coloured giant squirrel	Primary forest, old secondary forest and freshwater swamp forest	Fig generalist	Critically endangered
78.	*Rhinosciurus laticaudatus*	Rodentia	Sciuridae	Shrew-faced ground squirrel	Primary forest and secondary forest	Fig generalist	Critically endangered
79.	*Sturnus philippensis*	Passeriformes	Sturnidae	Chestnut-cheeked starling	Primary forest, secondary forest, forest fringes, gardens, parks, wasteland, mangroves and beach forest	Fig generalist	Very rare accidental or vagrant
80.	*Sturnus roseus*	Passeriformes	Sturnidae	Rosy starling	Open country including agriculture, grassland, sandy coastal landfill with scattered trees including casuarinas	Fig generalist	Rare accidental or vagrant
81.	*Sturnus sinensis*	Passeriformes	Sturnidae	White-shouldered starling	Strand woodland with casuarinas, and scrub and various open habitats, gardens and urban parkland	Fig generalist	Uncommon winter visitor or passage migrant
82.	*Sturnus sturninus*	Passeriformes	Sturnidae	Purple-backed starling	Primary forest, secondary forest, forest fringes, gardens, parks, wasteland, magroves and beach forest	Fig generalist	Common winter visitor or passage migrant
83.	*Sundasciurus tenuis*	Rodentia	Sciuridae	Slender squirrel	Primary forest, secondary forest, forest fringes and adjacent parklands	Fig generalist	Restricted to a few areas but common
84.	*Surniculus lugubris barussarum*, species *dicruroides*	Cuculiformes	Cuculidae	Drongo cuckoo	Primary forest, secondary forest, forest fringes, gardens, parks, wasteland, abandon agricultural land and back mangroves	Fig specialist	Uncommon resident breeder or winter visitor
85.	*Trenon curvirostra curvirostra*	Columbiformes	Columbidae	Thick-billed green pigeon	Primary forest, secondary growth, mangroves, parks and abandon wasteland	Fig specialist	Uncommon resident breeder
86.	*Treron fulvicollis fulvicollis*	Columbiformes	Columbidae	Cinnamon-headed green pigeon	Primary forest, secondary growth, mangroves and abandon wasteland	Fig specialist	Rare non-breeding visitor

S/No.	Scientific Name	Order	Family	Common Name	Habitat	Fig Dependence	Local Status
87.	*Treron olax olax*	Columbiformes	Columbidae	Little green pigeon	Primary forest, secondary growth, mangroves, parks, gardens and abandon wasteland	Fig specialist	Rare resident, breeding not proven, or non-breeding visitor
88.	*Treron vernans griseicapilla*	Columbiformes	Columbidae	Pink-necked green pigeon	Primary forest, secondary growth, mangroves, parks, gardens and abandon wasteland	Fig specialist	Common resident Breeder
89.	*Tupaia glis*	Scandentia	Tupaiidae	Common treeshrew	Primary forest, secondary forest, forest fringes and adjacent parklands	Casual fig eater	Widespread and common
90.	*Turdus obscurus obscurus*	Passeriformes	Turdidae	Eyebrowed thrush	Primary forest, secondary forest, forest fringes, gardens and parks	Fig generalist	Uncommon passage migrant or rare winter visitor
91.	*Zoothera citrina citrina*	Passeriformes	Turdidae	Orange-headed thrush	Primary forest, secondary forest, forest fringes, gardens and parks	Fig generalist	Rare winter visitor
92.	*Zoothera sibirica davisoni*, species *sibirica*	Passeriformes	Turdidae	Siberian thrush	Primary forest, secondary forest, forest fringes, gardens and parks	Fig generalist	Rare passage migrant

Table 3. Mammal species that have been recorded feeding on *Ficus* species syconia in Singapore, compiled from Shanahan et al. (2001).

S/No.	Scientific Name	Order	Family	Common Name	Habitat	Fig Dependence	Local Status
1.	*Arctictis binturong*	Carnivora	Viverridae	Binturong (bear-cat)	Primary forest and secondary forest	Fig specialist	Extinct
2.	*Arctogalidia trivirgata*	Carnivora	Viverridae	Three-striped palm civet (small-toothed palm civet)	Primary forest and secondary forest	Casual fig eater	Critically endangered
3.	*Cynopterus brachyotis*	Chiroptera	Pteropodidae	Common fruit bat (lesser dog-faced fruit bat)	Roosts in trees under clumps of bird's nest ferns/under palm fronds/in buildings	Fig specialist	Widespread and common
4.	*Cynopterus sphinx*	Chiroptera	Pteropodidae	Short-nosed fruit bat	Primary forest and secondary forest, also often found roosting under man-made structures	Fig specialist	Vulnerable
5.	*Macaca fascicularis*	Primates	Cercopithecidae	Long-tailed macaque	Primary forest, secondary forest, freshwater swamp forest, forest fringes and adjacent parklands	Fig generalist	Widespread and common
6.	*Macaca nemestrina*	Primates	Cercopithecidae	Pig-tailed macaque	Primary forest and secondary forest	Fig generalist	Extinct
7.	*Paguma larvata*	Carnivora	Viverridae	Masked palm civet	Primary forest and secondary forest	Fig generalist	Critically endangered
8.	*Paradoxurus hermaphroditus*	Carnivora	Viverridae	Common palm civet (toddy cat)	Primary forest, secondary forest, mangroves, forest fringes and adjacent parklands	Fig generalist	Widespread but uncommon
9.	*Penthetor lucasi*	Chiroptera	Pteropodidae	Dusky fruit bat	Caves and under rock shelters	Fig specialist	Endangered
10.	*Presbytis femoralis*	Primates	Cercopithecidae	Banded leaf monkey	Primary forest, secondary forest and freshwater swamp forest	Fig generalist	Critically endangered
11.	*Sus scrofa*	Artiodactyla	Suidae	Wild boar (wild pig)	Secondary forest, freshwater swamp forest, back mangroves, abandon agricultural land and wasteland	Casual fig eater	Restricted to a few areas but common
12.	*Viverra zibetha*	Carnivora	Viverridae	Large indian civet	Primary forest and secondary forest	Casual fig eater	Critically endangered

Table 4. Insect and mammal species that have been recorded to feed on leaves of *Ficus* species in Singapore, compiled from personal observations. Only one mammal is noted to feed on the leaves, *Cynopterus brachyotis*, compiled from Tan et al. (1998). Species are alphabetically arranged by their scientific name.

S/No.	Scientific Name	Order	Family	Common Name	Habitat	Fig Dependance	Local Status
1.	*Asota egens*	Lepidoptera	Noctuidae	Not available	Secondary forest and forest edge	Larval folivore of *Ficus xylophylla*	Common forest species
2.	*Asota plana*	Lepidoptera	Noctuidae	Not available	Secondary forest and forest edge	Larval folivore of *Ficus fistulosa*, *Ficus grossularioides*, *Ficus microcarpa*, *Ficus microsyce*	Common forest species
3.	*Asota subsimilis*	Lepidoptera	Noctuidae	Not available	Secondary forest and forest edge	Larval folivore of *Ficus fistulosa*	Common forest species
4.	*Chersonesia peraka peraka*	Lepidoptera	Nymphalidae	Little maplet	Primary to mature secondary forest	Larval folivore of *Ficus punctata*	Moderately rare
5.	*Cynopterus brachyotis*	Chiroptera	Pteropodidae	Common fruit bat (lesser dog-faced fruit bat)	Roosts in trees under clumps of bird's nest ferns, under palm fronds, eaves of buildings	Fig specialist	Widespread and common
6.	*Euploea mulciber mulciber*	Lepidoptera	Nymphalidae	Striped blue crow	Urban parks, gardens, forests and mangroves	Larval folivore of *Ficus globosa*, *Ficus heteropleura* and *Ficus microcarpa*	Widespread and common
7.	*Mecodina lanceola*	Lepidoptera	Erebidae	Not available	Primary to mature secondary forest	Larval folivore of *Ficus variegata*	Uncommon forest species
8.	*Phauda* species	Lepidoptera	Zygaenidae	Not available	Forest edge, suburbs and parklands	Larval folivore of *Ficus microcarpa*	Seasonal occurence