GUIDELINES
FOR THE CULTIVATION OF FOOD PLANTS FOR
WILDLIFE




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WILDLIFE

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INTRODUCTION

BACKGROUND

Malaysia is a country rich in biodiversity of flora and fauna. The core to this richness of biodiversity lies in the uniqueness of our country's tropical rainforests that have evolved over more than 130 million years ago. It is estimated that there are almost 18,000 types of plants found in Malaysia, including 2,700 species of endemic plants that can only be found in Malaysia.

In addition to serving as a habitat for wildlife, tropical rainforests that contain thousands of species of flora also serve as a source of food for herbivorous and omnivorous animals. Of all the plant species that are endemic in Malaysia, an estimated 500 species are of trees that produce edible fruits. Apart from the fruits, other parts of plants such as shoots, leaves, and flowers are also the main food sources for the wildlife in our country.

However, development activities such as agriculture, logging, housing, and road and dam constructions have contributed to the decline of flora and fauna diversity, leading to forest fragmentation. The loss of plant species that are a source of food for wildlife brings about negative impacts on these animals. Depletion of food resources forces the wildlife to leave their natural habitats, which can trigger conflict if they enter human settlements.

Forest fragmentation that is downsizing wildlife habitats has also contributed to the increase in wildlife deaths due to roadkill. In addition, forest fragmentation will also complicate the processes of biodiversity and tropical forest ecosystem conservation in Malaysia.

To overcome the inadequacy of wildlife habitat, various programmes have been planned and carried out by the Department of Wildlife and National Parks (DWNP). One of them is the Wildlife Habitat Management Programme under the 11th Malaysia Plan, which has planned and implemented activities to improve the quality of habitat in the areas that have been identified. The implementation of this programme has a positive impact on wildlife survival both directly and indirectly. Habitat enrichment management is an important element in holistic wildlife management. Conducive habitat will ultimately support the survival and independence of a species within the protected area. Several activities have been carried out for this wildlife habitat management programme, such as maintenance of grazing land and artificial grazing, replantation in grazing land, as well as additional programs such as the opening of new areas and reforestation.

Apart from that, DWNP together with all implementing agencies of the Improving Connectivity in the Central Forest Spine Landscape (IC-CFS) National Project, namely the Forestry Department of Peninsular Malaysia (FDPM), Forest Research Institute of Malaysia (FRIM), and State Forestry

Departments, have established a framework to increase the number of plants as food for wildlife, especially in areas that have been degraded or areas that have the potential to be used as wildlife corridors. However, there is still no specific reference that can be used as a guideline for the agencies involved in this programme. Therefore, on the initiative of the Wildlife Conservation Division, DWNP as the coordinator for the UNDP/GEF-GoM Project: Improving Connectivity in the Central Forest Spine Landscape (IC-CFS), an initiative has been taken to produce this guideline which contains information on wildlife that uses plants as food, species of plants that serve as food sources for wildlife as well as the cultivation method of these plants in the nursery and also in permanent plots.

OBJECTIVE

This guideline is intended to be used as a reference in identifying the plants that serve as food for the wildlife in Malaysia. This guideline can also be used as a reference by the DWNP, FDPM, and any related agencies, especially in the reforestation and rehabilitation processes, as well as the management of nurseries to ensure the production of good quality seedlings of the food plants. Finally, the publication of this guideline can also contribute to the government's efforts in increasing food sources for the wildlife and their populations, which could eventually help in reducing conflict and wildlife deaths in Malaysia.

Photo: Wreathed Hornbill (*Rhythiceros undulatus)* eating wild fruit

Photo: Silvered Leaf Monkey (*Trachypithecus cristatus*)

Chapter 1:
Plant-Eating Wildlife in Malaysia

Photo: Malaysian rainforest

Wildlife can be defined as animals that live freely in their natural habitat without being domesticated, controlled or owned by humans. In Malaysia, protected wildlife consists of animal species listed under the Wildlife Conservation Act 2010 [Act 716]. Most of the wildlife in Malaysia inhabits our tropical rain forest and the various plant species in the forest serve as a food source for the wildlife.

In general, plant-eating animals consist of herbivores and omnivores. Animals that use plants as a food source can be categorised into four groups, namely frugivores (fruit eaters), granivores (seed eaters), nectivores (nectar eaters), and folivores (leaf eaters).

In addition to the survival of the animal species itself, plant-eating wildlife also acts as an agent of pollination and seed dispersal. Bats and birds are two animals that play an important role in the early stages of forest formation by dispersing the seeds of pioneer plants. As forests begin to form and the diversity of plant species increases, more and more small and large mammals will come to the area, bringing along fruits and seeds from other nearby areas. Therefore, the presence of plant-eating animals is important to ensure the survival of trees in our tropical rainforests as well as to maintain the genetic diversity of a plant species in a population.

In this chapter, the wildlife that will be discussed is specific to vertebrate animals from the class of Mammalia and Aves (birds) that inhabit various types of forests in our country and use plants as a food source along with the IUCN (The International Union for Conservation of Nature) status of each species. The IUCN Red List has classified flora and fauna species into nine categories which are extinct (EX), extinct in the wild (EW), critically endangered (CR), endangered (EN), vulnerable (VU), near threatened (NT), least concern (LC), data deficient (DD), and not evaluated (NE). Species categorised as CR, EN, and VU are generally considered to be endangered. All wildlife species listed in this chapter have been referred to the *Red List of Mammals for Peninsular Malaysia Version 2.0* (PERHILITAN, 2017) and are listed in **Table 1.1 – Table 1.9**. The status of wildlife according to the Wildlife Conservation Act 2010 [Act 716] is also included in all the tables.

MAMMALIA

Order Chiroptera

The order Chiroptera encompasses all species of bats that can be found worldwide and represents one third of all mammalian species. This order can be divided into two suborders, Microchiroptera and Megachiroptera. Microchiroptera are small-sized bats that use the echolocation system, which is sound waves emitted by bats to determine the position, shape, and size of objects in their environment. In general, bats from the Microchiroptera group are insectivores and feed on various types of insects such as crickets, mosquitoes, and butterflies.

Megachiroptera is a group of large bats without the ability to echolocate. Of the eight families and 110 species of bats that have been recorded in Peninsular Malaysia, Megachiroptera is only represented by 18 species under one family, Pteropodidae (Lim et al., 2017). All bats in the family Pteropodidae are frugivores or nectivores that only feed on fruits or nectar.

Fruit bats are among the most important pollinators and seed dispersal agents in the ecosystems. Banana, *petai*, durian, and guava are some of the plant species that have been identified to be pollinated by bats (Kingston, 2006; Yazid et al., 2019). Among the bat species that play a significant role in pollination are nectar-eating bats of the genus *Eonycteris* sp. and *Macroglossus* spp. where a total of 32 pollen species have been identified as food sources for *Eonycteris spelaea*, *Macroglossus minimus*, and *Macroglossus sobrinus* (Start and Marshall, 1976).

Photo: Lesser dog-faced fruit bat *(cynerοpterus brachyotis)* with juvenile

Studies were also conducted on *Eonycteris spelaea* that inhabited caves in Batu Caves and found plant parts from 55 plant species including *Bauhinia strychnoidea*, *Artocarpus heterophyllus*, and *Musa* spp. (Lim et al., 2018).

The most common bat species, *Cynopterus brachyotis* has been reported to feed on 16 plant species in primary forests, 66 species in secondary forests, and 38 species in urban areas. From the faecal analysis conducted by Lim et al. (2017) on *Cynopterus brachyotis* in urban areas, agricultural areas, and secondary forests, fig trees of the species *Ficus fistulosa* have been identified as the most widely consumed plant by this species in all three sampling areas. This indicates that *Cynopterus brachyotis* plays a crucial role as a seed dispersal agent for various plants including pioneer plant species such as *Ficus* spp., which facilitates the initial succession process of an area.

Table 1.1 List of bat species from the family Pteropodidae found in Peninsular Malaysia

Family	Scientific name	Common name	Local name	IUCN Status	Local Conservation Status
Pteropodidae	*Aethalops alecto*	Grey Fruit Bat	Cecadu Bukit	LC	VU
	Balionycteris maculata	Spotted-Winged Fruit Bat	Cecadu Sayap Bertitik	LC	LC
	Chironax melanocephalus	Black-Capped Fruit Bat	Cecadu Kepala Hitam	LC	NT
	Cynopterus brachyotis	Lesser Dog-Faced Fruit Bat	Cecadu Pisang	LC	LC
	Cynopterus horsfieldii	Horsefield's Fruit Bat	Cecadu Pisang Besar	LC	LC
	Cynopterus sphinx	Short-Nosed Fruit Bat	Cecadu Siam	LC	LC
	Dyacopterus spadiceus	Dayak Fruit Bat	Cecadu Dayak	NT	NT
	Eonycteris spelaea	Cave Fruit Bat	Cecadu Gua	LC	NT
	Macroglossus minimus	Common Long-Tongued Fruit Bat	Cecadu Madu Bakau	LC	DD
	Macroglossus sobrinus	Hill Long-Tongued Fruit Bat	Cecadu Madu Bukit	LC	LC
	Megaerops ecaudatus	Tailless Fruit Bat	Cecadu Tiada Berekor	LC	LC
	Megaerops wetmorei	Wetmore's Tailless Fruit Bat	Cecadu Wetmore	VU	DD
	Penthetor lucasi	Dusky Fruit Bat	Cecadu Hitam Pudar	LC	LC
	*Pteropus hypomelanus**	Small Flying Fox	Keluang Kecil	LC	EN
	*Pteropus vampyrus**	Large Flying Fox	Keluang Besar	NT	EN
	Rousettus amplexicaudatus	Geoffroy's Rousette	Cecadu Besar	LC	NT
	Rousettus leschenaultii	Leschenault's Rousette	Cecadu	LC	DD

*Protected under the Wildlife Conservation Act 2010 [Act 716]

Order Rodentia

The order Rodentia in Malaysia is represented by porcupine, rat, and squirrel species. The animals under the order Rodentia have a varied diet where some are herbivorous and some are omnivorous that also help in the dispersal of pollen and seeds.

All three species of porcupines under the family Hystricidae are herbivores. Malayan Porcupines (*Hystric brachyura*), which are considered as minor pests in oil palm plantations, rubber plantations, and orchards, like to eat fruits such as pineapple and durian, as well as the roots and tubers of plants. The Brush-tailed Porcupines (*Atherurus macrourus*), which can also be found in farms and orchards, are also fond of roots, tubers and fruits. However, the Long-tailed Porcupine species (*Trichys fasciculata*) is slightly different, where in addition to fruits, this species also likes to feed on large seeds as well as the shoots of certain plants such as bamboo (Lim, 2016).

Species under the Muridae family inhabiting our tropical rainforest are also known to eat fruits along with the seeds. In general, these rat species are also known as granivores or seed predators where they feed on seeds, and as such, do not play an important role as seed dispersal agents. Most of the seeds found in the stomachs of some rat species are degraded, demonstrating their nature as seed predators. However, small-sized seeds found in the stomachs of these mice remain intact and have been successfully germinated (Nago et al., 2019). This implies that the Muridae family also serves as a seed dispersal agent for plant species with small seed size.

Fruits are also the main food source for some species of squirrels such as *Ratufa* spp., *Callosciurus* spp., and *Sundasciurus* spp. Small-sized flying squirrels from the genus *Iomys* sp., *Hylopetes* spp., and *Petaurillus* sp. are also dependent on fruits as their main food source. This is in contrast with large flying squirrels such as *Petaurista* spp., which prefer to eat leaves even though fruits are still part of their diet. From a study conducted in Merapoh, Pahang, *Petaurista petaurista* were seen eating fruit from Hairy Figs (*Ficus hispida*) and *Ketapang* (*Terminalia catappa*) (Miard et al., 2020). However, similar to the rat species under the Muridae family, the role of squirrels as seed dispersal agents is less clear because squirrels are also known to be seed predators. Even so, the nature of squirrels who love to collect and store fruit can contribute to seed dispersal when the fruit falls on the way to their nests (Lee et al., 2002).

Figure 1.1: Brown Spiny Rat (*Maxomys rajah*) (*Photo credit: Mohd Shahfiz Azman*)

Table 1.2 List of animal species from the order Rodentia found in Peninsular Malaysia

Family	Scientific name	Common name	Local name	IUCN Status	Local Conservation Status
Hystricidae	*Atherurus macrourus**	Asiatic Brush-Tailed Porcupine	Landak Nibong	LC	NT
	Hystric brachyura*	Common Porcupine	Landak Raya	LC	NT
	*Trichys fasciculata**	Long-Tailed Porcupine	Landak Padi	LC	VU
Muridae	*Bandicota indica*	Large Bandicoot Rat	Wirok Hitam	LC	LC
	Bandicota bengalensis	Lesser Bandicoot Rat	Wirok Ekor Pendek	LC	LC
	Berlymys bowersii	Bower's Rat	Tikus Bulu Kasar	DD	DD
	Chiropodomys gliroides	Tree Mouse	Tikus Buluh	LC	DD
	Hapalomys longicaudatus	Marmoset Rat	Tikus Monyet	EN	DD
	Lenothrix canus	Grey Tree Rat	Tikus Legong	LC	DD
	Leopoldamys ciliatus	Mountain Giant Rat	Tikus Bukit Besar	LC	DD
	Leopoldamys sabanus	Long-Tailed Giant Rat	Tikus Perah	LC	LC
	Maxomys inas	Mountain Spiny Rat	Tikus Bukit	LC	DD
	Maxomys rajah	Brown Spiny Rat	Tikus Duri Hitam Pudar	VU	LC
	Maxomys surifer	Red Spiny Rat	Tikus Duri Merah	LC	LC
	Maxomys whiteheadi	White-Headed Rat	Tikus Bangkung	VU	LC
	Mus caroli	Ricefield Mouse	Tikus Sawah Terkecil	LC	LC
	Mus musculus	House Mouse	Tikus Rumah Kecil	LC	LC
	Niniventer cameroni	Long-Tailed Mountain Rat	Tikus Bukit Ekor Panjang	VU	EN
	Niniventer cremoriventer	Dark-Tailed Tree Rat	Tikus Akar	VU	LC
	Niniventer fulvescens	White-Bellied Rat	Tikus Dada Putih	LC	VU
	Pithecheir parvus	Monkey-Footed Rat	Tikus Merah	DD	LC
	Rattus annandalei	Annandale's Rat	Tikus Tunggal	LC	LC
	Rattus argentiventer	Ricefield Rat	Tikus Sawah	LC	LC
	Rattus exulans	Little Burmese Rat	Tikus Kecil	LC	LC
	Rattus norvegicus	Norway Rat	Tikus Mondok	LC	LC
	Rattus diardii	House Rat	Tikus Rumah	LC	LC
	Rattus tiomanicus	Wood Rat	Tikus Belukar	LC	LC
	Rhizomys sumtrensis	Large Bamboo Rat	Dekan Besar	LC	NT
	Rhizomys pruinosus	Hoary Bamboo Rat	Dekan Kecil	LC	DD
	Sundamys muelleri	Grey Giant Rat	Tikus Lembah	LC	LC

Family	Scientific name	Common name	Local name	IUCN Status	Local Conservation Status
Pteromyidae	*Aeromys tephromelas*	Large Black Giant Flying Squirrel	Tupai Terbang Hitam	DD	DD
	Hylopetes lepidus[#]	Grey Cheeked Flying Squirrel	Tupai Terbang Pipi Kelabu	DD	DD
	Hylopetes spadiceus[#]	Red-Cheeked Flying Squirrel	Tupai Terbang Pipi Merah	LC	DD
	Iomys horsfieldii[#]	Horsefield's Flying Squirrel	Tupai Terbang Ekor Merah	LC	LC
	Petaurillus kinlonchii[#]	Selangor Pigmy Flying Squirrel	Tupai Terbang Terkecil	DD	DD
	Petaurista elegans[#]	Spotted Giant Flying Squirrel	Tupai Terbang Bintang	LC	DD
	Petaurista petaurista[#]	Red Giant Flying Squirrel	Tupai Terbang Merah	LC	NT
	Petinomys genibarbis[#]	Whiskered Flying Squirrel	Tupai Terbang Berjambang	VU	DD
	Petinomys setosus[#]	White Bellied Flying Squirrel	Tupai Terband Dada Putih	VU	DD
	Petinomys vordermanni[#]	Vordermann's Flying Squirrel	Tupai Terbang Kecil	VU	DD
	Pteromyscus pulverulentus[#]	Smoky Flying Squirrel	Tupai Terbang Kotor	EN	DD
Sciuridae	*Callosciurus nigrovittatus*	Black-Banded Squirrel	Tupai Tompok	NT	LC
	Callosciurus notatus	Plantain Squirrel	Tupai Merah	LC	LC
	Callosciurus caniceps	Grey-Bellied Squirrel	Tupai Perut Kelabu	LC	LC
	Callosciurus prevostii	Prevost's Squirrel	Tupai Gading	LC	NT
	Dremomys rufigenis	Red-Cheeked Ground Squirrel	Tupai Pipi Merah	LC	VU
	Lariscus insignis	Three-Striped Ground Squirrel	Tupai Belang Tiga	LC	LC
	Ratufa affinis[#]	Cream-Coloured Giant Squirrel	Tupai Kerawak Putih-Kuning	NT	VU
	Ratufa bicolor[#]	Black Giant Squirrel	Tupai Kerawak Hitam	NT	NT
	Rhinosciurus laticaudatus	Shrew-Faced Ground Squirrel	Tupai Naning	NT	LC
	Sundasciurus hippurus	Horse-Tail Squirrel	Tupai Ekor Kuda	NT	NT
	Sundasciurus tenuis	Slender Squirrel	Tupai Cerleh	LC	LC
	Sundasciurus lowii	Low's Squirrel	Tupai Ekor Pendek	LC	LC
	Sundasciurus tahan	Upland Squirrel			DD
	Tamiops macclellandi	Mountain Striped Squirrel	Tupai Bunga	LC	LC

[*]Protected under the Wildlife Conservation Act 2010 [Act 716]

[#]Totally protected wildlife under the Wildlife Conservation Act 2010 [Act 716]

Order Scandentia

There are only three species from the Tupaiidae family that can be found in Peninsular Malaysia, namely Pen-tailed Treeshrew, Common Treeshrew, and Lesser Treeshrew. All these squirrels are omnivores where their diet consists of insects, earthworms, fruits as well as seeds. Squirrels of the genus *Tupaia* were once considered a mere insect eater. However, from previous studies, fruits have also been recorded as part of their diet.

Previously, the role of the order Scandentia as seed dispersal agents was less clear and considered insignificant since the members of this order are also known to feed on seeds. However, a laboratory study conducted by Shanahan and Compton (2000) found that almost 100% of replanted *Ficus* spp. seeds excreted by *Tupaia* spp. successfully germinated. This proves that members from the order Scandentia are significant seed dispersal agents.

Table 1.3 List of animal species from the order Scandentia found in Peninsular Malaysia

Family	Scientific name	Common name	Local name	IUCN Status	Local Conservation Status
Tupaiidae	*Ptilocercus lowii**	Pen-Tailed Treeshrew	Tupai Akar Malam	LC	DD
	*Tupaia glis**	Common Treeshrew	Tupai Muncung Besar	LC	LC
	*Tupaia minor**	Lesser Treeshrew	Tupai Kecil	LC	DD

*Protected wildlife under the Wildlife Conservation Act 2010 [Act 716]

Order Insectivora

In Malaysia, the order Insectivora consists of 10 species of animals under three different families. In general, all members of the order Insectivora feed on insects. However, several studies have found that both species from the Erinaceidae family also feed on plants. Apart from captive Moonrats (*Echinosorex gymnura*) (**Figure 1.2**), which have been observed eating a wide variety of fruits, wild moonrats have also been recorded feeding on plant parts such as oil palm seeds (Whittow et al., 1977). In addition, *Hylomys suillus* has also been observed to consume fruits in the wild (Chiozza, 2016).

Figure 1.2: Moonrat (*Echinosorex gymnura*) (*Photo credit: Mohd Shahfiz Azman*)

Table 1.4 List of animal species from the order Insectivora in Peninsular Malaysia that eat plants

Family	Scientific name	Common name	Local name	IUCN Status	Local Conservation Status
Erinaceidae	*Echinosorex gymnura*	Moonrat	Tikus Ambang Bulan	LC	VU
	*Hylomys suillus**	Lesser Gymnure	Tikus Babi	LC	DD

*Protected wildlife under the Wildlife Conservation Act 2010 [Act 716]

Order Dermoptera

In Malaysia, the order Dermoptera is represented by only one species which is Flying Lemur (*Galeopterus variegatus*). Although the IUCN status of the flying lemur is least concern (LC), this species is a fully protected wildlife under the Wildlife Conservation Act 2010 [Act 716]. The main habitat for flying lemur is tropical rainforests, although it has been reported to be found in orchards and plantation areas.

Flying lemurs can be classified as folivores where their main diet consists of leaf parts of various types of plant with high tannin content as well as low potassium and nitrogen content (Agoramoorthy et al., 2006; Sulistiowati, 2019). In addition to leaves, flying lemurs have also been recorded feeding on the fruits, shoots, flowers, and sap of trees. Among the plant species known to be consumed by flying lemur in Malaysia are *Otak Udang* (*Buchanania arborescens*), *Jejawi* (*Ficus microcarpa*), *Kelat* (*Syzygium* spp.) and *Bintangor* (*Calophyllum soulattri*) (Dzulhelmi and Abdullah, 2009). Flying lemurs have also been observed eating *Rambai* fruit (*Baccaurea motleyana*) in Sarawak (Ketol et al., 2006).

Order Primate

There are 11 species of primates in Peninsular Malaysia, consisting of three families (**Table 1.5**). Primates play an equally important role in seed dispersal as they consume enormous quantities of fruits from a variety of plant species before spitting or excreting the seeds through faeces (Lambert, 1999). *Macaca* spp. has a very wide distribution especially in Asian countries. In Malaysia, Long-tailed Macaques (*Macaca fascularis)* can be found in a variety of habitats such as in primary and secondary forests, mangrove swamp forests, and areas close to human settlements. Naturally, long-tailed macaques are frugivorous animals that eat fruits as their primary source of nutrition apart from leaves, seeds, and flowers. However, due to their high tolerance to disturbances and changes in the environment, long-tailed macaques have easily adapted to various types of environments and are better known as omnivorous animals that feed on insects,

bird eggs, crabs, shrimps, and frogs. A total of 113 plant species have been recorded as food for long-tailed macaques. Among the plant species eaten by the monkeys are *Elaeis guineensis*, *Ficus variegata*, *Ficus microcarpa*, *Terminalia catappa*, *Areca catechu*, and *Musa* spp. (Kassim et al., 2017; Ruslin et al., 2019). As for the Pig-tailed Macaque (*Macaca nemestrina*) (**Figure 1.3**), it is categorised as vulnerable (VU) where the population is declining due to several factors, especially the conversion of forest oil palm plantations (Ruppert et al, 2018). Although pig-tailed macaques consume oil palm fruits, they still need forest areas as their main habitat. Pig-tailed macaques have also been recorded as the main seed dispersal agents for two rattan species, namely *Calamus castaneus* and *Daemonorops callicarpa* (Ruppert et al., 2014). The last *Macaca* species in Malaysia, the Stump-tailed Macaque (*Macaca arctoides*) is also categorised as vulnerable (VU) according to IUCN and can only be found in Perlis State Park. Not much is known about the diet of stump-tailed macaques due to the lack of studies on this species. However, a study conducted by Osman et al. (2020) found that a total of 145 plant species were recorded as part of the diet for stump-tailed macaques including *Saraca thaipingensis* and *Ficus superba*.

There are four species of langurs (*lotong*) in Peninsular Malaysia, namely Banded Leaf Monkey (*Presbytis femoralis*), Black-thighed Leaf Monkey (*Presbytis siamensis*), Silvered Leaf Monkey (*Trachypithecus cristatus*), and Dusky Leaf Monkey (*Trachypithecus obscurus*), all grouped as colobine monkeys. Leaves are the primary diet for colobine monkeys, although these primates are also known to feed on fruits in large quantities. A study conducted by Ruslin et al. (2018) recorded a total of 130 plant species consumed by Dusky Leaf Monkey (*Trachypythecus obscurus*), which mostly consist of leaves (51%) and fruits (49%). However, colobine monkeys were assumed to be seed predators as they devour large seeds. Nevertheless, small seeds have been reported to be excreted through faeces and therefore, colobine monkeys may play a role as seed dispersal agent for plants with small seeds (Matsuda, 2013).

All species under the family Hylobatidae are categorised as endangered species according to IUCN. Nevertheless, these primate species from the Hylobatidae family are considered to be the most effective seed dispersal agents among mammals as they consume various species of fruits in large quantities and deposit the seeds throughout their home range (McConkey and Chivers, 2007). *Ficus* spp. are one of the main species consumed by gibbons and siamangs. Among other plant species recorded to be eaten by *Hylobates agilis* and *Symphalangus syndactylus* are *Baccaurea* spp., *Dialium platysepalum*, and *Garcinia atroviridis* (Nongkaew, 2010). As for *Hylobates lar*, among the 35 species of plants recorded to serve as their food source are *Sarcotheca griffithii*, *Syzygium* spp., and *Garcinia parvifolia* (Subramaniam, 1981; Ungar, 1995).

The last primate species, the Slow Loris (*Nycticebus coucang*) has been categorised as vulnerable by the IUCN. The diet of the slow loris is different from that of other primates. Slow loris is an omnivorous animal that eats sap, nectar, flowers, fruit, leaves, and insects. Through a study conducted by Wiens (2002), slow loris is recorded to spend more time feeding on sap and nectar than other parts of the tree. Among the plant species that produce sap and are consumed by slow loris are *Buchanania arborescens*, *Chisocheton macrophyllus*, *Mangifera griffithii*, and *Buchanania sessilifolia*.

Figure 1.3: Pig-tailed macaque (*Macaca nemestrina*)
(*Photo credit: Mohd Shahfiz Azman*)

Table 1.5 List of animal species from the order Primate found in Peninsular Malaysia

Family	Scientific name	Common name	Local name	IUCN Status	Local Conservation Status
Cercopithecidae	*Macaca arctoides*#	Stump Tailed Macaque	Berok Kentoi	VU	VU
	Macaca fascularis*	Long-Tailed Macaque	Kera	LC	LC
	*Macaca nemestrina**	Pig-Tailed Macaque	Berok	VU	LC
	*Presbytis femoralis**	Banded Leaf Monkey	Lotong Ceneka	NT	NT
	*Presbytis siamensis**	Black-Thighed Leaf Monkey	Lotong Ceneka Siam	NT	NT
	*Trachypithecus cristatus**	Silvered Leaf Monkey	Lotong Kelabu	NT	VU
	*Trachypithecus obscurus**	Dusky Leaf Monkey	Lotong Cengkong	NT	NT
Hylobatidae	*Hylobates agilis*#	Agile Gibbon	Ungka Tangan Hitam	EN	VU
	Hylobates lar#	White-Handed Gibbon	Ungka Tangan Putih	EN	EN
	Symphalangus syndactylus#	Siamang	Siamang	EN	EN
Lorisidae	*Nycticebus coucang*#	Slow Loris	Kongkang	VU	NT

*Protected under the Wildlife Conservation Act 2010 [Act 716]

#Totally protected wildlife under the Wildlife Conservation Act 2010 [Act 716]

Order Proboscidae

Elephants (*Elephas maximus*) are the only animals under the order Proboscidae found in Malaysia and are categorised as an endangered species (EN) according to the IUCN list and fully protected under the Wildlife Conservation Act 2010 [Act 716]. To sustain their massive body size, elephants need to consume approximately 150 kg of food in a day (Vancuylenberg, 1977) and from studies that have been conducted, more than 100 species of wild plants have been identified as food sources to elephants (English, 2014). In general, the food reported to be preferred by elephants in the wild are leaves of monocotyledonous plants consisting of the palm family, ginger, bamboo, wild banana, and others. The parts of plant that elephants prefer are shoots and young stems that are rich in nutrients (Sukumar, 1992).

However, based on microhistological analyses on elephant dungs in Belum–Temengor forest complex, the types of plants eaten by elephants differ according to habitat (Yamamoto-Ebina et al., 2016). The main composition of elephant faeces inhabiting primary and secondary forests consists of the leaves of monocotyledonous plants (mainly from ginger and palm family), wood chips, and fibres from woody plants. This is in stark contrast to elephants inhabiting areas close to roads where almost half of the faecal content is dominated by grass (47%) followed by banana stems, wood chips, and fibre from woody plants which each contribute 10%–15% of the excrement content. This shows that elephants can eat many different types of plants to adapt to their environment. Elephants have also been recorded eating several types of fruits from the species *Sandoricum koetjape*, *Lepisanthes fruticosa*, and *Garcinia parvifolia* (English et al., 2014; Kitamura et al., 2007)

Order Perissodactyla

After the death of the last Sumatran rhino in Malaysia in 2019 at the Borneo Rhino Sanctuary, Sabah, the Malayan Tapir (*Tapirus indicus*), also known as *badak cipan* or *tenuk*, became the only animal under the order Perissodactyla that can still be found in our country. However, the IUCN status of critically endangered tapirs is of great concern.

Tapirs are herbivorous with 217 species of plants have been recorded as food sources for tapirs in semi-wild environments (Simpson et al., 2013). Tapirs are mainly folivores where they browse on leaves especially the young leaves and the shoot. However, as a generalist eater, tapirs are also known to eat fruits, flower buds, and parts of tree trunks or twigs. Among the plant species that have been recorded by Simpson et al. (2013) as preferred food sources for tapirs are *Xerospermum noronhianum*, *Aporosa prainiana*, *Baccaurea parviflora*, and *Syzygium pycnanthum*.

Table 1.6 List of animal species from the order Perissodactyla in Peninsular Malaysia

Family	Scientific name	Common name	Local name	IUCN Status	Local Conservation Status
Rhinocerotidae	*Dicerorhinus sumatrensis*#	Sumatran Rhinoceros	Badak kerbau	CR	CR
	Rhinoceros sundaicus#	Javan rhinoceros	Badak raya	CR	EX
Tapiridae	*Tapirus indicus*#	Malayan tapir	Tapir / Badak Cipan	EN	EN

#Totally protected wildlife under the Wildlife Conservation Act 2010 [Act 716]

Order Artiodactyla

In Malaysia, the order Artiodactyla consists of four different families (**Table 1.7**). The first family, which is Bovidae, includes banteng, gaur, and serow. Banteng in Peninsular Malaysia were once considered extinct in the 1950s. However, thanks to DWNP's efforts to reintroduce banteng to Taman Negara, they are no longer considered extinct and are now classified as critically endangered (CR). All members under the family Bovidae not only love to graze, but also feed on other plants that are not categorised as grass. For example, a study conducted in Malaysia found that gaur feeds on 89 species of plants, of which only 38 species are grass species (Weigum, 1972). Serow are also reported to consume more diverse plants when compared to goral in the Himalayan region (Himalayan goats), which are more selective (Suraprasit et al., 2020).

Apart from grazing grass, Sambar Deer (*Rusa unicolor*) also eat shrubs, leaves, and fruits. From a study conducted at a wildlife sanctuary in Thailand, sambar deer were observed to feed on 18 plant species out of 84 plants found in the area. Among the plants favoured by sambar deer are from the genus *Bauhinia* sp., *Jasminum* sp., *Terminalia* sp. as well as *Dioscorea* sp., all of which can also be found in Malaysia (Suksawat et al., 2018). Barking Deer (*Muntiacus muntjak*) also have the same feeding habits as unicolor deer. Even so, it prefers the bud of tall grass species such as weeds compared to grasses in the vegetative phase. One of the fruits eaten by barking deer is *Pauh Kijang* (*Irvingia malayana*), where they are reported to serve as seed dispersal agents for this plant species (Kassim, 1987).

Both species from the Tragulidae family, Large Mouse Deer (*Tragulus napu*) and Lesser Mouse Deer (*Tragulus kanchil*), are important fruit eaters which usually feed on fallen fruits on the forest floor. The reduction of fruit trees due to logging has caused these species to decrease in Sabah (Heydon and Bulloh, 1997). However, both mouse-deer also feed on the buds and leaves of shrubs and creepers (Farida et al., 2004). Unlike lesser mouse deer, large mouse deer is less dependent on fruits and prefers to eat leaves.

Wild Boar (*Sus scrofa*) and Bearded Pig (*Sus barbatus*) from the Suidae family are omnivores, whose food consists of various types of fruits, parts of leaves and roots of plants, mushrooms,

and insects. *Sus barbatus* also eats animals such as lizards, rodents, and snakes. Although both species will destroy the seed portion of the fruit eaten (seed predator), there are also still intact seeds that are excreted through the process of defecation. Attempts to propagate seeds found in *Sus scrofa* faeces were successful where over 50% of the propagated seeds were successfully grown (O'Connon and Kelly, 2012). This indicates that both species of pigs also play a role as seed dispersal agents.

Table 1.7 List of animal species from the order Artiodactyla found in Peninsular Malaysia

Family	Scientific name	Common name	Local name	IUCN Status	Local Conservation Status
Bovidae	*Bos gaurus*[#]	Gaur	Seladang	VU	EN
	Bos javanicus[#]	Banteng	Banteng	EN	CR
	Capricornis sumatraensis[#]	Serow	Kambing Gurun	VU	EN
Cervidae	*Rusa unicolor*[*]	Sambar Deer	Rusa Sambar	VU	EN
	Muntiacus muntjak[*]	Barking Deer	Kijang	LC	NT
Suidae	*Sus scrofa*[*]	Common Wild Pig	Babi Hutan	LC	LC
	Sus barbatus[#]	Bearded Pig	Babi Bodoh	VU	DD
Tragulidae	*Tragulus napu*[*]	Large Mouse Deer	Napuh	LC	NT
	Tragulus kanchil	Lesser Mouse Deer	Kancil	LC	LC

[*]Protected under the Wildlife Conservation Act 2010 [Act 716]

[#]Totally protected wildlife under the Wildlife Conservation Act 2010 [Act 716]

Order Carnivora

In general, members of the order Carnivora are carnivorous. However, there are also omnivorous species that can be found within this order, such as yellow-throated marten, bears, and almost all species from the family Viverridae.

Malayan Sun Bear (*Helarctos malayanus*) eats a wide range of food in the forest such as small animals, termites, beehives (honey), and even fruits. Among the fruits that have been recorded to be eaten by bears are durian, *kedondong*, and *Ficus* spp. Due to the frugivorous nature of these animals, bears are also reported to play a role as seed dispersal agents depending on the species of fruit eaten, the amount of seeds ingested as well as the area where faeces is excreted (McConkey and Galetti, 1999).

The diet for Yellow-throated Marten (*Martes flavigula*) consists of fruits, nectar, honey, and various types of small vertebrates and invertebrates. In Peninsular Malaysia, this species has also been recorded in oil palm plantations (Azlan, 2003).

Members of the family Viverridae play various important roles in the tropical rainforest including preys, predators as well as seed dispersers. Among the species consumed by Viverridae are birds, frogs, fish, rodents, and insects. In addition, the species under this family such as binturong and civets also feed on fruits as part of the diet and play a role as an important seed disperser, especially binturong. A study conducted on binturong found that 30% of the total seeds of some types of fruit given to binturong were excreted in good condition. All the seeds were then sown and 19%–35% were successfully germinated depending on the species of fruit (Colon and Campos-Arceiz, 2013). In Borneo, binturongs were also recorded to consume more *Ficus* fruit compared to Gibbons and Capped Hornbills and recorded the highest seed germination of all seeds excreted (Nakabayashi et al., 2019). Tree-stripped Palm Civet (*Arctogalidia trivirgata*) is also considered to have potential as a seed dispersal agent because its feeding and habits and excretion process are very similar to binturong. Apart from fruits, tree-stripped palm civet also feeds on nectar and sap from tree bark.

Although it is under the order Carnivora, Common Palm Civet (*Paradoxurus hermaphroditus*) is predominantly frugivorous that feeds on *Ficus* spp., a wide variety of forest fruits (depending on the season), and oil palm for those inhabiting areas near oil palm plantations. Common palm civet prefers fruits that have a high sugar content and a soft fruit filling.

Table 1.8 List of omnivore animal species under the Order Carnivora found in Peninsular Malaysia

Family	Scientific name	Common name	Local name	IUCN Status	Local Conservation Status
Mustelidae	Martes flavigula	Yellow-Throated Marten	Mengkira	LC	NT
Ursidae	*Helarctos malayanus*#	Malayan Sun Bear	Beruang	VU	VU
Viverridae	*Arctictis binturong*#	Binturong	Binturong	VU	LC
	Arctogallidia trivirgata#	Tree-Stripped Palm Civet	Musang Akar	LC	LC
	Cynogale bennettii#	Otter Civet	Musang Memerang	EN	EN
	Hemigalus derbyanus#	Banded Palm Civet	Musang Belang	NT	LC
	Paguma larvata#	Masked Palm Civet	Musang Lamri	LC	NT
	*Paradoxurus hermaphroditus**	Common Plam Civet	Musang Pulut	LC	LC
	Viverra megaspila	Large Spotted Civet	Musang Titik Besar	EN	NT
	*Viverra tangalunga**	Malay Civet	Musang Tenggalung	LC	LC
	Viverra zibetha#	Large Indian Civet	Musang Jebat	LC	DD
	*Viverricula indica**	Little Civet	Musang Kecil India	LC	NT

*Protected under the Wildlife Conservation Act 2010 [Act 716]

#Totally protected wildlife under the Wildlife Conservation Act 2010 [Act 716]

Photo: Yellow-Vented Bulbul (*Pycnonotus goiavier)*

Malaysia has a high diversity of avifauna species amounting to more than 800 species. However, deforestation caused by anthropogenic activities has resulted in forest fragmentation, which has a negative impact on bird communities that depend on forest areas for survival. The opening of oil palm plantations and paddy fields has led to a reduction in bird diversity and changes in the feeding patterns of certain bird species. Birds of woodpecker species, barbets, babblers, and leafbirds are among the birds that are sensitive to habitat changes and adapt poorly to disturbed environments.

Birds have a wide range of diet from plants such as fruits, nectar, and seeds, to small animals such as insects and earthworms. In addition to bats from the Pteropodidae family, birds also play a very important role as seed dispersers for pioneer tree species in tropical rainforests. Several species of birds also play a role as important pollinating agents. One of the factors that makes some birds as major seed dispersers is its relatively long daily movement that can reach tens of kilometres from the nest to the foraging area. This allows the seeds to spread evenly over the area traversed by the birds throughout the day. In contrast to primates that generally prefer fruits with high sucrose content, birds prefer fruits with high fructose and glucose content (Wehncke and Reyes-Amaya, 2019). Other factors that influence fruit selection among bird species are fruit colour, fruit size, nutrient content, and the level of fruit damage caused by insects.

Birds that inhabit forest areas are usually insect eaters, fruit eaters, or both. This is due to the high density of trees in the forest, which is a habitat to many types of insects and also the existence of various species of fruit trees (Azman et al., 2011). **Table 1.9** shows some of the bird species that are known to eat plants in the forests of Peninsular Malaysia by consuming fruits or nectar and therefore may potentially play important roles as seed dispersal and pollination agents.

Table 1.9 List of frugivorous and omnivorous bird species that can be found in the tropical rainforests of Peninsular Malaysia

Order	Family	Scientific name	Common name	Local name	IUCN Status
BUCEROTIFORMES	Bucerotidae	*Annorhinus galeritus*#	Bushy-Crested Hornbill	Enggang Belukar	NT
		Anthracoceros albirostris#	Oriental Pied Hornbill	Enggang Kelingking	LC
		Anthracoceros malayanus#	Black Hornbill	Enggang Gatal Birah	VU
		Berenicornis comatus#	White-Crowned Hornbill	Enggang Jambul Putih	EN
		Buceros bicornis#	Great Hornbill	Enggang Papan	VU
		Buceros rhinoceros#	Rhinoceros Hornbill	Enggang Badak	VU
		Buceros vigil#	Helmeted Hornbill	Enggang Bertopi	CR
		Rhabdotorrhinus corrugatus#	Wrinkled Hornbill	Enggang Berkedut	EN
		Rhythiceros subruficollis#	Plain-Pouched Hornbill	Enggang Rimba	VU
		Rhythiceros undulatus#	Wreathed Hornbill	Enggang Gunung	VU
COLUMBIFORMES	Collumbidae	*Chalcophaps indica**	Emerald Dove	Punai Tanah	LC
		Ptilinopus jambu#	Jambu Fruit- Dove	Punai Jambu	NT
		Treron curvirostra#	Thick-Billed Green Pigeon	Burung Punai Lengguak	LC
		Ducula aenea#	Green Imperial Pigeon	Pergam Besar	LC
		Ducula badia#	Mountain Imperial Pigeon	Pergam Bukit	LC
		*Treron vernans**	Pink-Necked Green Pigeon	Punai Gading	LC
		Treron capellei#	Large Green Pigeon	Punai Bakok	VU
		*Treron olax**	Little Green Pigeon	Punai Daun	LC
		Treron bicinctus#	Orange-Breasted Green Pigeon	Punai Siam	LC
CUCULIFORMES	Cuculidae	*Cacomantis merulinus*#	Plaintive Cuckoo	Burung Mati Anak	LC
		Cacomantis sonneratii#	Banded Bay Cuckoo	Sewah Takuweh	LC
		Phaenicophaeus curvirostris#	Chestnut-Breasted Malkoha	Cenuk Birah	LC
		Surniculus lugubris#	Square-Tailed Drongo-Cuckoo	Hamba Kera	LC

Order	Family	Scientific name	Common name	Local name	IUCN Status
GALLIFORMES	Phasianidae	*Arborophila charltonii*#	Scaly-Breasted Partridge	Siul Onak	VU
		Argusianus argus	Great Argus	Kuang Raya	VU
		*Gallus gallus**	Red Junglefowl	Ayam Hutan	LC
		Lopihura erythrophthalma#	Crestless Fireback	Ayam Pegar Mata Merah	NT
		Lophura ignita#	Crested Fireback	Ayam Pegar	NT
		Polyplectron malacense#	Malay Peacock-Pheasant	Kuang Pongsu	VU
		Rollulus rouloul#	Crested Partridge	Siul Berjambul	NT
GRUIFORMES	Rallidae	*Amaurornis cinerea*#	White-Browed Crake	Sintar Dahi Putih	LC
		*Amaurornis phoenicurus**	White-Breasted Waterhen	Ruak-Ruak	LC
PICIFORMES	Megalaimidae	*Calorhamphus fuliginosus*#	Brown Barbet	Takur Dahan	LC
		Megalaima australis#	Blue-Eared Barbet	Takur Akar	LC
		Megalaima chrysopogon#	Gold-Whiskered Barbet	Takur Jambang Emas	LC
		Megalaima henricii#	Yellow-Crowned Barbet	Takur Mahkota Kuning	NT
		Megalaima mystacophanos#	Red-Throated Barbet	Takur Raya	NT
	Picidae	*Yungipicus moluccensis*#	Sunda Pygmy Woodpecker	Belatuk Belacan Kecil	LC
PSITTACIFORMES	Psittaculidae	*Loriculus galgulus**	Blue-Crowned Hanging-Parrot	Bayan Serindit	LC
		*Psittinus cyanurus**	Blue-Rumped Parrot	Bayan Tanau	NT

Order	Family	Scientific name	Common name	Local name	IUCN Status
PASSERIFORMES	Aegithinidae	*Aegithina viridissima*#	Green Iora	Kunyit Hijau	NT
	Campephagidae	*Pericrocotus divaricatus*#	Ashy Minivet	Matahari Kelabu	LC
		Pericrocotus flammeus#	Scarlet Minivet	Matahari Besar	LC
	Chloropseidae	*Chloropsis cochinchinensis*#	Blue-Winged Leafbird	Daun Sayap Biru	EN
		Chloropsis sonnerati#	Greater Green Leafbird	Daun Hijau Besar	EN
	Cisticolidae	*Orthotomus sericeus*#	Rufous-Tailed Tailorbird	Perenjak Rimba	LC
	Corvidae	*Corvus enca*	Slender-Billed Crow	Gagak Paruh Lampai	LC
		Corvus macrorhynchos	Large-Billed Crow	Gagak Paruh Besar	LC
		Platylophus galericulatus#	Crested Jay	Gagak Berjambul	NT
		Platysmurus leucopterus#	Black Magpie	Gagak Kambing	LC
	Dicaeidae	*Dicaeum chrysorrheum*#	Yellow-vented Flowerpecker	Sepah Puteri Rimba	LC
		Dicaeum ignipectus#	Fire-Breasted Flowerpecker	Sepah Bunga Dada Api	LC
		Dicaeum maculatus	Yellow-Breasted Flowerpecker	Sepah Putih	LC
		Dicaeum percussus	Crimson-Breasted Flowerpecker	Sepah Puteri Pelangi	LC
		Dicaeum trigonostigma#	Orange-Bellied Flowerpecker	Sepah Puteri Dada Oren	LC
	Estrildidae	*Lonchura leucogastra**	White-Bellied Munia	Pipit Padi	LC
	Eurylaimidae	*Calyptomena viridis*#	Green Broadbill	Takau Selawit	NT
		Cymbirhynchus Macrorhynchos#	Black-And-Red Broadbill	Takau Rakit	LC
		Eurylaimus javanicus#	Banded Broadbill	Takau Belang	NT
	Irenidae	*Irena puella*#	Asian Fairy-Bluebird	Murai Gajah	LC
		Chloropsis cochinchinensis#	Blue-Winged Leafbird	Daun Sayap Biru	EN
		Chloropsis cyanopogon#	Lesser Green Leafbird	Daun Kecil	NT
		Chloropsis sonnerati#	Greater Green Leafbird	Daun Hijau Besar	EN
	Leiothrichidae	*Alcippe brunneicauda*#	Brown Fulvetta	Rimba Murai Coklat	NT

Order	Family	Scientific name	Common name	Local name	IUCN Status
PASSERIFORMES	Nectariniidae	*Arachnothera affinis*#	Grey-Breasted Spiderhunter	Kelicap Jantung Bukit	LC
		Arachnothera flavigaster#	Spectacled Spiderhunter	Kelicap Jantung Besar	LC
		Arachnothera longirostra#	Little Spiderhunter	Kelicap Jantung Kecil	VU
		Hypogramma hypogrammicum#	Purple-Naped Spiderhunter	Burung Kelicap Rimba	LC
		Prionochilus maculatus#	Yellow-Breasted Flowerpecker	Sepah Bunga Dada Kuning	LC
		Prionochilus percussus#	Crimson-Breasted Flowerpecker	Sepah Bunga Pelangi	LC
		Prionochilus thoracicus#	Scarlet-Breasted Flowerpecker	Sepah Putri	NT
		Dicaeum trigonostigma#	Orange-Bellied Flowerpecker	Sepah Puteri Dada Oren	LC
		Anthreptes singalensis#	Ruby-Cheeked Sunbird	Kelicap Belukar	LC
		Anthreptes simplex#	Plain Sunbird	Kelicap Kelabu	LC
		Nectarinia sperata#	Purple-Throated Sunbird	Kelicap Nibong	LC
		Arachnothera crassirostris#	Thick-Billed Spiderhunter	Kelicap Jantung Paruh Tebal	LC
		Arachnothera robusta#	Long-Billed Spiderhunter	Kelicap Jantung Paruh	LC
		Arachnothera chrysogenys#	Yellow-Eared Spiderhunter	Kelicap Jantung Telinga Kuning	LC
	Oriolidae	*Oriolus xanthonotus*#	Dark-Throated Oriole	Kunyit Leher Hitam	NT
	Passeridae	*Passer montanus*	Eurasian Tree-Sparrow	Ciak Urasia	LC
	Ploceidae	*Ploceus philippinus**	Baya Weaver	Ciak Tempua	LC

Order	Family	Scientific name	Common name	Local name	IUCN Status
PASSERIFORMES	Pycnonotidae	*Alophoixus bres*#	Scrub Bulbul	Merbah Pipi-Kelabu	EN
		Alophoixus finschii#	Finsch's Bulbul	Merbah Tekak Kuning	NT
		Alophoixus ochraceus#	Ochraceous Bulbul	Merbah Beringin	LC
		Alophoixus phaeocephalus#	Puff-Throated Bulbul	Merbah Perut Kuning	LC
		Brachypodius melanoleucos	Black-And-White Bulbul	Merbah Tanduk	LC
		Hemixos flavala#	Ashy Bulbul	Burung Merbah Abu	NT
		Iole olivacea#	Buff-Vented Bulbul	Merbah Riang	LC
		Ixos malaccensis#	Streaked Bulbul	Barau Bukit	NT
		Pycnonotus atriceps#	Black-Headed Bulbul	Merbah Siam	NT
		Pycnonotus brunneus#	Red-Eyed Bulbul	Merbah Mata Merah	LC
		Pycnonotus cyaniventris#	Grey-Bellied Bulbul	Merbah Kelabu	LC
		Pycnonotus erythrophthalmos#	Spectacled Bulbul	Merbah Kecil	NT
		Pycnonotus eutilotus#	Puff-Backed Bulbul	Merbah Coklat Berjambul	LC
		Pycnonotus finlaysoni#	Stripe-Throated Bulbul	Merbah Leher Berjalur	NT
		Pycnonotus plumosus#	Olive-Winged Bulbul	Merbah Belukar	LC
		Pycnonotus simplex#	Cream-Vented Bulbul	Merbah Mata Putih	LC
		Pycnonotus goiavier	Yellow-Vented Bulbul	Merbah Kapur	LC
		Pycnonotus zeylanicus#	Straw-Headed Bulbul	Barau-Barau	LC
		Rubigula melanicterus#	Black-Crested Bulbul	Merbah Jambul Hitam	CR
		Tricholestes criniger#	Hairy-Backed Bulbul	Merbah Bulu Tengkuk	LC
	Sturnidae	*Gracula religiosa**	Common Hill Myna	Tiong Emas	LC
	Timaliidae	*Pomatorhinus montanus*#	Chestnut-Backed Scimitar Babbler	Kekicau Paruh Sabit Kecil	LC
	Zosteropidae	*Zosterops everetti*#	Everett's White-Eye	Mata Putih Belukar	LC

Source: (Kaur et al., 2011; Moore et al., 2016; Payne, 1980; Saad et al., 2012; Yong et al., 2011; Norsham Suhaina, 2005; Azman et al., 2011)

*Protected under the Wildlife Conservation Act 2010 [Act 716]

#Totally protected wildlife under the Wildlife Conservation Act 2010 [Act 716]

Photo: Salak fruits *(Salacca glabrescens)*

Chapter 2:
Food Plants for Wildlife

Photo: Ara tree *(Ficus auriculata)*

Malaysia has one of the most complex tropical rainforest ecosystems in the world. These forests serve to stabilise water supply sources, soil fertility, and environmental quality; reduce flood damage; and act as buffers to reduce the effects of erosion and flood. In addition, the main function of forests is the habitat for conservation and preservation of biological diversity, including plants and wildlife. Forests in Malaysia are reported to be rich in various plants, including 2500 flowering plants that are habitats and food sources for 200 species of mammals, 600 species of birds, 110 species of snakes, 80 species of lizards, and thousands of insects (Jabatan Perhutanan Semenanjung Malaysia, 2021). Forests in Malaysia are divided into several strata, where each stratum supports different species of flora and fauna.

FLOWERING PLANTS AS FOOD FOR WILDLIFE

Malaysia has an ideal climate for the growth of various types of plants, in addition to being rich in a variety of genetic resources. There are two main groups of plants classified as angiosperm (flowering) and gymnosperm (non-flowering) plants. In the angiosperm group, it is estimated that about 370 species of fruiting plants with 16 species are classified as primary fruits, while the rest are classified as rare fruits (Rukayah, 2001). The flower is a specialised reproductive structure (gametophyte) in which it will grow into fruits and seeds for the purpose of reproduction. Compared to gymnosperm plants, this group is the most successful class of plant with high species diversity. The majority of flowering plants are pollinated by animals such as insects, spiders, bats, and birds.

Photo: Rattan fruits *(Calamus* spp.*)*

Flowering plants play an important role as food sources for herbivorous and omnivorous wildlife. There are several groups of wildlife that feed on flowering plants such as large mammals (such as tapirs, elephants, gaur, binturong), small mammals (such as bats, squirrels, flying lemur, civets, porcupines, mice), primates (including orangutans, long-tailed macaques, apes, langurs, gibbons), ungulates (such as deer, even-toed ungulate, mouse-deer, yellow-throated martens), and birds. A list of wildlife that makes flowering plants a food source is shown in **Table 2.1** and **Table 2.2**. Most flowering plants produce fruit and can be divided into two categories, namely non-seasonal (fruiting throughout the year) and seasonal (fruiting only at certain times). Flowering plants that bear fruit throughout the year are figs, bananas, papayas, sugarcane, Terengganu cherries, and *kedondong*. These non-seasonal plants provide a constant supply of food especially to wildlife. Examples of flowering plants that bear fruit according to the season are *langsat*, rambutan, durian, *rambai*, sapodilla, mangosteen, jackfruit, *asam kumbang*, horse mango, kwini, marian plum, sepam, and sentol. Under the group of flowering plants, there are two major groups, namely monocotyledonous plants and dicotyledonous plants. Among the distinguishing features of these two groups are the number of cotyledons, as well as the type of vein, root and stem.

MONOCOTYLEDONOUS PLANTS

Monocotyledonous plants have one cotyledon, parallel-veined leaves, fibrous roots, and a soft, non-woody stem. Among the examples of monocotyledonous plants that serve as source of food for various wildlife are grass, sugarcane, corn, ginger, banana and yam (**Table 2.1**).

Table 2.1 List of monocotyledonous plants in Malaysia and the plant-eating wildlife

No.	Family	Scientific Name	Local Name	Common Name	Wildlife
1	**AMARYLLIDACEAE**	*Crinum asiaticum*	Bakong	Crinum Lily	Elephant
2	**ARACEAE**	*Aglaonema nitidum*	Daun Lidah	Chinese Evergreen	Bird
3		*Aglaonema simplex*	Sumpuh Bulan,	Sagut	Bird, mammal
4		*Alocasia longiloba*	Keladi Rimau, Keladi Ular, Birah Kijang, Birah Hitam	Arrow-Leaf	Bird, small mammal
5		*Amorphophallus paeoniifolius*	Keladi Lekir, Lokai	Elephant Yam, Stink Lily	Bird, tapir, squirrel
6		*Amorphophallus prainii*	Bunga Bangkai	Corpse plant, Snake Plant	Tapir
7		*Amydrium medium*	Sarkat Gajah	Arum Lilies	Bird, mammal
8		*Colocasia esculenta*	Keladi	Elephant's Ear	Mammal
9		*Epipremnum aureum*	Sirih Gading	Devil's Ivy	Insect
10		*Epipremnum giganteum*	Akar Resdung, Rengut	Greater Epipremnum	Bird
11		*Hyptis suaveolens*	Selasih Hutan, Sepulut	Pignut	Elephant
12		*Homalomena deltoidea*	Keladi Hutan	Wild Yam	Elephant
13		*Rhaphidophora lobbii*	Akar Asam Tebing Paya, Akar Kelumpayang	The Root of Kelumpayang	Bat, arboreal mammal
14		*Syngonium podophyllum*	Tapak Angsa	Arrow-head, Goose Foot Plant	Bird
15	**ASPARAGACEAE**	*Dracaena elliptica*	Kaki Ayam, Pecah kelambu, Sabang Ensluai	Sabang Ensluai	Bird, small mammal
16	**BROMELIACEAE**	*Ananas comosus*	Nanas	Pineapple	Bird, primates, insect, rat, squirrel
17	**COMMELINACEAE**	*Amischotolype griffithii*	Setawar Hutan, Setawar Jantan, Tebu Gogok	Wild Setawar	Elephant
18		*Amischotolype gracilis*	Setawar Betina, Tebu Primat, Buah Anku	Wild Setawar	Elephant
19	**COSTACEAE**	*Costus speciosus*	Penawar Padang, Sedingin, Setawar Halia	Crepe Ginger, Malay Ginger	Bird, elephant, insect
20	**CYPERACEAE**	*Mapania cuspidata*	Serapat, Pandan Tikus	Serapat	Small mammals
21	**HYPOXIDACEAE**	*Molineria latifolia*	Lemba	Lemba	Elephant, tapir
22	**MARANTACEAE**	*Donax canniformis*	Bemban	Donax	Elephant
23		*Donax grandis*	Bumban	Donax	Elephant
24		*Phrynium pubinerve*	Lirek	Packing Leaf	Elephant
25		*Stachyphrynium latifolium*	Lirek	Lirek	Elephant

No.	Family	Scientific Name	Local Name	Common Name	Wildlife
26	**MUSACEAE**	*Musa acuminata*	Pisang	Banana	Bird, elephant, bat
27		*Musa acuminata* ssp.	Pisang Siamang/ Pisang Liar	Wild Banana	Bat, squirrel
28		*Musa balbisiana*	Pisang Liar	Wild Banana	Elephant, squirrel, bat, primates, bird, deer, rat
29		*Musa malaccensis*	Pisang Liar	Wild Banana	Bat, squirrel
30		*Musa truncata*	Pisang Liar	Wild Banana	Elephant, squirrel, bat, primates, bird, deer, rat
31		*Musa violascens*	Pisang Liar	Wild Banana	Bat, squirrel
32	**PALMAE (ARECACEAE)**	*Areca catechu*	Pinang Sirih	Areca Nut, Betel Nut Palm	Elephant, primates
33		*Arenga caudata*	Tukas	Palm	Bat, elephant, primates
34		*Arenga pinnata*	Kabong	Hooker's Fishtail Palm	Elephant
36		*Arenga westerhoutii*	Kerjim, Pokok Sagu	Westerhout's Sugar Palm	Elephant, primates
37		*Calamus angustifolius*	Rotan Getah	Water Rattan Palm	Elephant
39		*Calamus caesius*	Rotan Sega	Sega Rattan	Elephant
40		*Calamus castaneus*	Cucor, Rotan Cucor, Atap Cucor	Mountain Rattan	Elephant, primates
41		*Calamus draco*	Rotan Jernang	Rattan	Elephant
42		*Calamus erinaceus*	Rotan Bakau	Hedgehog Rattan, Mangrove Rattan	Elephant
43		*Calamus geniculatus*	Rotan Jahaca	Rattan	Elephant
44		*Calamus hirsutus*	Rotan Sabut	Rattan	Elephant
45		*Calamus insignis*	Rotan Batu	Remakable Rattan	Elephant
46		*Calamus javensis*	Rotan Lilin	Javanese Rattan	Elephant
47		*Calamus longipes*	Rotan Duduk	Rattan	Elephant
48		*Calamus luridus*	Rotan Kerai	Rattan	Elephant
49		*Calamus manan*	Rotan Manau	Manau Palm	Primates, bird
50		*Calamus micracanthus*	Rotan Jernang	Paper Rattan	Elephant
51		*Calamus ornatus*	Rotan Manau	Rattan	Primates
52		*Calamus penicillatus*	Rotan Batu	Rattan	Elephant
53		*Calamus radulosus*	Rotan Kikir	Rattan	Elephant
54		*Calamus scipionum*	Rotan Semambu	Semambu	Bird, elephant, primates, civet, squirrel
55		*Calamus pycnocarpus*	Rotan Kong	Rattan	Elephant
56		*Calamus georgei*	Rotan Senik	Rattan	Elephant

No.	Family	Scientific Name	Local Name	Common Name	Wildlife
57		*Caryota mitis*	Kabong Hutan	Clustered Fishtail Palm	Elephant
58		*Ceratolobus subangulatus*	Rotan Tunggal	Rattan	Elephant
59		*Chrysalidocarpus lutescens*	Pinang Kuning	Yellow Palm	Bat, Elephant
60		*Cocos nucifera*	Kelapa	Coconut	Elephant
61		*Corypha utan*	Gebang, Gembong	Buri palm	Elephant
62		*Daemonorops callicarpa*	Rotan Lumpit	Rattan	Primates
63		*Elaeis guineensis*	Kelapa Sawit	Oil Palm	Elephant, primates
64		*Eleiodoxa conferta*	Asam Paya/Kelubi	Marsh Sour Relish	Elephant
65		*Eugeissona tristis*	Bertam	Dull Bertam Palm	Elephant
66		*Iguanura geonomiformis*	Palas Tikus, Pinang Burung	Palm	Elephant
67		*Iguanura wallichiana*	Pinang, Terunok	Dwarft Palm	Bird, Elephant
68		*Johannesteijsmannia altifrons*	Daun Koh, Daun Payang, Daun Sar	Joey Palm, Umbrella Palm	Elephant
69		*Korthalsia flagellaris*	Rotan Udang	Rattan	Elephant
70		*Korthalsia laciniosa*	Rotan Dahan	Led beth	Elephant
71		*Korthalsia tenuissima*	Rotan Dahan Tikus	Rattan	Elephant
72	**PALMAE (ARECACEAE)**	*Licuala grandis*	Palas Kapas	Fan Palm	Elephant
74		*Licuala mirabilis*	Palas	Palas	Bat
75		*Livistona chinensis*	Serdang Cina	Chinese Fan Palm	Bird, bat
76		*Livistona rotundifolia*	Serdang Daun Bulat	Footstool Palm	Bird, bat
77		*Livistona saribus*	Serdang, Pokok Sah	Taraw Palm	Elephant
78		*Metroxylon sagu*	Pokok Sagu	Sago Palm	Elephant
79		*Myrialepis paradoxa*	Rotan Kertong	Kertong Rattan	Elephant
80		*Nenga gajah*	Pinang Gajah	Pinang Palm	Elephant
81		*Nenga grandiflora*	Pinang	Pinang Palm	Elephant
82		*Nenga macrocarpa*	Pinang	Large-fruited Nenga Palm	Elephant
83		*Nenga pumila*	Pinang	Dwarf Nenga Palm	Elephant
84		*Nypa fruticans*	Nipah	Nipa Palm	Crab
85		*Oncosperma horridum*	Bayas, Nibung	Mountain Nibung Palm, Thorny Palm	Elephant, primates
86		*Oncosperma tigillarium*	Nibong	Nibong Palm, Palmae	Bird, elephant
87		*Orania sylvicola*	Ibul, Kayu Baluhur	Forest Palm, Ibul palm	Elephant
88		*Pholidocarpus macrocarpus*	Kepau	Kepang Palm	Elephant
89		*Pinanga disticha*	Pinang	Pinang	Primates

No.	Family	Scientific Name	Local Name	Common Name	Wildlife
90	**PALMAE (ARECACEAE)**	*Pinanga malaiana*	Pinang, Lagong	Pinang	Elephant
91		*Pinanga polymorpha*	Pinang	Pinang	Elephant
92		*Plectocomia elongata*	Rotan Badak	Giant Rattan Palm	Elephant
93		*Plectocomiopsis geminiflora*	Rotan Gilang	Rattan	Elephant, bat
94		*Ptychosperma macarthurii*	Palma Macarthurii	Macarthur Palm	Bat
95		*Roystonea regia*	Sawit Diraja	Florida Royal Palm	Bat
96		*Salacca glabrescens*	Salak	Salak Palm	Bird, primates
97	**PANDANACEAE**	*Freycinetia ciliaris*	Pandan	Pandan	Elephant
98		*Freycinetia malaccensis*	Rancang Besi	Pandan	Elephant
99		*Pandanus artocarpus*	Mengkuang	Pandan	Elephant
100		*Pandanus amaryllifolius*	Daun Pandan, Pandan Wangi	Pandan	Insect
101	**POACEAE (GRAMINEAE)**	*Bambusa vulgaris*	Buluh	Bamboo	Primates, elephant, mouse, wild boar, sun bear
102		*Brachiaria decumbens*	Rumput Ceylon	Ceylon Grass	Elephant, wild boar, deer, napoh, sambar deer, tapir
103		*Brachiaria humidicola*	Rumput Koronivia	Koronivia Grass	Elephant, wild boar, deer, napoh, sambar deer, tapir
104		*Brachiaria mutica*	Rumput Para	Para Grass	Deer
105		*Brachiaria ruziziensis*	Rumput Ruzi	Congo Grass, Ruzi Grass	Deer
106		*Centotheca lappacea*	Rumput Darah, Rumput Silat Kain, Rumput Lilit Kain	Barbed Grass	Elephant
107		*Dendrocalamus asper*	Buluh Betung	Giant Bamboo	Elephant
108		*Dinochloa scabrida*	Buluh Pemanjat	Bamboo	Elephant
109		*Hymenachne amplexicaulis*	Rumput Kumpai	West Indian Marsh Grass	Elephant
110		*Oryza sativa*	Padi	Paddy	Elephant
111		*Oryza ridleyi*	Padi Liar	Wild Paddy	Elephant
112		*Panicum maximum*	Rumput Guinea	Guinea Grass	Elephant, wild boar, primates, deer, gaur, squirrel
113		*Paspalum conjugatum*	Rumput Kerbau	Buffalo Grass, Carabao Grass	Gaur
114		*Pennisetum purpureum*	Rumput Gajah, Rumput Napier	Napier Grass, Elephant Grass	Elephant, wild boar, deer, slow loris, napoh, gaur, sambar deer, tapir

No.	Family	Scientific Name	Local Name	Common Name	Wildlife
115	**POACEAE (GRAMINEAE)**	*Phragmites karka*	Perumpung	Common Reed	Elephant
116		*Phyllostachys* sp.	Buluh Asia	Asian Bamboo	Primates, elephant
117		*Saccharum officinarum*	Tebu	Sugarcane	Elephant
118		*Schizostachyum grande*	Buluh Semeliang	Clumping Bamboo, Malaysian Weed-Bamboo	Elephant
119		*Schizostachyum zollingeri*	Buluh Dinding	Slender Bamboo	Elephant
120		*Setaria sphacelata*	Rumput Setaria	African Bristlegrass	Elephant, wild boar, deer, napoh, sambar deer, tapir
121		*Thysanolaena latifolia*	Buluh Tebrau, Rumput Buluh	Tiger Grass	Gaur, elephant
122		*Triticum aestivum*	Rumput	Wheat Grass	Elephant, rodents, squirrel, porcupine
123		*Zea mays*	Jagung	Corn	Elephant, bird, deer, civet, squirrel, insect
124	**SMILACACEAE**	*Smilax setosa*	Akar Banar, Akar Gadong	Bearded Smilax	Primates
125	**ZINGIBERACEAE**	*Alpinia aquatica*	Meroyan Siamang, Munkanang	Aquatic Ginger	Bird
126		*Alpinia galanga*	Lengkuas	Siamese Ginger	Elephant
127		*Alpinia javanica*	Lengkuas Hutan, Tepus	Ginger Lily	Elephant
128		*Alpinia ligulata*	Timbang	Ginger	Elephant
129		*Curcuma longa*	Kunyit	Turmeric	Elephant
130		*Elettaria cardamomum*	Pelaga	Cardamomum	Elephant
131		*Etlingera elatior*	Kantan	Torch Ginger	Bird, small mammals, elephant
132		*Etlingera littoralis*	Tepus	Ginger	Small mammals, squirrel, rodents, porcupine
133		*Etlingera punicea*	Halia Hutan, Tepus	Ginger	Small mammals, squirrel
134		*Globba patens*	Meroyan Berok	Ginger	Elephant, wild boar, squirrel, primates, insect
135		*Globba pendula*	Meroyan Jarum, Meroyan Tinggal	Ginger	Elephant, wild boar, squirrel, primates, insect
136		*Hornstedtia* spp.	Halia	Ginger	Elephant, wild boar, squirrel, primates, insect
137		*Hornstedtia scyphifera*	Senggang	Great Spindle Ginger	Primates

No.	Family	Scientific Name	Local Name	Common Name	Wildlife
138	ZINGIBERACEAE	*Languas cannifolia*	Puar Minyak	Ginger	Elephant
139		*Plagiostachys crocydocalyx*	Halia	Ginger	Small mammals, squirrel, mouse
140		*Zingiber* spp.	Halia	Ginger	Elephant

Family Poaceae

Photo: Elephant Grass *(Pennisetum purpureum)*

Poaceae is a family of large monocotyledonous flowering plants. It is also known as grasses and has evolved successfully to occur in almost all ecosystems. It includes grain grasses, bamboos, and natural pasture grasses and species grown in backyards and meadows. Grass is one of the most common elements of the herbivorous diet especially for ruminant groups. Among the grass-eating wildlife are elephants, squirrels, slow loris, deer, pigs, gaur, and various types of insects. Among the types of grass that are widely eaten are Napier, Guinea, Ruzi, and Signal grass.

Napier grass (*Pennisetum purpureum*) or elephant grass is a type of grass grown for animal feed. This grass is reported to be very suitable to grow in various places from the ground-level altitude of 0–3,000 ft above the sea level in areas that are open to full sunlight (Mohd Anim, 2017). Guinea grass (*Panicum maximum*) or also known as horse grass is a type of vertical grass, deep rooted, and has long leaves and flower stalks, with its height ranging between 1.5 and 2 m (Mohd Anim, 2017). This grass is resistant to long dry seasons but needs a humid climate to thrive. It is also able to live in the shade and is suitable to be integrated under coconut plantation areas.

Ruzi grass or its scientific name *Brachiaria ruziziensis* is a creeping grass that is less than

1.5 m tall and filled with fine-grained flowers. Grass germination is faster through seeds or stem cuttings. This grass is often used as a permanent or semi-permanent pasture for grazing, mowing, and green food or straw. Meanwhile, Signal grass (*Brachiaria decumbens*) is a tropical grass having a wide distribution throughout South America, Australia, Indonesia, Vanuatu, and Malaysia due to its adaptation to various soil types and environments (Low, 2015). This grass grows upright, clumped, and creeping. Signal grasses reproduce year-round, have bright green and medium hairy leaves, with 7–20 mm width and 5–25 mm length (Jabatan Perkhidmatan dan Perusahaan Ternak Sabah, 2007). Like other types of grass, among the animals that feed on this grass are elephants, squirrels, slow loris, deer, pigs, and gaur.

Sugarcane is also included in the grass family (Poaceae) and is a plant that has an erect stem without branches and grows on clumps of fertile soil. Its height is in the range of 1.8–3.0 m with a segment diameter of about 5–10 cm (Mohd Anim, 2011). Among the wildlife that eats sugarcane are elephants, orangutans, monkeys, pigs, and sun bears. In the monocotyledon class, corn also belongs to the family Poaceae. Corn has a round, hollow stem, and the corn leaves form a sheath around it. The corn flowers are not prominent and do not bloom, only droop. Corn seeds grow as small grains with a hard, uncovered outer coating to encourage dispersal by animals. Among the animals identified to eat corn are elephants, birds, deer, civets, squirrels, and various types of insects.

Family Zingiberaceae

The Zingiberaceae family is a herbaceous plant that does not have hard stems and is also known as a tuberous plant. Ginger belongs to this group, and it is the largest order in the family Zingiberaceae with about 56 genera and about 1,300 species (Britannica, 2020). This aromatic herb usually grows in moist areas in the tropics, which makes the forest ecosystem in Malaysia a suitable habitat for its growth. Wildlife such as elephants, pigs, squirrels, and groups of primates such as long-tailed macaques and various types of insects make its leaves as their diet.

Family Musaceae

Musaceae is the banana family. There are approximately 91 species that have been successfully identified under this family (Christenhusz and Byng, 2016). Wild banana species that are often found in Malaysian forests are *Musa balbisiana*, *M. acuminata*, *M. acuminata* ssp. *malaccensis*, *M. gracilis*, and *M. violescens*. They are found growing in clusters, originating from the same parent with a high population distribution in any locality. They have flowers or "male buds" that grow in various colours from red to dark red, purple, or yellow, while the fruit colour is green or bluish. The fruit is full of seeds found and has an astringent taste. These banana species are not consumed by humans; however, among the animals that have been recorded to feed on wild species of bananas are groups of primates, deer, birds, squirrels, pigs, bats, and elephants. While most animals feed mainly on the fruits, elephants on the other hand also like to eat banana stems.

Family Arecaceae

Arecaceae is a family of perennial flowering plants (plants that live more than two years) in the order Arecales. Plants in this family are better known as palms and have growth characteristics as climbers, shrubs, and large stemless plants. The plants that are widely eaten under this family are from the rattan species. Among the wildlife that make the Arecaceae a source of food are elephants, birds, small mammals, tapirs, squirrels, bats, and insects.

DICOTYLEDONOUS PLANTS

Dicotyledonous plants have two cotyledons, veined leaves, a taproot system, and hard and woody stem. Most fruit trees in Malaysia fall under the dicotyledonous group. For the fruiting trees, they are categorised into main fruit trees and rare fruit trees (Rukayah, 2001). This grouping is made based on the cultivation status, potential use, and popularity of the trees. The main fruit trees are trees that have commercial value and are widely grown in our country. Among the fruits that are widely commercialised are durian, rambutan, *langsat*, mangosteen, and mango. However, the group of dicotyledonous plants that are widely eaten by wildlife are rare trees which can be found in our tropical rainforest.

Rare trees

Rare trees are defined as trees that are rarely found in urban landscape and rarely commercialised. Usually, these trees grow naturally in forest areas or are planted in villages as ornamental plants, for personal use, or even as a side income generation. There are more than 140 types of rare trees that can be found in Malaysia, including Canistel (*Pouteria campechiana*) (**Figure 2.1**), *Asam Gelugor* (*Garcinia atroviridis*) (**Figure 2.2**), Rambai (*Baccaurea motleyana*) (**Figure 2.3**), and Terengganu Cherry (*Lepisanthes alata*) (**Figure 2.4**). Rare fruit trees are one of the important food sources for wildlife, given their distribution and habitat in the forest (**Table 2.2**). Most rare trees produce fruits; however, not all of them are edible as they might contain toxins that can cause intoxication, dizziness, or even death. Due to this factor as well as the lack of scientific research, most of the rare tree species are often overlooked and this can lead to their extinction, if no appropriate attention is given.

Rare trees are present in several vegetative forms such as shrubs, epiphytes, root trees, and strangler trees. Among all rare fruit trees, some grow all year round while some species are seasonal and produce low quality of fruit, sensitive to microclimate changes, and take a long time to bear fruit. Furthermore, some species have strong and unpleasant odour, aroma, and pungency.

Figure 2.1: Canistel (*Pouteria campechiana*)

Figure 2.2: Asam Gelugor (*Garcinia atroviridis*)

Figure 2.3: Rambai (*Baccaurea motleyana*)

Figure 2.4: Terengganu Cherry (*Lepisanthes alata*)

Table 2.2 List of rare and wild trees in Malaysia and the plant-eating wildlife that feed on them

No.	Family	Scientific Name	Local Name	Common Name	Wildlife
1	**ACHARIACEAE**	*Pangium edule*	Kepayang	Rowal Fruit/Sis Nut	Primates
2	**ANACARDIACEAE**	*Anacardium occidentale*	Gajus	Cashew	Bird
3		*Bouea macrophylla*	Kundang Daun Besar	Gandaria/Plum Mango	Primates, squirrel
4		*Bouea oppositifolia*	Remia	Plum Mango/ Marian Plum/ Rumenia	Bird, squirrel
5		*Bouea microphylla*	Kundang Daun Kecil/ Rumenia	Gandaria/Plum Mango	Primates
6		*Buchanania arborescens*	Otak Udang	Sparow's mango	Primates, lemur
7		*Buchanania sessilifolia*	Otak Udang Daun Tajam		Primates
8		*Mangifera caesia*	Binjai	Mango	Primates
9		*Mangifera foetida*	Macang/Bacang	Horse Mango/Gray Mango/Indian Mango	Primates, gaur
10		*Mangifera griffithii*	Rawa	Rawa	Primates, squirrel, bird
11		*Mangifera indica*	Mempelam Telor/Padi	Mango	Primates
12		*Mangifera lagenifera*	Lanjut/Machang	Common Mango	Bat, primates, squirrel, bird
13		*Mangifera odorata*	Kuini	Kuwini/Saipan Mango	Primates, elephant
14		*Mangifera pajang*	Bambangan	Bambangan	Bat, primates, squirrel, bird
15		*Mangifera pentandra*	Pauh	Pauh	Primates
16		*Mangifera quadrifida*	Asam Kumbang	Asam Kumbang	Primates, squirrel, bird
17		*Spondias cytherea*	Kedondong	Golden Apple/ Ambarella	Tapir, squirrel, primates

No.	Family	Scientific Name	Local Name	Common Name	Wildlife
18	ANNONACEAE	*Alphonsea elliptica*	Mempisang	Mempisang	Tapir, primates, bird, bat, squirrel
19		*Annona muricata*	Durian Belanda	Soursop	Insect, squirrel
20		*Annona reticulata*	Nona	Custard Apple	Insect, squirrel
21		*Annona squamosa*	Nona Sri Kaya	Sugar Apple/ Sweetsop/Custard Apple	Bat, bird
22		*Polyalthia beccarii*	Larak/Mempisang	Larak	Bird
23	BURSERACEAE	*Canarium odontophyllum*	Dabai/Kedondong	Sarawak Olive	Primates
24	CLUSIACEAE	*Scutinanthe brunnea*	Kedondong Sengkuang	Kedondong Sengkuang	Primates, bat, bird, insect
25		*Calophyllum soulattri*	Bitangor	Bitangor Bunut/ Malang-Malang/ Nicobar Canoetree	Primates
26		*Garcinia atroviridis*	Asam Gelugor	Garcinia	Primates, elephant, squirrel, insect
27		*Garcinia dulcis*	Mundu	Yellow Mangosteen	Elephant, primates
28		*Garcinia hombroniana*	Beruas	Seashore Mangosteen	Elephant, primates, squirrel
29		*Garcinia mangostana*	Manggis	Mangosteen	Elephant, primates
30		*Garcinia griffithii*	Kandis/Kandis Gajah	Apple-Kandis	Elephant, primates
31		*Garcinia nervosa*	Manggis Beruang	Pear Mangosteen	Porcupine
32		*Garcinia prainiana*	Kecupu/Mencupu/ Cerapu	Button Mangosteen	Primates, squirrel
33		*Garcinia parvifolia*	Kandis/Kundong	Brunei Cherry/ Wild Yellow Kandis/Kandis/ Assam Kandis	Primates, elephant
34	DIOSCOREACEAE	*Dioscorea alata*	Ubi Badak	Water Yam	Boar, Sambar deer
35	EBENACEAE	*Diospyros discolor*	Buah Mentega	Butter Fruit/Velvet Persimmon/Velvet Apple	Primates
36		*Diospyros malabarica*	Bisbul/Epal Baldu	Malabar Ebony	Primates

No.	Family	Scientific Name	Local Name	Common Name	Wildlife
37	EUPHORBIACEAE	*Elateriospermum tapos*	Perah	Pogoh Nut	Primates, squirrel
38		*Macaranga hypoleuca*	Mahang	Mahang Putih	Tapir, bird, gaur
39		*Sapium baccatum*	Ludai	Ludai	Deer, mouse deer, lesser mouse deer
40	SALICACEAE	*Flacourtia inermis*	Rukam Masam	Plum Of Martinique/ Thornless Rukam	Bird
41		*Flacourtia rukam*	Rukam	Rukam	Bird
42	GNETACEAE	*Gnetum gnemon*	Melinjau/Belinjau	Gnemon Tree/ Spanish Joint Fir	Squirrel
43	LEGUMINOSAE/ FABACEAE	*Archidendron bubalinum*	Kerdas	Kerdas	Primates, squirrel, insect
44		*Bauhinia strychnoidea*			Bat
45		*Cynometra cauliflora*	Katak Puru	Nam Nam	Bird, insect
46		*Dialium indum*	Keranji	Velvet Tamarind	Primates
47		*Dialium platysepalum*	Keranji Kuning Besar		Primates
48		*Parkia speciosa*	Petai	Bead Bean/ Malayan Stink Bean	Bat, primates, squirrel, bird, elephant, insect
49		*Pithecellobium jiringa*	Jering	Jering	Bat, primates, squirrel, bird, elephant, insect
50		*Tamarindus indica*	Asam Jawa	Tamarind	Elephant, bird
51		*Saraca thaipingensis*	Gapis/Golak/Saraca Kuning/Bunga Asoka	Yellow Saraca	Primates
52	LECYTHIDACEAE	*Barringtonia acutangula*	Putat/Gajah Beranak	Indian Putat/ Freshwater Mangrove/Red Barringtonia/ Stream Barringtonia/ Indian Oak/Itchy Tree/Wild Almond	Elephant
53		*Barringtonia racemosa*	Putat	Cassowary-pine/ China-pine/ Brackwater Mangrove/Powder-puff Tree	Elephant, bat, primates

No.	Family	Scientific Name	Local Name	Common Name	Wildlife
54		*Antidesma bunius*	Berunai	Chinese Laurel/ Currantwood	Primates, squirrel, bird
55		*Aporosa prainiana*	Sebasah	King ex Gage	Tapir
56		*Baccaurea motleyana*	Rambai	Common Rambai	Primates, squirrel, bird, lemur
57		*Baccaurea parviflora*	Setambun	Wild Rambai	Primates, tapir
58	**PHYLLANTHACEAE**	*Baccaurea polyneura*	Jentik-Jentik	Jentik-Jentik	Bird, primates
59		*Baccaurea ramiflora*	Anggur Burma	Burmese Grape	Bird, squirrel, primates
60		*Baccaurea reticulata*	Tampoi	Tampoi	Primates, tapir
61		*Phyllanthus acidus*	Cermai	Star Gooseberry/ Gooseberry Tree/ Malay Gooseberry	Bird
62		*Phyllanthus emblica*	Buah Melaka	Indian Gooseberry/ Amla	Bird
63	**MALPIGHIACEAE**	*Malpighia glabra*	Barbados Cherry	Acerola/Barbados Cherry/Wild Crape Myrtle/Manzanita	Bat, primates, squirrel, bird
64	**MALVACEAE**	*Durio zibethinus*	Durian	Durian	Primates, squirrel, fox, bird, tiger, bat
65		*Sterculia foetida*	Kelumpang	Bastard Poon Tree/ Java Olive Tree/ Hazel Sterculia// Wild Almond Tree/ Skunk Tree	Bird
66	**MELIACEAE**	*Aglaia korthalsii*	Keriat/Sekiat	Keriat/Sekiat	Squirrel, bird
67		*Chisocheton macrophyllus*	Bekak		Primates
68		*Lansium domesticum*	Langsat	Langsat	Bird, primates
69		*Lansium parasiticum*	Duku	Langsat/Lanzones/ Longkong	Bird, primates
70		*Sandoricum koetjape*	Sentul	Kechapi/Sentol/ Red Santol/Wild Mangosteen	Bird, primates, elephants
71	**MORACEAE**	*Artocarpus communis*	Sukun	Breadfruit	Primates, slow loris, tapir

No.	Family	Scientific Name	Local Name	Common Name	Wildlife
72	MORACEAE	*Artocarpus odoratissimus*	Terap	Marang/Green Pedalai/Johey Oak	Tapir, gaur, primates
73		*Artocarpus rigidus*	Temponek	Monkey Jackfruit	Primates
74		*Artocarpus heterophyllus*	Nangka	Jackfruit	Bat
75		*Ficus aurantiacea*	Ara	Roxburgh Fig	Bird, tapir
76		*Ficus auriculata*	Ara	Climbing Fig	Bird
77		*Ficus benjamina*	Beringin	Weeping Fig/ Benjamin Fig	Bird, tapir
78		*Ficus cucurbitina*	Ara	Ara	Bird
79		*Ficus deltoidea*	Mas Cotek	Mistletoe Fig	Bird, primates, squirrel
80		*Ficus dubia*	Bayas	Bayas	Bird
81		*Ficus fistulosa*	Ara Serapat	Common Yellow Stem-Fig	Bat, bird
82		*Ficus francisci*	Ara	Ara	Bird
83		*Ficus globosa*	Ara Paya	Ara Paya	Bird
84		*Ficus hispida*	Ara Senial	Ara Senial	Squirrel
85		*Ficus microcarpa*	Jejawi	Chinese Banyan/ Malayan Banyan/ Indian Laurel/ Curtain Fig	Bird, primates, tapir
86		*Ficus racemosa*	Ara Gugup	Cluster Fig/Red River Fig/Gular	Bird
87		*Ficus scortechinii*	Ara Melukut	Ara Melukut	Tapir, bird
88		*Ficus sinuata*	Ara	Ara	Bird
89		*Ficus superba*	Ara	Sea Fig	Primates

No.	Family	Scientific Name	Local Name	Common Name	Wildlife
90	**MORACEAE**	*Ficus tinctoria*	Ara Bonggol	Dye Fig/Humped Fig	Bird, primates, tapir
91		*Ficus variegata*	Ara Kelepong	Common Red Stem Fig	Primates
92	**MYRISTICACEAE**	*Myristica fragrans*	Buah Pala	Nutmeg	Porcupine, bird, squirrel
93	**MYRTACEAE**	*Eugenia uniflora*	Cermai Belanda	Surinam Cherry/ Red Brazil Cherry	Bird
94		*Rhodomyrtus tomentosa*	Kemunting	Rose Myrtle	Bird
95		*Syzygium aqueum*	Jambu Air	Watery Rose Apple/ Water Apple/Bell Fruit	Insect, bird, primates, squirrel
96		*Syzygium cinereum*	Keriang	Keriang	Bird
97		*Syzygium cumini*	Keriang Dot	Jambolan/Java Plum	Bird, squirrel
98		*Syzygium densiflorum*	Jambu Mawar	Jambu Mawar	Bird, squirrel
99		*Syzygium gratum*	Gelam Tikus	Eugenia	Squirrel, mouse-deer
100		*Syzygium jambos*	Jambu Mawar	Rose Apple	Bird
101		*Syzygium malaccense*	Jambu Bol	Malay Apple/ Malaysian Apple/ Mountain Apple	Bird, primates
102		*Syzygium polyanthum*	Salam	Indian Bay Leaf/ Indonesian Bay Leaf	Bird
103		*Syzygium pycnanthum*	Kelat	Wild Rose Apple	Tapir, bird, primates
104		*Syzygium samarangense*	Jambu Mawar	Wax Apple/Java Apple/Semarang Rose-Apple/Wax Jambu	Bat, bird, primates, squirrel
105	**OPILIACEAE**	*Champereia griffithii*	Cemperai	False Olive	Bird

No.	Family	Scientific Name	Local Name	Common Name	Wildlife
106	**OXALIDACEAE**	*Averrhoa bilimbi*	Belimbing Buluh	Bilimbi/Cucumber Tree	Bird, insect
107		*Sarcotheca griffithii*	Pupoi	Pupoi	Primates
108	**PRIMULACEAE**	*Ardisia crispa*	Mata Ayam	Coral Berry	Bird
109		*Ardisia elliptica*	Mempenai/Lutus/ Periah	Shoebutton Ardisia/Duck's Eye/Coralberry	Squirrel
110	**PUNICACEAE**	*Punica granatum*	Buah Delima	Pomegranate	Squirrel
111	**RUBIACEAE**	*Morinda citrifolia*	Noni/Mengkudu	Indian Mulberry/ Great Morinda/ Cheesefruit	Elephant, bird, primates
112	**RUTACEAE**	*Citrus aurantifolia*	Limau Nipis	Key Lime	Insect
113		*Citrus grandis*	Limau Bali	Pomelo/Shaddock/ Pummelo	Bird
114		*Citrus microcarpa*	Limau Kasturi	Calamondin/ Calamansi/Musk Lime/Panama Orange/Golden Orange/China Orange	Bird
115	**SAPINDACEAE**	*Arytera littoralis*	Bidara Emping	Bidara Emping	Bird
116		*Dimocarpus longan*	Mata Kucing	Longan	Bat, squirrel, bird, primates
117		*Lepisanthes alata*	Ceri Terengganu	Chinese Averrhoa/ Malaysian Lepisanthes/ Terengganu Cherry	Bat, squirrel, bird, primates
118		*Lepisanthes fruticosa*	Setenggek	Chammaliang/ Cherry	Bat, squirrel, bird, primates, elephant
119		*Lepisanthes rubiginosa*	Mertajam/Kelat Layu	Mertajam/Kelat Kayu	Tapir
120		*Litchi chinensis*	Laici	Lychee	Bat, primates, squirrel
121		*Nephelium cuspidatum*	Lotong	Lotong	Primates, squirrel, insect

No.	Family	Scientific Name	Local Name	Common Name	Wildlife
122	**SAPINDACEAE**	*Pometia pinnata*	Kasai/Lansir	Matoa/Taun Tree/ Island Lychee/ Tava/Pacific Lychee	Squirrel, primates, bird
123		*Xerospermum noronhianum*	Gigi Buntal/Kikir Buntal/Rambutan Pacat		Tapir
124	**SAPOTACEAE**	*Chrysophyllum cainito*	Kameto	Star Apple/Achras Cainito/Cainito/ Caimito	Bird, bat
125		*Manilkara kauki*	Sawah	Caqui	Primates, bird
126		*Manilkara zapota*	Ciku	Sapodilla/ Naseberry/Sapota/ Chikoo/Chico/ Nispero	Primates
127		*Mimusops elengi*	Mengkula/Bunga Tanjung	Spanish Cherry/ Medlar/Bullet Wood	Bat, bird
128		*Pouteria campechiana*	Kuning Telor	Eggfruit Tree/ Canistel/Amarillo/ Telor/Sapote Borracho/Zapote	Primates, squirrel
129	**THYMELAEACEAE**	*Phaleria macrocarpa*	Mahkota Dewa	God's Crown Fruit	Squirrel

Status of rare tree conservation in Malaysia

Rare fruit trees are still considered as wild plants. While some have already undergone partial domestication, generally they are still under-exploited for commercial purposes. The biological status of most rare fruit species is still unclear: some of the species have been officially documented, while some have yet to be documented. As such, most of these rare species are less known in the commercial market, and eventually they are forgotten. If no conservation measures are taken, these species will continue to be overlooked before becoming extinct forever. The rare fruit species are a component of the floral biodiversity for this country. In addition to serving as a food source to various wildlife, they also serve to maintain the balance of the tropical rainforest ecosystem as a water catchment area and as a stabiliser of the earth's surface temperature.

Therefore, several research centres have taken the initiative to conserve rare trees as well as carry out natural forest re-enrichment projects. Among the agencies responsible for this conservation project include Department of Wildlife and National Parks (DWNP), Malaysian Agricultural Research and Development Institute (MARDI), Forestry Department, Forest Research Institute Malaysia (FRIM), Putrajaya Botanical Garden, Malaysian Agricultural Park, Shah Alam National

Botanical Garden, Sebiew River Agricultural Park, Bintulu, Tenom Agriculture Department, Sabah, Central Terengganu Development Authority (Ketengah), Sultan Ahmad Shah Environmental Trust (SASET), Borneo Rhino Alliance (BORA), One Stop Borneo, and various others. Many rare trees have been replanted, especially in the recreational areas of ecotourism to preserve the wealth of these trees apart from serving a role as research centres. For instance, among the rare trees found in the Putrajaya Botanical Garden are *tampoi*, starfruit, *keriang* tree, velvet apple, Chinese apple, *mempisang*, Indian putat, and rukam.

Challenges of rare tree conservation

There are several issues and challenges faced in conserving the species diversity of rare trees. The main challenge is that some rare fruit seedlings are very difficult to find due to the limited number of suppliers. This is due to the supply of seeds that is difficult to obtain from its native habitat; moreover, most of the species are seasonal. In addition, these species have a long dormancy period in addition to having recalcitrant seeds that contain high water content, making them difficult to be stored.

For growers of rare fruit trees, among the issues faced is the attack of pests such as termites, mealybugs, beetles, mites, and borer caterpillars. As for young trees, they are often at risk to be damaged by crop enemies such as pigs, primates, and squirrels. In addition, the fruits are also often attacked by pests such as mealybugs, flies, beetles, thrips, mites, and aphids that affect the fruit quality, causing losses to farmers. In addition, serious attacks of crop enemies during the fruit season by animals such as pigs, monkeys, and squirrels have affected farmers' incomes especially for rare fruits that are in high demand during the season such as kwini, *bacang*, and *binjai*.

Some rare trees have a significant height of up to 40 m especially for trees that have aged like *bacang*, *binjai*, kwini, *rambai*, *tampoi*, *jentik-jentik*, and tapos. This complicates the maintenance and care processes for the trees, consequently making harvesting difficult. The maintenance and harvesting costs for large trees are also quite high and not profitable for farmers. For the same reason, some species of rare fruit trees are not suitable to be planted in the home compound.

Photo: Mealybugs (*Planococcus)*

FOOD SELECTION BY WILDLIFE

Parts of plants eaten by wildlife

Wildlife feeding choices vary according to the group. Some animals have a general dietary range and do not focus on specific parts of the tree. The parts of a tree that are often eaten by wildlife are the roots, shoots, fruits, leaves, flowers, and stems.

Tapirs are a group of generalists in which they do not have a specific diet. Tapirs usually eat leaves, shoots, and twigs but rarely chew bark. Tapirs are grazers where their diet usually consists of saplings, and it is estimated that they eat more than 200 species of trees. For trees with a height up to 1.5 m, the tapir will eat the shoots of the tree as they are, while for trees with a height up to 2.3 m, the tapir will bite and graze the tree branch to reach higher shoots. For higher shoots up to 5.5 m, the tapir will break the main stem by biting and bending the tree. Lastly, for trees with a height reaching 8.3 m, the tapir will push the tree to the ground before savouring the shoots (Simpson et al., 2013).

The diet of the primate group includes more than 410 plant species, of which 222 are from timbers (Yaakob and Chua, 2002). Long-tailed macaques and langur species favour shoots, flowers, seeds, and fruits. The black-furred gibbon species, on the other hand, prefers to eat shoots while lar gibbon and agile gibbon prefer fruits compared to other parts. The ungulates usually eat fruits, shoots, and leaves of flowering plants.

The bat species are frugivores, and rare fruits are their main food. In addition, they also eat flowers and leaves. Among the rare trees eaten by bats are *mempisang*, *kedondong*, velvet apple, and many more (**Table 2.2**). As for gaur, the parts of flowering plants that they mostly eat are shoots, herbs/shrubs, grass, and bark. Meanwhile, squirrels usually eat fruits, leaves, seeds, and stems and sometimes flowers as part of their diet. Elephants are more general in their food selection. One of the main diets of elephants in Peninsular Malaysia is palm. Among their main foods are roots, leaves, and fruits such as forest bananas, watermelons, and papayas. In fact, elephants also prefer non-woody stems such as banana stems and sugarcane.

Factors influencing food selection by wildlife

Among the factors influencing food selection by wildlife are forest type, forest strata, fruit size, and fruit type. Forest type influences wildlife food choices. For primary forests, most of the trees are tall, hardwood trees. For forests that have been explored, they become secondary forests through the succession process. Succession is the gradual and sequential replacement of

one species by another. For grazers like tapirs, deer, and gaur, they prefer plants from secondary forests due to their tendency to choose young shoots as their diet.

Forest strata also influence wildlife food choices. The forest is divided into several strata, namely the forest floor, understory, canopy, and emergent layer. Large mammals such as tapirs, elephants, deer, and gaur prefer to eat shoots, fallen ripe fruit, or tree trunks that are less than 8 m tall on the forest floor. There are also species of birds that inhabit this layer like pheasants, pigeons, nightingales, and flowerpeckers. Among the animals that inhabit understorey layer are squirrels, langurs, orangutans, bats, and birds like starlings, parrots, common koel, green birds, and woodpeckers. These types of animals prefer to eat shoots and fruits as the tree branches in this layer are strong and sturdy.

Photo: Malabar Plum (*Syzygium cumini)*

Birds, civets, bats, flying squirrels, binturong, slow loris, and primates such as long-tailed macaques, gibbons, and langurs are among the animals inhabiting canopy layer of the forest. They usually feed on fruits on tall trees such as figs, binjai, jejawi, and banyan. As for the emergent layer, animals that inhabit this layer are hornbills, barbets, orioles, warbler, magpie, finch, or babbler which feed mainly on fruits. Typically, primates and birds that inhabit this layer spend more time resting and engaging in social interactions to avoid enemy and predator threats.

The size of fruit may also attract different group of frugivores. Generally, small fruits are eaten by small birds (nightingales, pigeons) and squirrels, while large fruits are eaten by hornbills, civets, binturong, gibbons, bats, orangutans, and long-tailed macaques. Fallen ripe fruits such as durian and mangosteen are usually eaten by those inhabiting the forest floor such as porcupines, pheasants, pigs, deer, mouse-deer, and tapirs while fruits that remain on tree trunks such as rambai, langsat, jackfruit, and so on are eaten by the arboreal group, which is animals that live on trees or flying animals such as primates, squirrels, binturong and birds.

Among other factors that influence food selection by wildlife are fruit colour and fruit season. The colour of the fruit plays a role in attracting wildlife. Birds prefer brightly coloured fruits such as figs, rambutan, Terengganu cherries, and others. In addition, evergreen or non-seasonal rare fruit trees are eaten by various species of wildlife due to their availability all year round.

Importance of wildlife to flowering plants

The interaction between flowering plants and wildlife can be categorised as mutualism in which both parties benefit from the relationship. Flowering plants provide food supply and habitat to wildlife and in return, the wildlife plays a role as pollinators and seed dispersers. Pollination is the process by which pollen from a male flower that has a male gamete is transferred to a female flower that has a female gamete to be fertilised. This process is a must for species evolution and survival of flowering plants because it produces seeds and fruits. This pollination process is usually done by insect groups such as bees, wasps, flies, and beetles. In addition, there are other wildlife that acts as pollinating agents such as bats, rats, civets, spiders, and birds.

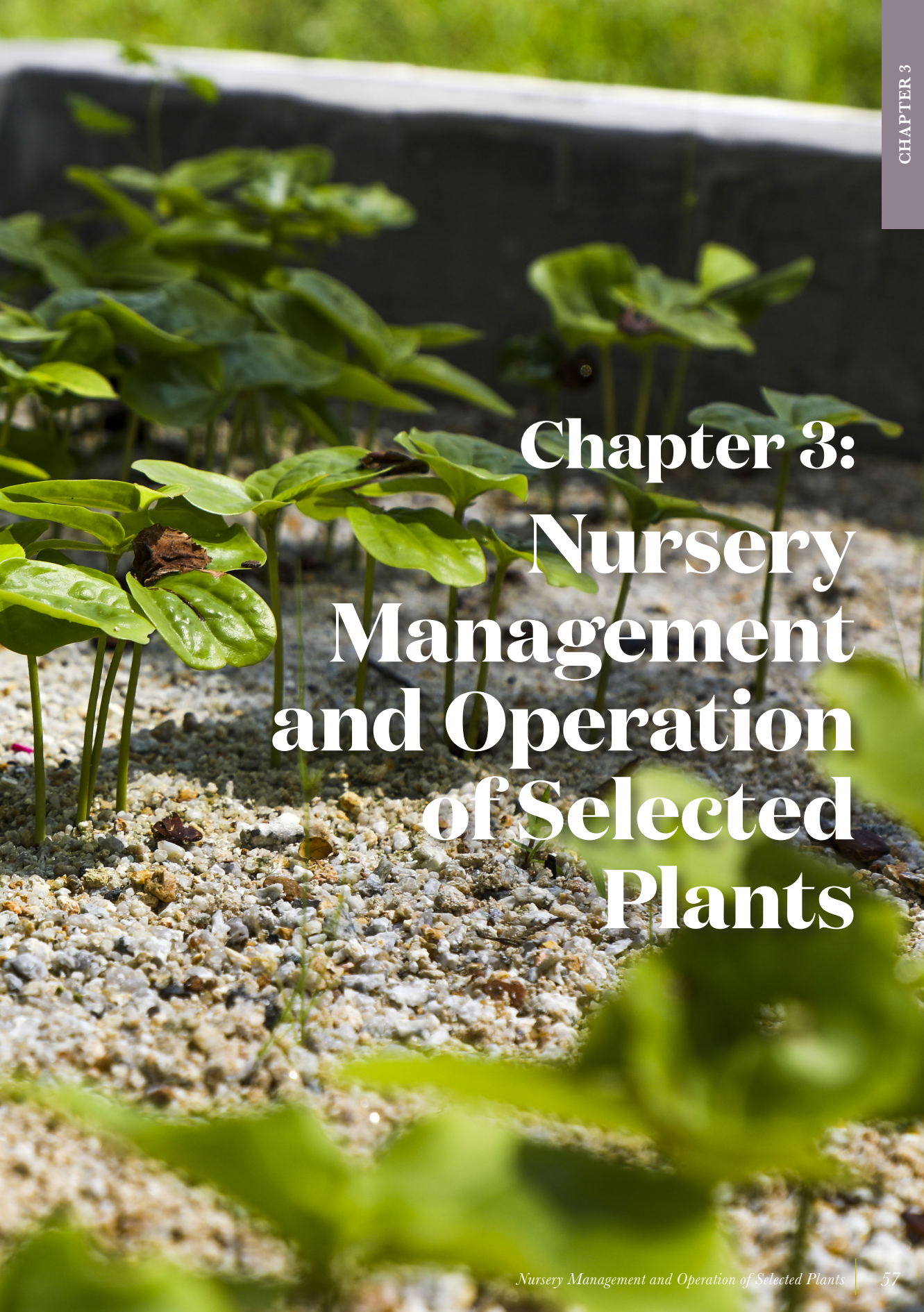
Ripe fruits are eaten by frugivores as a source of energy and subsequently, this group of frugivores acts as a seed dispersal agent. These seeds are spread through faeces and will then germinate and grow into new trees and form a forest landscape rich in flora and fauna. Among the animals that act as seed dispersal agents are bats, birds, tapirs, and gibbons.

Plants as keystone species

Keystone species are species that control the composition of communities in a habitat. The fig tree (*Ficus* spp.) is believed to act as a keystone species in tropical rainforests. *Ficus* maintains the population composition of vertebrate frugivores, which comprise a large portion of the total vertebrate biomass in tropical rainforests (**Figure 2.5**). It is estimated that at least 60 species of birds and 17 species of mammals eat figs in Peninsular Malaysia (Yaakob, 2005). *Ficus* spp. are widely distributed in Malaysia with 102 species have been identified (Turner, 1995), and may serve as the most important food source for frugivores in tropical rainforests especially in lowland areas. The production of figs which is mostly non-seasonal ensures a continuous food source for frugivores such as sun bears, bats, orangutans, squirrels, bearcats, birds, civets, and others.

Figure 2.5: Frugivores that eats figs (*Photo credit: Chun Xing Wong*)

Photo: Growing plants from seeds



Chapter 3: Nursery Management and Operation of Selected Plants

This chapter describes guidelines on nursery management and operation practices for some selected rare plants. Systematic nursery management is required to provide a supply of quality and best rare tree planting material for the development of new areas or replanting of rare trees in degraded forest areas to ensure the survival of wild animal species. Quality planting material will only be obtained from proper nursery management practices and methods that are in accordance with established procedures and have a neat and systematic planning. This includes the aspects of selection of suitable areas, complete infrastructure development, appropriate design, and most importantly, proper management methods of all aspects in the nursery.

ESTABLISHMENT OF NURSERIES

i. The main components of the nursery

a. Location

The recommended characteristics of the nursery are a flat area; proximity to clean water sources (Figure 3.1), roads, and electricity supply; and not being under the shade of large dense trees.

Figure 3.1: Clean water resources

b. Topography

A flat or slightly sloping area with a gradient not exceeding 3% is suitable as a nursery location because it facilitates an effective surface drainage process. Areas that have the potential and risk of flooding should be avoided. If the nursery is at a sloping area, terraced steps should be built according to the area size, and water supply should be ensured to reach the nursery area. Avoid choosing areas near bushes so as not to become breeding grounds for crop enemies and venomous animals, as well as avoiding the risk of pests and diseases.

c. Soil

The soil texture of the loamy sand type (**Figure 3.2**) with moderate water drainage is suitable for facilitating nursery activities. Soil testing can also be done by obtaining expert services from the Department of Agriculture to find out soil characteristics, acidity levels, nutrient content, soil fertility, and soil suitability for any type of crop. Area cleaning is also encouraged to avoid areas with gravels, large rocks, stumps, carcasses, lumps of clay, and others.

Figure 3.2: Sandy loam

d. Water

Clean water sources for nursery irrigation can be obtained from various means such as rivers, waterfalls, springs, lakes, and ponds that can be pumped into tanks (**Figure 3.3**), and sprinkler systems can be used.

Figure 3.3: The source of clean water pumped into tanks

e. Sources of electricity and telecommunications

A stable supply of electricity and telecommunication systems are required to generate the operation of equipment in the nursery such as sprinkler systems, water pump, storage stations, computers, and telephone lines. Telecommunication cables, signal strength, and receptions are crucial if the nursery's operations rely on remote/wireless controllers and sensors.

f. Nursery structure build

Nurseries should be built in a long (east–west) and wide (north–south) orientation so that the entire tree under this structure receives consistent sunlight throughout the day. The structure should be built on strong concrete pillars as bases and galvanised iron as the roof structure. The roof structure is based on plastic netting with a light transparency rate of 70% while the floor consists of crusher run rock or aggregate rock for soil ventilation and water drainage systems.

ii. Water management in nurseries

Nursery management activities involve works such as watering, fertilising, moisture control, and species naming. However, human resources and sapling management skills are often a problem. Thus, there is an important need for automated water management system to ensure the quality of rare seedlings sown (**Figure 3.4**). A proper irrigation system will keep the soil moist and prevent the saplings from drying out and dying.

Figure 3.4: Automatic water sprinkler for watering plant

Water management in nurseries involves two aspects, namely irrigation and drainage. Irrigation is required when the soil moisture level in each polybag drops to 50%. With a proper irrigation system, the soil moisture level can be raised back to 100% or the 'soil wet limit' while drainage is required to prevent the nursery from becoming waterlogged, which in turn would encourage the growth of disease vectors and pests.

Types of irrigation systems:

- Sprinkler irrigation system
- Drip irrigation system
- Surface irrigation system

a. Sprinkler irrigation systems are very suitable for nurseries that have plant material in tubes. Several factors need to be taken into account to design a sprinkler irrigation system, namely:

b. Area map: An area map provides information on the land area, perimeter of the nursery, and topographic conditions of the soil to determine the nursery position, sprinkler layout, and distance from water sources.

c. Water resources: The location, quantity, and quality of water as well as the chemical content that may be present in the water.

d. Weather/climate conditions: Information that needs to be known is daily temperature, air humidity, rainfall distribution, and wind direction.

e. Soil type: Information that needs to be known is soil series, soil structure and texture, soil water holding properties, and water infiltration rate by soil. This is to ensure that the nursery area does not become waterlogged.

f. Water pump power: The selection of the water pump is based on the nursery area, the position of the water source, engine power, water pump capacity as well as the type of power source to run the water pump. The selection of water pump power must take into account the position of the endmost sprinkler and the irrigation radius that covers all areas of the nursery.

Photo: Sprinkler irrigation system

iii. Fundamentals of nursery management

a. Fertiliser

- Organic fertiliser
- Chemical fertiliser
- A combination of chemical and organic fertilisers
- Complete & balanced nutrient content (varies according to the type of crop)

Figure 3.5: Chemical and organic fertilisers used in nurseries

b. Water source

- Continuous water supply (springs, rivers, ponds, domestic water supply)
- Clean– not contaminated (toxic/sediment/ iron suspension etc.)
- Clear
- Odourless
- Tap water supply from the Water Supply Department
- Mountain water (flowing)
- Lake water pH 6.5 – 7.5

c. Irrigation

<u>The nursery pipeline consists of:</u>

- Clean water source
- Tanks & injectors
- Pump & timer
- Filters

Figure 3.6: Electric pump used in nursery

<u>Pump & timer</u>

- 2.0 HP: watering up to 2500 bags
- 1.0 HP: watering up to 1000 bags
- 0.5 HP: watering up to 300 bags
- Timer: adjustable up to 5 minutes

d. Plant media

General features:

- Has 20%–40% air space
- Water holding rate 60%–80%
- Disease free
- Cheap
- Eco-friendly
- Ability to control nutrients, pH, and temperature
- Easily obtained

Figure 3.7: Layers of soil and sand are put into the concrete mixer evenly before being sent to storage

Figure 3.8: Filling the tube medium manually

e. Container for plants

Figure 3.9: Black polybags of various sizes

Figure 3.10: Root trainer tubes with various cell numbers

f. Seed

Figure 3.11: Plant material from seeds

Figure 3.12: Seedling nursery where the seeds are sown

SOWING AND PROPAGATION OF CROPS

Sources of plant material

Sources of plant material for rare fruits are obtained through several methods, namely:

a. Purchase of saplings in sales centres

The trees to be purchased are selected by assessing the health level of the tree, straight stems, and healthy leaves. The size is also necessary to be taken into account because of the high cost for large sized trees. In addition, the procedure of species naming also needs to be emphasised because there are often errors in species naming from commercial nurseries.

b. Propagation by seed from parent tree

Seeds from fruits that have matured or fallen during fieldwork, especially during the fruit season. The seeds will be packed well and brought back to the nursery for sowing and germination processes.

c. Transplanting seedlings obtained around the parent tree

Most seedlings of rare and wild fruit species can be obtained around the parent tree. During the fruit season, the fallen ripe fruit will germinate and grow abundantly around the canopy. These seedlings can be dug up and transferred into small plastic containers and taken to the nursery for sowing. During the transplant process, it is best to take precautionary measures to avoid damaging the main roots.

d. Stem cuttings

Stem cutting method should only be used as the last option if no seedlings or mature seeds are found. However, it should be noted that not all species are suitable for this method. Cuttings of stems, branches, or twigs are wrapped with wet tissues to retain the moisture of the cut and are taken back to the nursery. In the nursery, the stems are further cut to approximately 9 inches long and dipped in fungicide and root-promoting hormone (Seradix) before being planted in polybags containing soil mixtures.

Figure 3.13: Collecting wild saplings that germinate naturally under the parent tree

Figure 3.14: Small wild saplings of 3 – 5 cm were collected to get a high percentage of survival

Method of sowing

Seeds that have been collected during fieldwork will be sown after being brought back to the nursery with the following steps:

a. Seeds are sorted according to their respective species.

b. All seeds are cleaned by removing the wings, mucus and skin before being washed and dried.

c. Seeds of rare fruit trees are usually large in size, and therefore can be directly sown into polybags after being treated with fungicides. The planting media used is 3 parts soil:2 parts sand:1 part organic matter.

Maintenance of seedlings in the nursery

First Stage Nursery

a. Saplings from the sown seeds in the raised bed will be transferred to the polybag at the second stage nursery area after 4–6 leaves have sprouted or after 2 weeks.

b. Saplings from stem cuttings will be transferred to the second stage nursery after they start to grow roots and leaves.

c. Saplings dug from the ground are placed in polybags and transferred to the second stage nursery after growing new shoots and looking healthy.

d. Saplings are watered 2 times daily in the morning and evening.

Second Stage Nursery

a. Only healthy saplings are placed in the second stage nursery, while saplings that have symptoms of being attacked by pests and diseases should be removed so as not to infect other saplings.

b. After 12 months, healthy saplings will be transferred to the preparation area before being planted at selected forest habitats.

c. At the preparation area, the shading will be gradually reduced to 50% and 60% of the light intensity up to the date of planting.

d. Insecticides are only given if necessary.

e. The saplings can be placed at the nursery for up to 2 years. Long periods of time being kept in polybags can cause the roots of the seedlings to penetrate the polybag and eventually make their way into the soil.

f. Fertilisation: 1 teaspoon per polybag once every 2 weeks.

g. Watering: 2 times daily morning and evening.

Preparation of seedlings for planting

a. Make a selection of suitable places for planting in selected forest habitats.

b. Make the planting hole larger than the polybag size approximately 2×2×2 ft to make it easier for the tree roots to grow.

c. Mix root booster fertiliser (CIRP) with soil to be used for covering later.

d. Insert the sapling into the hole.

e. Cover the sapling with the soil prepared earlier to the soil level in the polybag.

f. Finally, water the soil to retain its moisture.

The following is a summary of sowing and propagation methods for some selected rare and wild plants as well as grass species that often become food choices for wildlife (**Table 3.1**). There are seventeen species that have been identified namely fig tree, *Ficus racemosa* (Moraceae); rambai, *Baccaurea motleyana* (Phyllanthaceae); *macang hutan*, *Mangifera foetida* (Anacardiaceae); Terengganu cherry, *Lepisanthes alata* (Sapindaceae); *asam gelugor*, *Garcinia atroviridis* (Clusiaceae); *kelat*, *Syzygium campanulatum*, *Syzygium polyanthum*, and *Syzygium pycnanthum* (Myrtaceae); durian, *Durio zibethinus* (Malvaceae); sentul, *Sandoricum koetjape* (Meliaceae); *mentega*, *Diospyros blancoi* (Ebenaceae); noni, *Morinda citrifolia* (Rubiaceae); ginger, *Zingiber* spp. (Zingiberaceae); kantan, *Etlingera* spp. (Zingiberaceae); and guinea grass, *Panicum maximum* (Poaceae); napier grass, *Pennisetum purpureum* (Poaceae); and ruzi grass, *Brachiaria ruziziensis* (Poaceae).

Table 3.1 Summary of planting and propagation methods for selected rare plant and grass species

No	Family/ Species	Local Names	Plant Material Sources	Sowing/Reproduction Methods	Preparation of Seedlings for Planting
1.	**MORACEAE** *Ficus racemosa*	Fig tree/ Tangkol (Ululublog, 2019)	- Seed - Stem cuttings - Air-layering method (water or compost)	- For seeds, as soon as the planted seeds germinate and produce leaves, they are transferred into polybags containing soil medium. - For stem cuttings, stems are cut to a thickness of 15–25 mm. The breeding success rate is estimated at 10%. - Sowing through air layering is the most effective method (can achieve 80% of reproductive yield) but involves handler expertise, while sowing through seed is the most cost-effective way to produce saplings in large quantities.	- Seed viability: 6 months if stored at room temperature and can reach more than two years if stored in the refrigerator. - Seed germination is at a rate of 11% if soaked first in hot water for 10 minutes. Meanwhile, untreated seeds had a germination rate of 5%. - Seedlings will germinate within 10 to 15 days if placed in moist conditions and under shades.
2.	**PHYLLANTHACEAE** *Baccaurea motleyana*	Rambai (Awang et al., 2014)	- The collected seeds are cleaned by removing the remnants of the attached contents.	- The seeds are sown in a sandy soil medium which produces a relatively high percentage of germination. - After 3 to 4 weeks, the first leaf will emerge and when 3 to 4 leaves have appeared, the seedlings will be transferred into a polybag measuring 6″×8″. - Seedlings are placed in the nursery with exposure to 50% – 70% light.	- Saplings are ready to be planted in the field when they are one year old (2 ft). - A month before transplanting, hardening of tree trunks is done by placing the seedlings in full sunlight. - Placed under sunlight for a month before planting to ensure the tree can adapt to relatively dry weather.
3.	**ANACARDIACEAE** *Mangifera foetida*	Macang hutan (Mohd Anim, 2011)	- Cultivation is through seeds.	- The recommended *macang* planting distance is 12×12 m or more. Planting holes are prepared and filled with basic fertilisers and organic fertilisers. - The use of *macang* seedlings that are grafted will produce trees that mature early and quickly bear fruit than trees planted from seeds. - Watering work is done regularly until the tree grows. - Fertilisation with organic fertilisers and chemical fertilisers at a ratio of nitrogen, phosphorus, potassium (NPK) 12:12:17:2 + trace elements (TE) when the tree is suitable for fruiting at a rate of 1.2–1.5 kg per tree for 3 applications.	-The planting of *macang* trees is by using seeds sown in polybags.

No	Family/ Species	Local Names	Plant Material Sources	Sowing/Reproduction Methods	Preparation of Seedlings for Planting
4.	**SAPINDACEAE** *Lepisanthes alata*	Perupok/ Terengganu cherry (Mustaffer et al., 2020)	-Seeds are sown in the nursery and will germinate after 5 to 7 days of sowing. After 3 weeks the seedlings can be transferred to polybags measuring 8 inches wide × 10 inches tall using three parts mixed soil, two parts sand, and two parts organic soil.	- The collected seeds are processed and separated according to three size classes namely small, medium, and large and evaluated for (i) the weight of 100 seeds, (ii) seed size in terms of length and thickness, (iii) germination percentage, (iv) seedling bud length, (v) stem diameter, and (vi) fitness index. - Seed sizes with higher germination are sown in nursery trays with peat soil medium, peat soil and sand mixture as well as peat cube technology under 50% sunlight in seedling nurseries. Survival rates are observed after 3 weeks of seedling transplantation. - Seedlings are placed in the nursery under 50% sunlight and watered twice a day. - Fertilisation of seedlings with 10 g of nitrogen, phosphorus, potassium (NPK) (15:15:15) fertiliser should be given to each sapling once a month.	- When the sapling reaches the age of three months, it can be planted in the garden or farm. - The use of peat cubes improves the root system and reduces the rate of root shock during sapling transplantation: seedlings are easier to handle during transplantation and reduces the risk of root damage.
5.	**CLUSIACEAE** *Garcinia atroviridis*	Asam gelugor (Harress, 2017)	-Planted using seedlings sown from ripe fruit seeds.	- Seeds are sown on nursery media after drying for a few days.	- The seeds will take about 3 to 4 weeks to germinate and mature, and are old enough to be transplanted into the soil of permanent plot after being kept in a nursery for at least 18 months with a planting distance of 9×9 m. - Holes as deep as 2 ft are dug and sprinkled with basic fertiliser before the saplings are transplanted.
6.	**MYRTACEAE** *Syzygium campanulatum*	Kelat (Mohd Anim, 2013; Hamdan et al., 2020; Tsan and Awang, 2021)	-Production is through stem cuttings, shoot grafting, air layering, and seedlings.	- This plant is easily grown using seedlings purchased from nursery operators. - Planting holes are prepared and mixed with basic fertilisers such as Muriate of Potash (MOP) and organic fertilisers. - Fertilisation of this plant requires nitrogen, phosphorus, potassium (NPK) fertilisers with a ratio of 15:15:15. - Watering and weeding activities after planting should be performed to obtain healthy and quality trees. - The tree is easy to grow and practically has no symptoms of pest attacks or serious diseases.	- Seed production requires mature seeds to produce quality trees. However, semi-ripe fruits in the 7th week have also been found suitable for seed acquisition. Therefore, fruit harvesting in the short period between the two phases of fruit development, namely the semi-ripening phase and the mature phase is very important.

No	Family/ Species	Local Names	Plant Material Sources	Sowing/Reproduction Methods	Preparation of Seedlings for Planting
7.	**MYRTACEAE** *Syzygium polyanthum*	*Kelat* (Sardjono, 2016)	-Planting through seedlings, stem cuttings, and air layering.	- *Kelat* trees mostly propagate naturally. - Seeds can survive in shady areas for a long time. - Seedlings must undergo hardening process in the nursery before planting. - The optimum planting distance in the field is 6×6 m. However, in forest areas, a distance of 2×3 m can be used due to the limited area size.	- Seeds of this species lose germination capability after 4 to 6 weeks. - Fresh seeds should be sown directly in a loose medium and under a shady area. They should not be planted too deep as it will reduce the germination percentage. - Germination occurs as early as 1 to 3 weeks after sowing and begins to bud between the fifth and twelfth week.
8.	**MYRTACEAE** *Syzygium pycnanthum*	*Kelat* (Mudiana, 2008)	- Cultivation by stem cuttings from parent trees and air layering. -The selected stem cuttings should be in ideal condition and uniform size.	- The recommended planting distance of *kelat* trees is between 2 and 3 m. Trees are able to grow with minimal care and require only watering and care in the early stages of planting. - Cultivation does not require special media and can be done on plant media such as soil, a mixture of compost and soil, as well as compost from dried leaves.	- Seeds are taken from mature and ripe fruit (the skin surface of the fruit is dark red-orange, and the flesh of the fruit is soft). Usually, mature and ripe fruit will fall from the parent tree and continue to germinate during the rainy season.
9.	**MALVACEAE** *Durio zibethinus*	Durian (Bidin, 2016)	- Breeding technique is by bud grafting or cleft grafting. - Breeding material is obtained from the source of the parent tree in which authenticity is confirmed.	- Propagation of durian seedlings can be done by using several types of grafting techniques such as i) bud grafting and ii) cleft grafting. The bud grafting technique is done by inserting a short scion that has intact bud points. This part of the scion will be cut short and then cut in half lengthwise in the longitudinal direction. This part will be matched with the root stock, where the cambium layer has been exposed by skinning. Parafilm will be used to wrap the junction of the scion and the tree. After a few weeks, these buds will burst and become the main stem of durian seedlings like its original parents. Cleft grafting technique is where the entire section will be grafted with the rootstock. Part of the rootstock stem will be cut and sliced to form a 'V' opening. The scion will be attached to the 'V' opening and wrapped with parafilm. -Durian can be grown using four systems, namely the equilateral triangle system, the rectangular system, the square system, and the quincunx system. -The advantage of the equilateral triangle system is that it can provide 15% more tree planting space compared to the square system while the rectangular system can provide space between rows for maintenance purposes or intercropping. The advantage of the quincunx system is that it can maximise land use because this system provides space for the planting of filler trees in the middle of the crop rows of the square system.	- All seedlings that will be transplanted to the farm must go through a hardening process to avoid shocks that may cause the seedlings to die or stunted tree growth. - This process will involve exposing the seedlings to full sunlight in stages or reducing the frequency of watering.

No	Family/ Species	Local Names	Plant Material Sources	Sowing/Reproduction Methods	Preparation of Seedlings for Planting
10.	**MELIACEAE** *Sandoricum koetjape*	Sentul (Orwa et al., 2009)	-Planting of sentul trees can be done with seeds, air layering, or cutting method.	-The easiest method is to sow good and healthy sentul seeds in polybags at nurseries. The sentul seeds has a germination rate of 90-95% in 16 to 31 days which they are then ready to be transplanted. - Ensure that the seeds used are free from pests and diseases, produce fresh green leaves and do not wither, have strong plant stems and shady plant branches.	- The planting distance is the same as durian trees, which is 10 and 12 m in between planting holes. Sentul trees grow quickly in fertile soil and will bear fruit within 5 to 7 years after planting.
11.	**EBENACEAE** *Diospyros blancoi*	Mentega (Mohd Anim, 2019)	-Using seeds and root shoots (takes 7 to 10 years to bear fruit). -To produce fruit quickly, the method of grafting is done which is to attach the branches of the ripe mentega fruit tree to the rootstock produced from the seeds. - Seeds can also be bought in stores and its characteristics is that it has a slice at the base of the branch or a V shape.	- Seeds are sown in polybags. - Purchased seeds are left for 1 to 2 weeks to adapt to the new environment.	- Planting mentega seedlings in the field or forest can be done after the seeds have adapted to the new habitat environment for 1 to 2 weeks.
12.	**RUBIACEAE** *Morinda citrifolia*	Mengkudu (Gawas, 2002; Ysuhaimi, 2017)	- Can be propagated through seeds or stem cuttings.	-**Seeds:** Seeds are washed and sown on a sand bed (approximately 1 cm deep) that is constantly moistened. Once four leaves have developed, the saplings are transferred into a perforated black polybag measuring 15×22.5 cm that contains nursery soil. -**Stem cuttings:** Seedlings from stem cuttings can be transferred into a polybag containing nursery soil after the stem cuttings are 2 weeks old with the shoots measuring approximately 5 to 7 cm.	- Field planting takes place after the plants have reached 6–7 leaf stages, which takes roughly seven months from the time they were transferred into polybags.

No	Family/ Species	Local Names	Plant Material Sources	Sowing/Reproduction Methods	Preparation of Seedlings for Planting
13.	**ZINGIBERACEAE** *Zingiber* spp.	Ginger (Yasser and Mohamad, 2016)	**Selection of ginger varieties** - The good characteristics of ginger are large rhizome and pale yellow colour. **Preparation of ginger seeds** -Ginger seeds are produced from mature ginger rhizomes that are 9 to 10 months old. Selected mature ginger will be separated and cut to a size of 7 to 11 cm long with 2 to 3 bud points on each cut so that the ginger seeds germinate quickly. -Seed rhizomes are then treated with fungicide such as Previcur N by soaking for 3 to 5 minutes before sowing.	- Ginger seed rhizomes can be planted in two ways, namely sown in nursery containers or sown in polybags. - Nursery containers (5×1 m) are filled with coco peat and seeds are sown at a distance of half a foot from each other. After 21 days, the sown ginger seedlings can be transferred into polybags. - Rain protection structure and fertigation irrigation system should be provided before the planting process begins. **Selecting a medium and preparing a polybag** - The recommended planting medium is 100% coco peat. Coco peat is put in a black polybag measuring 24″ wide × 16″ high with no holes. A total of 3 to 4 holes to drain excess water are made 2″ from the base of the polybag on the left and right sides. - Coco peat is wetted and drained before being put in a polybag. Polybags are arranged closely left and right of the divider pipe. Each polybag is equipped with a 1.0 mm (diameter) microtube that channels nutrients from the fertiliser solution tank.	**Transplanting ginger seedlings** - Before planting, the planting medium in the polybag is rinsed by running clean water using a prepared fertigation irrigation system for 2 hours every day until the excess clear water comes out from the polybag. - Ginger seedlings from rooted nursery containers (21 days sown), are transferred into polybags. After the process of transplanting ginger seedlings is completed, fertiliser-free irrigation is given twice a day, for 4 minutes each time for 2 days. The fertiliser solution will be channelled to the crop bags from the third day after planting.

No	Family/ Species	Local Names	Plant Material Sources	Sowing/Reproduction Methods	Preparation of Seedlings for Planting
14.	**ZINGIBERACEAE** *Etlingera* spp.	Kantan	-Kantan trees can be planted using rhizomes or seeds. However, the cultivation of kantan using seeds is not recommended except for breeding purposes because the growth is relatively slow and takes too long to produce results, which is about two years. -Cultivation using rhizomes can produce results faster than using seeds.	- Rhizomes can be obtained from mature kantan trees that reach a height of about 15 to 20 ft and have produced flowers. Taking rhizomes from immature trees is not recommended because the growth of the tree is not encouraging. - Rhizomes that have been pruned can be planted in moist peat soil. Swampy, sandy soils and clay types of soil are not suitable for planting kantan trees. - Newly planted rhizomes should be watered once a day to ensure that the tree receives enough water to produce new saplings.	- Kantan rhizomes with shoots are extracted from the crown. The rhizomes are cut, and each cut should preferably have 2–3 bud points and fibrous roots to encourage growth. - Planted rhizomes will produce new offspring after 2 to 3 weeks. - For the 4th week period, watering can be reduced as the tree is more stable depending on weather conditions. NPK fertilisation with high nitrogen (N) content can be given to promote tree growth and maintain the chlorophyll content in the leaves. - The mature rhizome should be cut to reduce the nutrient capacity so that more nutrients can be channelled to the seedlings. - Within 4 to 6 months, kantan trees will produce more saplings. - Within 1 year, the kantan tree can reach a height of between 8 to 10 ft. The use of NPK fertilisers with high phosphorus (P) content is very important at this time to promote tree and root growth. - Within 2 years, the kantan tree can reach a height of up to 16 to 20 ft and begin to produce its flowers. NPK fertilisation with high potassium (K) content is recommended to promote flower production.
15.	**POACEAE** *Panicum maximum*	Guinea grass/ horse grass (Jabatan Perkhidmatan Veterinar Negeri Pulau Pinang, 2007; Jabatan Perkhidmatan Haiwan Dan Perusahaan Ternak Sabah, 2007)	- Planting through seeds and vegetative parts such as slip cuttings where the grass clumps are split up and trimmed.	- Seeds are sown at a rate of 2 to 3 kg/ha. The seeds planted should not exceed a depth of 1 cm. Rolling the soil after seeding can help germination and growth of seeds. - Planting through stem cuttings is planted at contours every 0.5 to 0.6 m in a row between 1.25 to 1.5 m, or almost 40 cm in a triangular pattern for faster production. - For less fertile soils, fertilisation should be done using 20–40 kg/ha P, and about 50 kg/ha N if harvesting is limited during planting. Maintenance fertilisation is required especially in cut and haul systems. N deficiency can cause crops to be unable to compete with other species. The maintenance requirement is 200–400 kg N/ha/ year is required to increase fertility and production on less fertile soils. - Soils with a pH less than 5 need lime to increase the pH to 5.5–6.	- Selected seeds must be fresh and tested before planting because some seeds have genotypes that can reach the maximum level of seeding up to 18 months after harvest, while other seeds only require a few months.

No	Family/ Species	Local Names	Plant Material Sources	Sowing/Reproduction Methods	Preparation of Seedlings for Planting
16.	**POACEAE** *Pennisetum purpureum*	Napier grass/ elephant grass (Mohd Anim, 2017; Mustaffer, 2019)	- Through stem cuttings (stem cuttings are cut at approximately 3–4 segments).	There are 3 types of cultivation techniques, namely: i) Cane style where canes are laid in rows and covered with soil ii) Cutting style where the cuttings are placed at 45° inside the planting holes. iii) Slip cutting method - Grass is planted at a distance of 100 cm between rows and 60 cm in rows for vegetative and clump techniques. - Seed cuttings will be watered and allowed to grow for a period of 90 days or three months before the first harvest to allow the roots to grow well before being harvested manually. -Fertilisation is done using NPK 15:15:15 fertiliser at a rate of 150 kg/ha (at a grass age of four weeks or a month) and urea fertiliser at a rate of 75 kg/ha (at a grass age of eight weeks or two months). Organic manure (animal manure) can also be used.	- The grass is chosen from the mature stem section and cut into 20–25 cm long to be planted for seedling. - Seedlings should be in good condition, still fresh, and have the size of 2–3 segments or at least 2 buds. - Land is ploughed for planting and drainage system preparation. If there is no irrigation system, planting during the rainy season will suffice to accelerate growth.
17.	**POACEAE** *Brachiaria ruziziensis*	Ruzi grass (Schultze-Kraft and Teitzel, 2016)	-Through seeds and stem cuttings	- Seeds are sown at a rate of 2.5–10 kg/ha depending on the quality of the seeds and should be sown between 1.5–2.5 cm in the soil. To obtain a high germination percentage, ruzi grass needs fertile soil containing a mixture of nitrogen, phosphorus, and potassium (NPK) fertilisers.	- The use of fresh seeds will cause the growth of grass to be stunted due to the impermeable seed layer. Fresh seeds should be treated with sulphuric acid for 15 minutes to increase the germination percentage.

NURSERY RECORD HANDLING

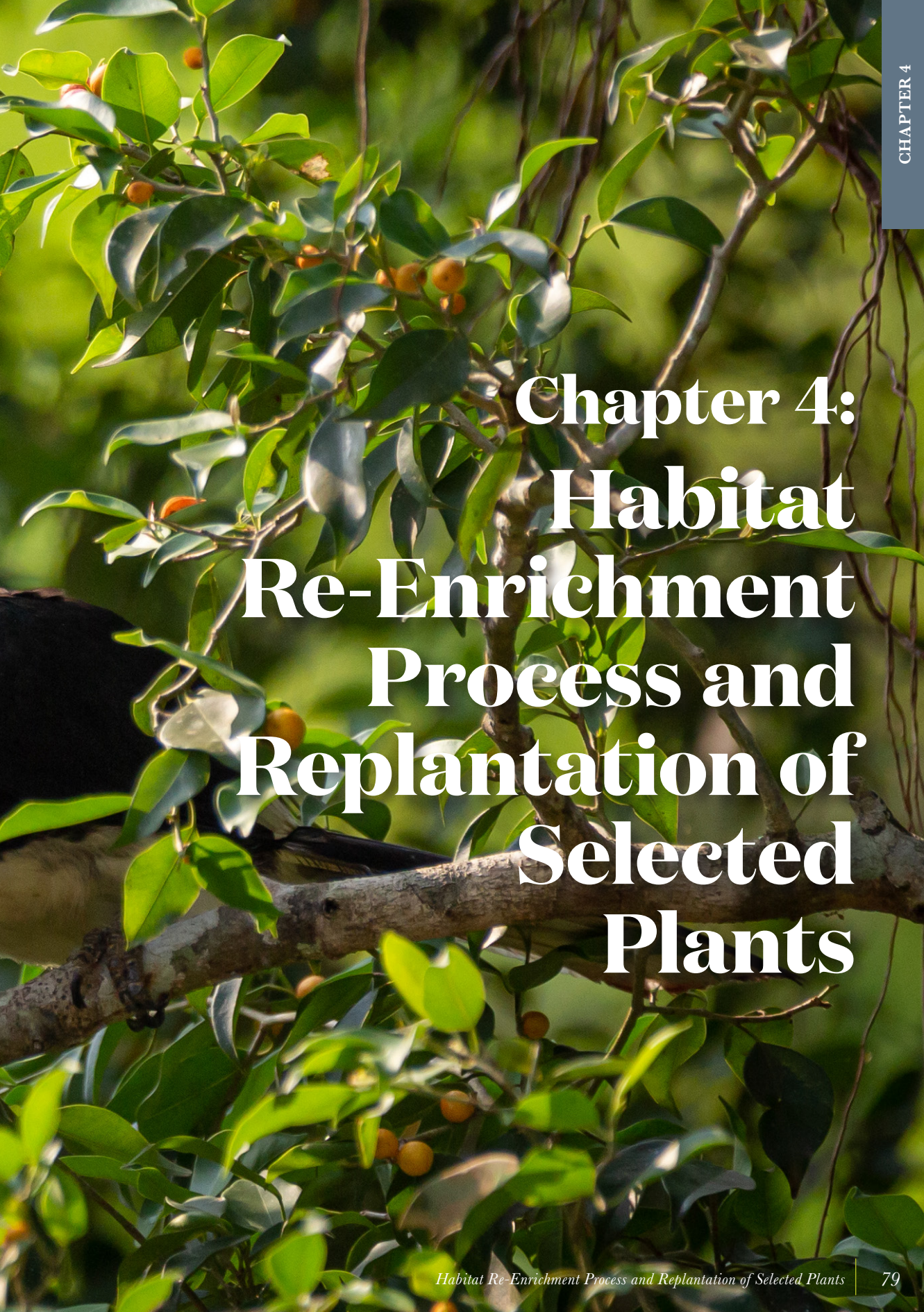
Nurseries have many units such as machinery workshops or equipment stores, chemicals, pesticides, and fertilisers that need to be placed separately; therefore, some records need to be prepared exclusively for each unit. Nursery officers need to arrange the position of shelves or cabinets, prepare a record for each shelf or unit to facilitate the monitoring task, checking inventory, adding inputs, updating data, annual analysis, and so on. It is very important to have labels and records for each shelf and storeroom to ensure all items are well arranged and easy to find.

Some files can be stored in digital form to facilitate systematic file system management. To avoid double counting, nursery managers can think of digital counting methods or inventory systems that are easy to store and re-access in digital form. For privately operated nurseries, administrative management records related to emoluments, staff welfare, utility records, payment receipts and invoices, business licenses as well as correspondence need to be kept regularly to facilitate site operation.

Photo: All measurement used in fertilising are recorded

Photo: Worker referred to record before setup the timer

Photo: Oriental Pied Hornbill (*Anthracoceros albirostris*)



Chapter 4: Habitat Re-Enrichment Process and Replantation of Selected Plants

The previous section of this guideline describes the works involving saplings in nurseries. This chapter will describe the process of replanting in permanent plots, after the seedlings are successfully sown in the nursery. Seedlings from seeds, stem cuttings, shoot cuttings, air layering, and other breeding methods will be transferred to permanent plots when they are mature enough, and this period varies according to the plant species. Slow-growing trees such as *asam gelugor* (*Garcinia atroviridis*) can only be transplanted from the nursery to a permanent plot after 2 years. However, there are also tree species that are suitable for transplanting to permanent plots at the age of 8 months to a year. **Figure 4.1** and **4.2** show the differences in terms of size for asam gelugor and durian saplings in the early stages of planting and the final stages before being transplanted to the permanent plots.

Figure 4.1: Asam gelugor saplings at the early stage (right) and the final stage (left) of planting before being transplanted to the permanent plot

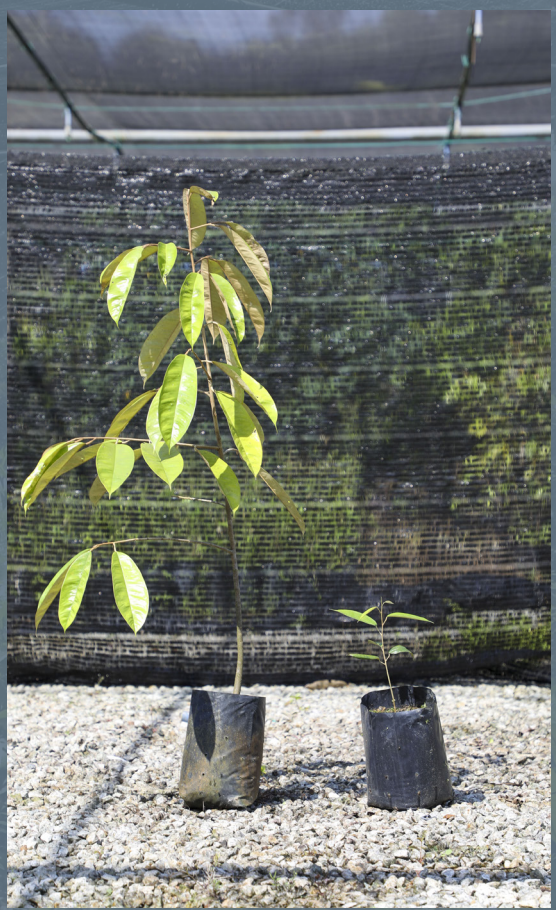


Figure 4.2: Durian saplings at the early stage (right) and the final stage (left) of planting before being transplanted to the permanent plot

Several steps need to be done before, during, and after the transfer of seedlings to permanent plots, which are:

- Identification of permanent plot location
- Selection of crops suitable for mixed cropping
- Preparation of land on the permanent plot
- Planting process
- Maintenance process

Permanent plots consist of farmland, orchards, derelict areas, or forest areas. Each of these areas has different soil structures and composition which could accommodate different plant species that could attract different species of wildlife depending on its food plants. However, there are many overlapping locations where these animals can be found, such as mining areas that accommodate the survival of animals such as snakes, civets, lizards, birds, tapirs, otters, and others, which can also be found in mangrove areas. As these animals can be present in different ecosystems, it is crucial for us to continue to help in the restoration of disturbed environment by doing replanting activities to stabilise the food chain of wild animals.

Generally, location plays an important role to ensure the success of a particular replanting project. For example, one should avoid from planting trees under the shade as it could prevent the trees from getting enough sunlight to grow. One should also be well informed on the structure of the permanent plot and avoid planting trees along potential waterway. Planting trees on the roadside adjacent to the forest areas is also one of the worrying issues in wildlife conservation as it is believed to increase the frequency of roadkill in Malaysia. In a recent study conducted in Terengganu and Pahang, the incidence of roadkill in rainforest road segments was found to be higher with decreasing distance from the nearest water body, trees and shrub (Hui et al., 2021). The probability of roadkill incidence in rainforest habitat decreases to zero beyond 30m distance from the trees, and with a distance of more than 25m from the nearest shrub, a sharp drop can also be seen in the occurrence of roadkill. Wildlife may be attracted to the presence of vegetation along the roadside which could serve as their habitat, food source or as cover while roaming around their home ranges. This could increase the possibility of roadkill incidence which is not only caused by the wildlife hovering around the vegetation along the roadside, but also due to the limited visibility for drivers by the presence of trees and shrub along the road (Hui et al., 2021; Kang et al., 2016).

The death of the endangered Malayan Tapir due to roadkill has also been investigated. It was found that the incidence of roadkill in Pahang and Terengganu occurred hundreds of kilometres away from the nearest eco-viaduct while in Negeri Sembilan, the location of roadkill involving Malayan Tapir was approximately between 15.29 km and 45.04 km from the nearest eco-viaduct (Kasmuri et al., 2020). In addition, Malayan Tapir were also involved in roadkill in states without eco-viaduct such as in Johor, Kelantan and Selangor. The data suggested the urgent need to construct more eco-viaduct or any crossing structure in all states with a better design and good maintenance in order to attract more wildlife in utilizing this facility. Some preventive interventions that can be taken to reduce roadkill in forested areas are by removing roadside bushes, installing fences or road dividers along the areas with high vegetation, and building drainage or trench between the forest and the road. Thorough planning is therefore needed in future replanting activities in any particular site by assessing the type of land or soil, species of existing tree in surrounding forests as well as the species of wildlife present in the area.

Many initiatives have been undertaken by various parties in efforts to re-enrich wildlife habitats. A report in 2014 stated that the forest cover area in Malaysia has increased to 61% from 56.4% in 2010. Meanwhile, the latest report in May 2021 reported that ongoing initiatives have helped in increasing forest cover by 2.6% over the past 13 years. Among the programmes that have been and are being carried out are:

- Sustainable Forest Management (PHSB)
- Central Forest Spine (CFS)
- Heart of Borneo (HoB)
- 100 Million Tree Planting Campaign
- Forest Landscape Restoration (FLR)

All these activities are very helpful in the process of re-enrichment of wildlife habitat. Efforts by the government in collaboration with private agencies and NGOs have shown results and need to be continued. A good forest ecosystem will help the stability and success in sapling planting activities before transplanting to permanent sites.

PREPARATION BEFORE PLANTING IN PERMANENT PLOTS

To begin the first step in replanting rare fruit trees to attract wildlife, planting locations and types of crops need to be identified. The Central Forest Spine (CFS) of Peninsular Malaysia is an important natural landscape of Malaysia and consists of three main ecoregions which are Dry Inland Forest, Mangrove Forest and Peat Swamp Forest. Among the suitable locations for the replanting activities within these ecoregions are secondary forest areas, abandoned forests, or abandoned mining areas. These locations, which originally housed a wide variety of wildlife, are no longer suitable habitats as they have been encroached upon. The encroachment of these areas has caused many wild animals to be affected and in turn reduced the population of those animals.

Therefore, such areas need to be revitalised by planting suitable plants. To ensure that the replanting project can be done successfully, the type of trees to be planted in the area must be suitable for the planting location. Replanting locations are usually barren and derelict land. Therefore, the condition of the soil at the planting site needs to be assessed so that appropriate treatment can be done. In general, the soil pH should not be too acidic or alkaline. Suitable soil for crops is at pH 7 which is a neutral soil condition. If the soil in the permanent plot is very acidic, the soil needs to be treated prior to planting. In general, the rule of thumb is to treat the soil using lime such as Ground Magnesium Limestone (GML) or Christmas Island Rock Phosphate (CIRP). The next process is to add nitrogen content to the media through compost, animal excrement, bonemeal, and other suitable components. These substances will

Figure 4.3: Example of a hole dug prior to seedling planting

help to increase the bacterial population in the soil in accordance with the increase in soil pH. The distribution of agricultural lime containing magnesium, calcium, and ferrous content is very suitable for treating high acidity soils such as peat soils. All of these treatments need to be applied to the holes dug for planting mature saplings (**Figure 4.3**).

For soil at permanent plots that is too alkaline, especially permanent plots close to limestone hills, the soil should be pre-treated using powdered sulphur and urea phosphate. Organic fertilisers from vegetables and crops are also suitable for neutralising alkaline soils. The use of Christmas Island Rock Phosphate (CIRP) is very helpful in increasing the phosphate content in the soil. CIRP is mixed in the planting hole before the planting process is done. The appropriate soil preparation period before saplings are planted on permanent plots is within 7 – 14 days.

Since most replanting activities are carried out near the disturbed original habitat, there is no need to provide a buffer zone. However, this situation is dependent on the location of the permanent plot. The same goes for the need to plant a species outside its original habitat (*introduced species*). It is recommended that the tree species to be planted are from the same species which can be found in the original forest.

Table 4.1 listed some examples of planting locations, enrichment measures that can be taken, and the types of mixed crops that are suitable to be planted in order to attract and support wildlife survival.

Table 4.1 Planting locations and the proposed types of crops to be planted on permanent plots as well as the types of wildlife involved

No.	Replanting Locations	Soil and Environmental Conditions	Enrichment of Cultivation Locations	Proposed Mixed Crops	Types of Wildlife
1.	**Secondary forest**	- Relatively dry soil compared to primary forests, moderately high temperature, less shade.	- Increasing cover trees and large trees around the secondary forest to provide better shade.	- Most species of fruit trees are suitable for this area. - Among them are durian, mempisang, fig, rambai, forest cherry, and others.	- These trees are the main food source for various wildlife such as elephants, deer, wild boars, bats, birds, and so on.
2.	**Abandoned land**	- Most of the abandoned land is paddy field or garden land that is no longer productive. - The soil conditions are relatively dry with a wide variety of trees. Most are shrubs.	- Adding more trees in the surrounding area to accommodate the saplings that will be planted in the area.	- Almost all trees bear fruit as in the secondary forest and also rhizomatous plants such as ginger, galangal, kantan, and *temu lawak*.	-These rhizomatous plants are favoured by small mammals such as squirrels, mongoose, shrews, civets, and others.
3.	**Mine area**	- Sandy and silty soils, high permeability, high surface temperature, low water holding, low fertility.	- Extensive use of organic matter, improved irrigation systems, addition of clay soils, perfect tempering, slope levelling, the use of mulch to reduce temperature and prevent weeds, lime treatment to change soil pH.	- Early stage: Cash crops such as cassava, sweet potatoes, chillies, celery, vegetables, and Chinese turnip. - Second level: Once the mine area has been enriched, this area can be interspersed with low-maintenance fruit trees such as guava, starfruit, papaya, and mango.	-Among the animals found in this area are snakes, civets, monitor lizards, birds, tapirs, otters, and others.
4.	**Mangrove swamp area**	- Constantly submerged soil conditions, anoxic substrates, high salinity, low oxygen level.	- Helping the flow of oxygen by building a temporary watermill.	- Mangrove tree species such as *Rhizophora mucronata*, *Rhizophora apiculata*, various types of *tumu* and *nyireh*.	- This area is a habitat for monkeys, snakes, civets, otters, birds, and others.
5.	**Peat swamp area**	- This area contains about 90% water, is constantly waterlogged, and has a low mineral content. -Formed from decay of organic matter such as leaves, twigs, and wood that occurs slowly on the base surface of the coil or sand. - This semi-decayed organic material makes the peat water acidic (pH 3–5) and brown or black.	- Replanting and enrichment planting of trees in peat swamp forests begin with the collection of seeds and/or wild saplings. - If the area has dried up due to hot weather and exposure, water level control should be done. - Enrichment of soil through fertilisation of soils and minerals with a composition of potassium, nitrogen, and phosphorus in a ratio of 1:1:3.	-Agricultural development in peatland is dominated by coconut-cocoa and sago crops for the traditional agricultural system. -The types of permanent crops suitable for planting are oil palm, coffee, cocoa, and fruits such as cempedak, jackfruit, rambutan, and mempelam as well as other shallow and medium-rooted crops. - Planting of peat swamp forest tree species e.g., *Macaranga* sp. (Mahang), *Euodia* sp. (Tenggek Burung), *Anisoptera marginata* (Mersawa paya), *Calophyllum ferrugineum* (Bintangor paya), and so on.	-Peat swamps in Peninsular Malaysia accommodate a total of 238 species of plants, bird species such as hornbills, and 81 species of fish, which include betta fish as well as downstream freshwater fish. - Peat swamp forests provide habitat and protection for endangered reptile species such as the Malayan gharial (*Tomistoma schlegelii*), rare mammals such as leopards (*Panthera pardus*), honey bears/sun bears (*Helarctos malayanus*), and tapirs (*Tapirus indicus*).

PLANTING PROCESS, CARE AND MAINTENANCE AFTER PLANTING

Once the replanting location has been determined, the next step is to prepare a suitable site for planting. This is followed by the process of planting appropriate plants. Since the replanting location is on permanent and large-scale plots, it is quite difficult to control abiotic factors such as humidity, exposure to sunlight, drainage, and other requirements. Therefore, several factors need to be taken into account to ensure that the saplings can grow well. Among them are:

Planting Time

Selecting the right time to start planting is very important. Saplings are recommended to be moved to a permanent site at the end of rainy season, because the soil is soft during this time. This facilitates the digging process and lessens the need to water the saplings. It is not recommended to plant the saplings in the dry season which can cause them to be exposed to sunlight for a long period of time. For example, for the West Coast area, the rainy season usually ends in February. Therefore, the period after that time is appropriate to start planting. However, this situation depends on the weather conditions at the planting location.

Method/Type of Crop

For the replanting process to attract and accommodate wildlife, the appropriate method of cultivation is mixed crops. The mixed planting method can be done by planting saplings that are of the same species as the trees in the original habitat. For example, if the permanent plot is an explored secondary forest land, then replanting is done to restore the disturbed area. Therefore, the saplings planted should involve some species from the original forest. In this way, the trees can adapt to the environment better than the tree species that are not found in the native forest. Pollination agents found in the native forest will assist the pollination process of saplings planted on permanent plots. Replantation which involves only a single species increase the risk of disease and pest outbreak as there are no other plant to curb the spread of the disease and restrict pest infestation. In fact, environmental adaptation may also take longer if the cultivation method is a single-type crop only. An example of mixed crop is shown in **Figure 4.4**.

Figure 4.4: Example of mixed crops for permanent plots consisting of various plant types such as *mentega* trees, mango trees, asam gelugor trees, and others

For large-scale permanent plots and challenging locations such as slopes, timber forest areas, and unproductive areas, watering is quite difficult. Therefore, it is very important to maintain soil moisture naturally by planting trees such as creeping legumes or shrubs such as Pintoi peanut (*Arachis pintoi*), Yellow dots (*Sphagneticola trilobata*), sambang getih/red ivy (*Strobilanthes alternata*), Japanese roses (*Portulaca grandiflora*), and little ruby (*Alternanthera dentata*). Planting grass or shrubs in advance before planting larger saplings helps to maintain the moisture of the soil and the area around the permanent plot. This method can prevent the soil from becoming dry due to sunlight exposure over a long period of time.

Irrigation

If the tree planting on the permanent plot is done at a small scale, then an irrigation system using a dripper or sprinkler can be used. For large-scale planting activities, watering using these methods will require high costs. Therefore, it is very important to ensure that the saplings are transferred to the permanent plot only when they have matured. Mature saplings will be able to find and obtain groundwater resources on their own through the root system. However, if the humidity in the soil is very low, then manual watering or an irrigation system should be employed to prevent the seedlings from stagnating or dying. Regular monitoring is very important to ensure that the saplings can live and grow well.

Fertilisation

Several stages of fertilisation need to be done to ensure that the saplings grow well after being transferred to a permanent plot, namely:

- Preliminary fertilisation should be done before the saplings are planted into the planting hole by mixing organic fertiliser into the plant media.

- The next fertilisation process is recommended to be done one month after the saplings are planted into the planting hole to increase their growth.
- Systematic fertilisation should be done for the first 3 years to ensure the saplings grow well.
- This is followed by fertilisation to encourage flowering and fruit growth.
- Among the suitable organic fertilisers are compost, peat, manure, and other organic fertilisers while appropriate chemical fertilisers include a mixture of nitrogen, phosphorus, and potassium such as NPK fertilisers.

Maintenance

The maintenance measures that need to be done to ensure that the seedlings will survive and grow well are:

- Weed control
- Prevention of pests and diseases
- Monitoring of tree growth
- Control of crop enemies

Weed and pest control methods need to be done systematically to reduce the risk of stunted, injured, or dead saplings. As with nurseries, saplings planted on permanent sites are also vulnerable to pest attacks and diseases. Saplings are usually vulnerable to pest attacks such as scale insects, stem borer caterpillars, leaf caterpillars, pinhole beetles, and termites as well as other diseases that can cause slow growth rates to saplings and if not controlled, death.

Apart from maintenance against pests, monitoring should also be done on tree growth. Continuous monitoring and evaluation are necessary to ensure that the saplings grow well. Periodic inspections should be done to detect the presence of pests or any conditions that could affect the growth of saplings in permanent locations. If there are symptoms of pest infestation or a lot of weed growth, then follow-up treatment can be done as soon as possible.

In general, the methods of planting and care are almost the same for most forest fruit trees. However, there are some differences that need to be noted to ensure that the cultivation method is suitable for the tree species in question. The processes of soil preparation, planting, and post-planting maintenance for some selected tree species are included in **Table 4.2** as a guide.

Table 4.2 Soil preparation before planting on permanent plots, planting process as well as post-planting care

No.	Plant Types	Preparation of Land at Location	Planting Process	Prevention & Maintenance
1.	MORACEAE *Ficus racemosa* Fig tree	- Requires well-drained and fertile soil. The best soil for planting fig trees is clay that has a lot of organic matter and gets a lot of moisture. - Suitable soil pH for planting fig trees is between 6.0 and 6.5.	- Planting fig trees in permanent locations are best done during the dry season. - The planting hole is at least 50×50 cm. Preferably a 1×1 m hole. - The minimum distance of a fig tree is 5 m from other plants. - Receives direct sunlight. - The soil is mixed with a little organic compost and perlite. - Water needs to be poured into the hole before the fig saplings are placed into the planting hole. - The sapling is then watered.	- Choose fig trees that are free of root-knot nematodes. - Needs full sunlight and adequate growth space. - Make sure there is not too much nitrogen in the soil. - Fertilise the soil in the early years of planting. - Good care of fig trees require minimal pruning. - Pruning is done at the end of the rainy season before growth begins so that the plants are not injured.
2.	PHYLLANTHACEAE *Baccaurea motleyana* *Rambai*	- Suitable soil is sandy soil. - One year-old *rambai* seedlings with a height of 2 ft are suitable for planting to a permanent location. - The hardening process of the tree trunk should be done a month before transplanting to a permanent location by exposing the saplings to full sunlight. - *Rambai* species are suitable to be grown in relatively low-lying areas. If planted in hilly areas, it should be planted according to the contours.	- The ideal planting distance is 10×10 m because the *rambai* tree has a large canopy. - Planting work is best done during the rainy season because the *rambai* saplings need a lot of water during early growth. - In the early stages of planting, fertilisation using a compound fertiliser of sodium, phosphorus, potassium (NPK) 15:15:15 (80 g/tree) is given monthly in the first year. - In the second year, the fertiliser rate is increased to 300 g/tree every 2 months. The application of chemical fertilisers is alternated with organic matter. - When the tree has started to produce flowers (third year), sodium, phosphorus, potassium (NPK) compound fertiliser 12:12:17:2 (500 g/tree) is given every 2 months for the fertilisation process.	- Weeding activities are done periodically to ensure that the trees do not compete with weeds. - Control using herbicides can also be done if necessary. - Monitoring for the presence of termites should be done every month until the area is found to be free of termites. - For disease and pest control, pesticide spraying is done when necessary to prevent infestation.
3.	ANACARDIACEAE *Mangifera foetida* *Macang hutan*	- Suitable soils are alkaline soils and those that have a high clay content. - The optimum pH is between 5.5–7.5. - Has good water drainage.	- The recommended planting distance for the 2-year-old seedlings of *macang* trees is 12×12 m or more. - Planting holes should be prepared and filled with basic and organic fertiliser. - Fertilisation with organic fertilisers and chemical fertilisers NPK 12:12:17:2 TE.	- Trees need to be monitored for the presence of stem borer beetle (*Rhytidodera simulans*) which will damage branches and fruit borer beetle, *Cryptorhynchus mangiferae* which damages fruit. - The infestation of stem caterpillars and fruit borer caterpillars should be controlled with systemic pesticides.
4.	MYRTACEAE *Syzygium campanulatum* *Kelat*	- Soils with good drainage and have a small amount of mineral salt elements (saline soils/salt spray). - The relatively moist soil helps the growth of *kelat* trees.	- Plant holes are dug and filled with basic fertilisers such as MOP and mixed organic fertilisers. - Fertilisation of this plant requires sodium, phosphorus, potassium (NPK) fertiliser 15:15:15 . - The planting distance is independent of other trees. - This species does not have a specific planting distance.	- Pruning should be done regularly when the tree is quite mature. - This tree is easily infected with fungus in the rainy season. Therefore, fungicide spraying should be done when necessary.

No.	Plant Types	Preparation of Land at Location	Planting Process	Prevention & Maintenance
5.	SAPINDACEAE *Lepisanthes alata, L. fruticosa* Terengganu cherries	- Loam type soil with good drainage. - Suitable for planting in hilly or sloping areas. - Requires low temperature. - Ploughing is required if cherry trees are planted in hilly or sloping areas.	- Holes 60×60×60 cm are dug four weeks before planting. - If the soil pH is less than 4.5, GML lime should be sprinkled into the hole and covered using mixed soil. - The holes are filled with dry organic fertiliser a week before planting. During planting, CIRP is inserted around the hole. Seedlings need to be watered and mulched. - Growth fertiliser (15:15:15) is given at a certain rate at the age of 1–2 years, 4 times a year. Fruit fertiliser 12:12:17:2 is sown around the tree canopy at the age of 3 years and above, 4 times a year. Requires at least 18 L of water per day in the early stages of planting and watered 2 times a day.	- Pruning activities need to be done from the beginning of growth to form the tree canopy so that it is balanced and productive. - Mulching done at the base of planted trees will limit the growth of weeds from competing for food, water, and sunlight. - If weed problems still exist in the early stages of cultivation, the application of chemical pesticides should be carried out in a controlled manner. - The use of lawnmowers is also encouraged to reduce the use of chemical pesticides.
6.	CLUSIACEAE *Garcinia atroviridis* *Asam gelugor*	- *Asam gelugor* trees are suitable to be planted in fertile soil that is openly ploughed. - Ideally transplanted to a permanent plot when the saplings reach the age of 2 years. - Saplings planted in the shade have a good chance of growing.	- The planting distance is 9×9 m and the land area is vacant (no other crops). - Holes as deep as 2 ft are dug and sprinkled with basic fertiliser before the saplings were transplanted. - Fertilisation is done by sprinkling 30 to 50 g of NPK fertiliser 12:12:17:2 placed at the base of the tree 3 times a year.	- Pruning should be done to trees that have reached a height of 2–3 m in height to facilitate the process of fertilisation and pest control. However, to mimic the wild habitat, pruning is not necessary. - The *asam gelugor* is a hardy species and symptoms from diseases or pest attacks have not been reported much.  **Photo:** *Asam gelugor*
7.	ZINGIBERACEAE *Zingiber* spp. Ginger	- Suitable to be planted in areas with high shade. - Areas with high rainfall distribution help accelerate the growth of saplings because the ginger family requires large quantities of water in the early stages of planting.	- Ploughing is done to a depth of about 30 cm. - The soil is left for 1 week to kill fungi and pests using sunlight. - Organic fertiliser or compost is sown in the soil area. - The recommended planting distance is 60 cm. - Organic fertiliser/compost is given at the beginning of planting as basic fertiliser. Subsequent fertilisation is performed at the ages of 3 months, 6 months, and 10 months. - Ginger plants do not need too much water for growth except at the beginning of the planting.	- Weed cleaning is done once every 3 weeks. Once the ginger is 6–7 months old, weed cleaning is no longer needed. - The base of the ginger tree must be piled with soil to cover the ginger rhizomes that appear on the ground. Piling is done when the ginger plant has 3–4 stems (2 months and 4 months after planting), after the soil begins to erode. - Pest control is done by spraying pesticide and cleaning of diseased crop residues.

No.	Plant Types	Preparation of Land at Location	Planting Process	Prevention & Maintenance
8.	ZINGIBERACEAE *Etlingera* spp.	- The most ideal type of soil used for this plant is the sandy loam type. - Soil that does not hold water is important to prevent roots from rotting in the soil. - Kantan trees are suitable for planting in areas with temperature around 24–33 °C that receive rainfall between 1800–2200 mm.	- Kantan trees are planted using rhizomes or seeds. Rhizomes are faster to give produce than seeds. - Rhizomes that have root sucker or basal shoot need to be removed and cut. Ideally have 2–3 points of buds and root fibre to promote growth. - The recommended crop distance is 2 m between rows and 1 m in the row, with a crop hole of 20×20×20 cm. - Dry leaf mulch is used to prevent young buds from drying. - Fertilisation using organic fertilisers in the 4th month, followed by NPK fertilisers in the 5th, 7th and 9th month after planting.	- This plant needs to be pruned to promote the growth of new leaf and increase the production of flowers. - In the first year, weed control is carried out by spraying herbicides around trees. - In terms of diseases and pests, there are no serious symptoms that attack this crop. However, termite attacks may occur if there is a lot of rotting wood. Chlorpyrifos insecticide spray on the side affected by termite attacks will help control this problem.
9.	MALVACEAE *Durio zibethinus* Durian hutan	- Suitable for planting in sandy soils to sandy loam. - Undulating areas, slopes of 6°–12°, and hillsides are very suitable. - Durian seedlings need a little shading in the early stages of growth. Farm areas are recommended to be planted with temporary shade crops such as bananas planted 6 months earlier.	- Planting holes measuring 60×60×60 cm. Holes are dug a month before planting and exposed to sunlight. Subsequently, they are covered using more fertile and loose topsoil. - Young durian trees are fertilised 4–6 times a year in small quantities. Mature trees are given more fertiliser with a frequency of 3–4 times a year. - Generally, durian cultivation uses drip irrigation system.	- Pruning is started from the early stages of growth starting 3–6 months after planting. - Fruit thinning is done if the fruit has characteristics such as being bent, has been attacked by insects, and has more than one fruit on one stalk. - The main disease is tissue infection due to canker (*Phytophthora palmivora*). - Insect and weed control are done by spraying pesticides and herbicides.
10.	MELIACEAE *Sandoricum koetjape* Sentul	- Planted at an altitude of 0–1000 ft above sea level. - Grows well in the lowlands. - Suitable soils are loose clayey and sandy loam.	- Planting holes with a size of 51×51×51 cm are dug, and the soil is mixed with compost or fertiliser. Husk mixture is used to close the hole. - Watering is done 1–2 times a day at the beginning of growth. - Suitable fertilisers are NPK fertilisers, organic fertilisers, and fruit-stimulating hormones.	- Exposure to *Phanerochaete salmonicolor* will cause disease. - The infected part has to be removed. - Miticide spraying is done to prevent mites.
11.	EBENACEAE *Diospyros blancoi* *Mentega*	- Crops that can be grown in a variety of soil types. - A type of robust tree.	- Planting holes measuring 50×50 cm with a depth of 50 cm are prepared. The holes are filled with organic fertiliser and CIRP and left for 2–3 weeks before planting. - A hole distance of 3×3 m is provided if planting in large quantities is desired, to provide space for *mentega* trees to grow. - Watering is done after planting is complete. - NPK fertiliser 15:15:15 and organic fertiliser.	- The care of *mentega* trees is almost the same as other crops, which is by doing weed control and fertilisation. - Weeds are controlled manually and can also be controlled using herbicides.  **Photo:** *Mentega*

No.	Plant Types	Preparation of Land at Location	Planting Process	Prevention & Maintenance
12.	RUBIACEAE *Morinda citrifolia* *Mengkudu*	- *Mengkudu* cultivation is suitable using beach clay, loamy soil, and sandy soil.	- The crop area is ploughed to a depth of 25–30 cm followed by loosening, two weeks later. - Good irrigation because stagnant water will damage the *mengkudu* trees. - The size of the planting hole is 0.3×0.3×0.3 m. - TSP fertiliser and GML lime are used as base fertilisers at a rate of 100 g/hole. Liming is done 2 weeks after TSP fertiliser application.	- Pruning is very important for this tree. This is to enable the production of alternate stems on the tree branch. - A double stem will give a greater number of branches and in turn produce more fruits. - Fungal and pesticide control is done by spraying, when necessary.
13.	POACEAE *Panicum maximum* Guinea grass/horse grass *Pennisetum purpureum* Napier grass/ Elephant grass *Brachiaria ruziziensis* Ruzi grass	- Suitable soil types are peat soil, red soil, sandy soil, and BRIS soil. - The structure of the cultivation area is wider whether it is a hilly area, flat land, undulating, or watery path. - Napier grass or elephant grass needs fertile soil that is crumbly soil. If planted on sandy soil, the grass should be given livestock manure. - Horse grass or guinea grass is resistant to drought but still needs a humid climate to thrive. - Suitable if planted with shade trees such as coconut trees. - Ruzi grass is suitable on all types of soil, especially sandy bris soil.	- Areas should be ploughed and loosened at least 14 days before planting to increase the mineral content in the soil. - Fertilisation is done by sowing NPK fertiliser 15:15:15 around the base of the grass. - Fertilisation of napier grass using NPK fertiliser is done 2 times a year: at the time of soil preparation and 6 months later at a rate of 200 kg/ha. Nitrogen (N) fertiliser is given at the rate of 200 kg per hectare per year in several applications or each time after 2–4 times of napier grass cutting activity. - Horse grass or guinea grass is encouraged to be planted with legumes because legume root nodules bind nitrogen in the air and supply nitrogen to horse grass. - Like horse grass, ruzi grass will also show better growth if grown alongside legume crops.	- This plant does not require meticulous care. - There are no serious insect problems but if any part is affected by caterpillar attack, that part should be removed. - Grass stems should be cut periodically to encourage growth. - Napier grass requires a longer period before the first harvest can be made which is 35–42 days after planting. - Meanwhile, horse grass only needs 18–21 days before it can be cut to encourage the growth of its leaves. - Ruzi grass is also recommended to be cut every 4–6 weeks. A more frequent cutting will result in the growth of more new leaves.  **Photo:** Ruzi grass

EFFECTIVENESS OF REPLANTING ACTIVITIES

Once the replanting project has been carried out, there is a possibility of conflict between humans and animals in the replanting locations. In some places, replanted trees have been cut down by the surrounding residents to reduce the presence of pests and dangerous animals such as primates, pigs, birds, and snakes, which then invite the presence of predatory animals and pests such as tigers and elephants. Therefore, concerted actions that benefit all parties should be taken. Among them are setting the location of plantings that are relatively far from public settlements, protecting the areas recorded as important locations for biodiversity and birds (IBA) and high conservation value (HCV) areas as well as launching awareness campaigns on the importance of replanting to the natural ecosystems.

Efforts to increase wildlife sanctuary and permanent forest reserve under the Wildlife Conservation Act 2010 are expected to curb conflicts between humans and animals. In addition, the initiative undertaken through the Improving Connectivity in the Central Forest Spine (IC-CFS) project will continue to support the efforts to maintain a biodiversity-rich area involving three major forest landscapes in Peninsular Malaysia. This effort is essential for the survival of wildlife and humans. Public awareness in replanting activities also plays an important role in ensuring the effectiveness of the activities carried out.

After the interest for all parties has been accounted for and the replanting activity on the permanent plot is in full blast, the growing and self-sufficient saplings need to be monitored. In order to assess the effectiveness of tree-replanting activities in attracting and sustaining wildlife, periodical monitoring such as follows is crucial.

Preliminary Monitoring

Preliminary monitoring is done by identifying the animal species found in the cultivation area in the earliest years of cultivation (less than 2 years). This monitoring can be done by recording an inventory of insects and animals found in the replanting area.

Advanced Monitoring

Further monitoring is recommended to be done periodically once the saplings have flowered. At this time, the presence of pollinating agents such as bees, butterflies, bats, birds, squirrels, and monkeys will not only help the pollination process but will also attract other animals that are predators to the pollinating agent. Animals such as civets, snakes, deer, and wild boars are also expected to be detected in this permanent plot due to the presence of food sources found in the replanting area.

Final Monitoring

Final monitoring can be done after more than 50% of the planted tree species have produced fruit. Even so, the duration of this final monitoring depends on the current situation. Fruit-eating animals and predators of these frugivores are most likely to be detected in this permanent plot as their food sources are available in this area. This cycle will continue exponentially as the trees produce fruit and in turn attract more wildlife to the planting area. The presence of these small animals will also contribute to the presence of large-sized animals such as tigers and elephants. The presence of indicator species and flagship species such as elephants, tapirs, tigers, and others is a sign that this replanting area has succeeded in producing an increase in habitat network for wildlife previously affected by deforestation activities.

Photo: Sentul fruits *(Sandoricum koetjape)*

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