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Research Article

Evaluation of Vegetative Characters and Distribution of *Artocarpus* in Perak Province for Field Guide Development

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ABSTRACT

The aim of this study is to evaluate vegetative characters for development of a workable vegetative field guide and to map *Artocarpus* in Perak Province. Morphological characters of *Artocarpus* were examined based on modified Hickey and Berg et al. methods, and then evaluated using numerical analysis. Thirty-nine morphological characters were evaluated using Multi-Variate Statistical Package (MVSP) and Phylogeny Analysis Using Parsimony (PAUP) showing that these characters are of taxonomic significance at genus, tribe and species level. Bole lenticel and bark colour prove to be of taxonomic significance at subgenus level whilst leaves shapes, leaves texture, latex, and venation can lead to species identification. A total of 14 species of *Artocarpus* were successfully collected (n>350) from specified regions within Perak Province. The distribution shows that Batang Padang, has the highest number of *A. nitidus* whilst southern part of Perak Province shows the most diverse of *Artocarpus* members. It is concluded that the finding of this research partly supported useful morphological characters made by Berg et al. (2006). It also shows that vegetative characters are useful as field guide to determine *Artocarpus* genus and subgenus.

Keywords: *Artocarpus*, Moraceae, Vegetative morphology, Field guide

1. INTRODUCTION

Jackfruit (*nangka*), cempedak and breadfruit (*sukun*) are representatives of the genus *Artocarpus* in the Moraceae family. This family is easier to be identified by its copious white milky latex in all organs, stipules and circular leaf scar (Berg, Corner & Jarret, 2006). *Ficus*, being one of the largest genera in the Moraceae family, is given a full identification and description of its morphological characteristics. *Ficus* is easily identifiable by its waxy glands, which may be seen on the lower margin of the leaves. Another feature that distinguishes *Ficus* from *Artocarpus* is the presence of secondary aerial roots, which indicate that the plant is a hemi-epiphyte or climber. Certain *Artocarpus* species have vivid orange or dark red lateral roots with latex, which *Ficus* does not have.

The last comprehensive review of *Artocarpus* was conducted by Berg, Corner, and Jarret in 2006 through Flora Malesiana. However, this revision was based on Jarret's monograph, which dates back approximately 57 to 58 years. The species identification was primarily relying

on reproductive characteristics, specifically the type of inflorescence. Relying solely on reproductive organs for identification can cause delays, as these parts may not be readily available throughout the year. Some species, such as *A. integer* (cempedak) and *A. integer* var. *silvestris* (bangkong), may be difficult to differentiate, as only *A. integer* has been thoroughly evaluated in Flora Malesiana. Similarly, *Artocarpus heterophyllus* and *A. kemando* may pose challenges due to their almost identical vegetative morphological traits. Not all members of Artocarpus were revised in Flora Malesiana; for example, *A. dadah* was omitted, and to date, the revision of this species has only been mentioned in Tree Flora of Sabah and Sarawak Volume 3, dating back to 2000. A more consistent and precise morphological description is needed to facilitate field identification of the genus. Taxonomic classification of the families has also proven problematic, as several sources contradict each other. Flora Malesiana (2006) listed *A. elasticus* and *A. scortechinii* as synonyms, but Plant List (2003) recognizes *A. scortechinii* as a valid name for the species. Furthermore, morphological investigations have revealed high similarities between the two species, with differences observed mainly in bark texture and leaf abaxial surface texture. Thus, this article delves into the utility of vegetative characters as a field guide for rapid identification of this genus.

2. MATERIAL AND METHODS

A total of 14 species of Artocarpus were collected in the Perak region, as well as some parts of Perak Province, including the southern part of Kedah and the northern part of Selangor areas. Samples collected were processed into herbarium vouchers for morphological examination, both with the naked eye and under a microscope. Some fresh samples were observed under a dissecting microscope to examine micro-morphological features such as indumentum and venation. Morphological characters were examined based on Berg et al. (2006) with some modifications and Hickey (1999). Additionally, variation in habitat information was also utilized for the same purpose. The vegetative characters were evaluated by analyzing them using numerical analysis tools such as the Multi-Variate Statistical Analysis Package (MVSP) and PAUP to determine relationships among taxa. The distribution of Artocarpus was mapped based on both herbarium data and field collection.

3. RESULTS AND DISCUSSION

This study focused on examining the morphological variation of bark and leaf architecture. All samples collected during the field trip were processed into herbarium voucher specimens. Morphological differences and similarities in the bark and leaf architecture of each species were analyzed based on Hickey's (1999) methodology. *Ficus hispida* was utilized as an outgroup for this study due to its close relation to the genus being studied.

3.1. General Feature

In general, all samples studied exhibited white latex and symmetrical leaf types, with no presence of arms. These vegetative features could be utilized as diagnostic characters for Moraceae. However, while all species possessed white latex, *Artocarpus* and its counterpart genus, *Ficus*, differed in several key characteristics. All studied *Artocarpus* members shared features such as buttress roots, very sticky white latex, and rough bark texture, whereas *Ficus* lacked buttresses, had smoother bark texture, and its latex was only slightly sticky (see Table 1). The locality and habitat of species were found to be helpful in the identification process, as members of the genus tend to thrive in certain types of conditions. Aside from species intentionally cultivated for their economic and medicinal value, wild species exhibit

preferences for specific habitats, which can aid in the identification process. Most species are typically found in lowland areas, but some are restricted to specific habitat conditions. For instance, *Artocarpus rigidus, A. lanceifolius, and A. glaucus* are exclusively found in hillside areas, while *A. teysmanii, A. nitidus, A. integer* var. *silvestris, A. kemando,* and *A. dadah* are restricted to swampy areas (Table 1). The bole characteristics investigated in this study encompass three main categories: bark texture, presence of lenticels, and other peculiar and distinctive features. When used in conjunction with other criteria, bark color also proves to be significant at the species level. Apart from sharing a rough bark texture, Artocarpus members exhibit two main types of bark color: greyish and grey-brownish. The presence of lenticels further aids in distinguishing between each member of the genus. Most of the studied members show no lenticels, except for six species: *A. elasticus, A. scortechinii, A. integer* var. *silvestris, A. glaucus, A. kemando,* and *A. dadah*. All these species display lenticels less than 3mm in size. Additionally, only *A. integer* var. *silvestris* exhibits new leaf growth at the syncarp scar, a feature not observed in any other studied members of the genus (Table 1).

3.2. Leaf Blade

Through closed observation, although all of the studied species shared the same types of leaves arrangement, the texture of the leaf blade surface divided them into a few different categories. Majority of the studied sample shared smooth adaxial surface but a few species have scabrous adaxial surface texture namely, *A. camansi, A. scortechinii* and *A. rigidus*. *Artocarpus glaucus* distinguished itself from the members of the genus by having glaucous adaxial leaf surface. Majority of the members of *Artocarpus* shared alternate spiral phyllotaxy type but a few species have distichous type namely, *A. glaucus* and *A. nitidus* (Table 2). The shape of the leaf blade holds taxonomic significance in distinguishing members of the genus. While most Artocarpus species exhibit an elliptic leaf blade shape, there are exceptions. For instance, *Artocarpus glaucus* and *A. kemando* both display elliptic to sub-ovate leaf blades, while *A. camansi* showcases an elliptic to sub-ovate leaf blade shape. *Artocarpus dadah*, commonly referred to as wild Nangka, features an oblong leaf blade shape, whereas *A. heterophyllus*, known locally as commercial Nangka, displays an ovate to elliptic leaf blade shape. This distinction can serve as a diagnostic character for differentiating between wild and commercially grown Nangka (Table 2).

The majority of family members exhibit a cuneate leaf base type. However, *Artocarpus nitidus* and *A. dadah* display a round leaf base shape. Additionally, variations in fresh leaf color can further aid in distinguishing members of the genus. These colors range from dark green to greenish to shiny green. Some species also feature white to brown dots all over their young leaves, notably *A. integer* (Commercial Cempedak) and *A. integer* var. *silvestris* (Wild Cempedak) (Table 2). The mature leaves of the studied specimens indicate that the majority of members have entire margins, while *A. camansi* and *A. altilis* exhibit lobed-incised margins extending down to the midrib, forming a broad U-shaped sinus. However, there is considerable variation in the juvenile leaf margins among *Artocarpus* genus members. Most species display lobed-incised margins that form broad U or V-shaped sinuses. These juvenile margin characteristics can be confusing for the identification process, as the leaves are not fully developed, and it is not recommended to rely on them as distinguishing features (Table 3).

The presence of indumentum, or the covering of hair (trichomes), on the abaxial and adaxial surfaces of the studied species further aids in distinguishing each member of the genus. Although the majority of the studied samples (*A. scortechinii, A. camansi, A. rigidus, A. lanceifolius, A. integer* var. *silvestris*, and *A. glaucus*) share the presence of trichomes on both sides of the leaf lamina blade, the nature of the trichomes varies between species. This variation can contribute to building distinguishing characteristics that can be used to differentiate each

species. For example, *Artocarpus scortechinii* has long brownish and scattered trichomes on both sides of the leaves, while *A. camansi* has dense white long trichomes on its adaxial surface and short scattered white trichomes on its abaxial surface. *A. rigidus*, on the other hand, has short brownish trichomes, but they are rarely present on both the adaxial and abaxial surfaces. *A. lanceifolius* has very short white trichomes, also rarely present on both surfaces. *A. integer* var. *silvestris*, on the other hand, displays long brownish trichomes that are rare on the adaxial surface, while short brownish trichomes are rare on the abaxial surface of the leaves. *A. glaucus* shows short white scattered trichomes on both surfaces of the leaves. Some species exhibit trichomes only on the abaxial surface of the leaves. For instance, *Artocarpus elasticus* has long brownish trichomes scattered all over the surface of the leaves, while *A. altilis* has short white scattered trichomes on the leaf surface. *A. nitidus* and *A. integer*, on the other hand, display very short white and rare trichome distribution on the leaf surface. *Artocarpus* dadah exhibits short white and scattered trichomes on the abaxial surface of the leaves. The remaining studied samples do not show trichomes on either surface of the leaves (Table 3).

3.3. Venation

Venation has proven to be highly taxonomically significant in distinguishing the studied species. While the majority of the specimens exhibit simple pinnate venation, one particular species displays pinnate lobe venation, namely, *A. altilis*. This feature could be utilized as a distinguishing characteristic, given that *A. altilis* is the only member of *Artocarpus* possessing this trait. Additionally, all studied specimens, including the outgroup, exhibit weak brochidodromous apical lateral venation (Table 4 and 5). Vein spacing varies between the members of the genus. Some of the species show more uniform veins spacing. This includes *A. heterophyllus, A. camansi, A. nitidus, A. teysmanii, A. glaucus* and *A. dadah*. Species that show decreasing distances toward base of the veins spacing are *A. rigidus* and *A. kemando.* The remaining members of the genus shows an increasing distance of veins spacing towards the center (Table 4 and 5). The 3rd venation of the studied sample shows variation within the members of the genus. Although, majority of the species shared mix opposite alternate percurrent type of 3rd veins, some of the species show an alternate percurrent and opposite percurrent type of vein category. Almost all studied species show similarity in agrophic venation. Only *A. kemando* shows absent of agrophic venation. All studied species have sinuous vein course, some are prominent while some are barely visible through observation (Table 4 and 5).

3.4. Petiole Features

The outline of the petiole provides an additional key that can be used to differentiate species among the members of *Artocarpus*. While the majority of studied species exhibit a normal petiole base, some species have swollen petiole bases, namely *A. elasticus, A. scortechinii, A. camansi*, and *A. altilis.* Almost all studied species do not have a geniculate (bend-like) feature. One species, in particular, stands out from the rest of the *Artocarpus* members by lacking trichomes on its petiole, namely *A. altilis*. The trichome color of the studied samples ranges from whitish to brownish. These results support studies conducted by Berg et al. (2006) (refer to Table 6).

3.5. Additional Key

Majority of the studied species show full amplexicaul stipule feature (Table 7).

Table 1. General features of studied species

No	Species	Habitat	Tree's height (m)	Type of tree	Buttress	Bark color	Bole			Sap features	Armed
							Bark texture	Lenticel presenting	Other special features		
1	*A. heterophyllus*	Cultivated lowland	5-7	Small tree	Present	Greyish	Rough	Absent	N/A	VSW	Absent
2	*A. elasticus*	Hillside	9-21	medium to large	Present	Greyish	Rough	Lenticel ≤3mm	N/A	VSW	Absent
3	*A. scortechinii*	Lowland area	11-12	Medium tree	Present	Greyish	Rough	Lenticel ≤3mm	N/A	VSW	Absent
4	*A. camansi*	Lowland area	10	Medium tree	Present	Greyish	Rough	Absent	N/A	VSW	Absent
5	*A. altilis*	Cultivated	5-6	Small tree	Present	Greyish	Rough	Absent	N/A	VSW	Absent
6	*A. rigidus*	Hillside	9-20	Medium tree	Present	Grey brownish	Rough	Absent	N/A	VSW	Absent
7	*A. nitidus*	Swampy area	21-23	Medium tree	Present	Grey brownish	Rough	Absent	N/A	VSW	Absent
8	*A. lanceifolius*	Hillside	20-22	Medium to large	Present	Grey brownish	Rough	Absent	N/A	VSW	Absent
9	*A. teysmanii*	Swampy area	19-22	Medium tree	Present	Grey brownish	Rough	Absent	N/A	VSW	Absent
10	*A. integer* var.*silvestris*	Swampy area	5-6	Small tree	Present	Dark grey	Rough	Lenticel ≤3mm	New leaves at syncarp scar	VSW	Absent
11	*A. integer*	Cultivated lowland	5-6	Small tree	Present	Greyish	Rough	Absent	N/A	VSW	Absent
12	*A. glaucus*	Hillside	18	Medium tree	Present	Greyish	Rough	Lenticel ≤3mm	N/A	VSW	Absent
13	*A. kemando*	Swampy area	9	Small to medium	Present	Greyish	Rough	Lenticel ≤3mm	N/A	VSW	Absent
14	*A. dadah*	Swampy area	21	Medium tree	Present	Greyish	Rough	Lenticel ≤3mm	N/A	VSW	Absent
15	*F. hispida*	lowland	6	Small tree	Absent	Greyish	Smooth	Absent	N/A	SSW	Absent

Small tree (≤30 ft/≤9m). Medium tree (30-70ft/9-21m). Large tree (> 70ft/ > 21m, VSW = Very Sticky White sap, STW = Slightly Sticky White sap

Table 2. Leaves of studied species I

No	Species	Size		Typeof leaves	Texture		Symetrical of lamina	Phylotaxy	Leaf blade shape	Leaf apex	Leaf base shape	Fresh leaves color (above)
		Width (cm)	Length (cm)		Adaxial	Abaxial						
1	*A. hetero-phyllus*	7-9	12-13	Simple	Smooth	Smooth	Symmetry	Alternate spiral	Ovate to elliptic	Short acuminate	cuneate	Dark green shiny
2	*A. elasticus*	12-13	45-54	Simple	Smooth	Leathery	Symmetry	Alternate spiral	Elliptic	Acuminate	cuneate	Dark green
3	*A. scortechinii*	25	38	Simple	Scabrous	Leathery	Symmetry	Alternate spiral	Elliptic	Acute	Cuneate	Green wavy vertical
4	*A. camansi*	40-60	90-95	Simple	Scabrous	Scabrous	Symmetry	Alternate spiral	Elliptic to sub-ovate	Acuminate	cuneate	Dark green shiny
5	*A. altilis*	30	58	Simple	Smooth	Scabrous	Symmetry	Alternate spiral	Elliptic	Acute	cuneate	Green shiny
6	*A. rigidus*	12-15	26-30	Simple	Scabrous	Scab-ridulous	Symmetry	Alternate spiral	Elliptic	Acute	cuneate	Dark green
7	*A. nitidus*	6.5	18.8	Simple	Smooth	Smooth	Symmetry	Distichious	Ovate	Acuminate	Round	Green shiny
8	*A. lanceifolius*	13-17	34-41	Simple	Smooth	Smooth	Symmetry	Alternate spiral	Elliptic	Acuminate	cuneate	Dark green
9	*A. teysmanii*	6-8	11-14	Simple	Smooth	Smooth	Symmetry	Alternate spiral	Ovate	Acute	Cordate	Grenish
10	*A. integer* var. *silvestris*	7-9	20-25	Simple	Smooth	Scabrous	Symmetry	Alternate spiral	Elliptic to ovate	Acuminate	cuneate	Dark green with white to brown dots
11	*A. integer*	6-8	16-19	Simple	Smooth	Scabrous	Symmetry	Alternate spiral	Elliptic to ovate	Short acuminate	cuneate	Dark green with white to brown dots
12	*A. glaucus*	11-12	21-26	Simple	Gloucous	Gloucous	Symmetry	Distichious	Elliptic to sub-obovate	Acuminate	Round	Greenish
13	*A. kemando*	5.0-6.5	14-18	Simple	Smooth	Scab-ridulous	Symmetry	Alternate spiral	Elliptic to sub-obovate	Acuminate	cuneate	Greenish
14	*A. dadah*	8-10	18-26	Simple	Smooth	Scabrous	Symmetry	Distichious	Oblong	Acute	Round	Greenish
15	*F. hispida*	9-12	20-22	Simple	Scabrous	Scabrous	Symmetry	Oposite	Sub-obovate	Acuminate	Cuneate	Greenish

Table 3. Leaves of studied species II

No	Species	Leaf margin type		Trichome/indumentum on matured leaf		
		Juvenile	Mature	Trichome presenting (Present/absent)	Adax indumentum (mono/Polymorphic)	Abax indumentum (mono/Polymorphic)
1	*A. heterophyllus*	Entire	Entire	Absent both side	Absent	Absent
2	*A. elasticus*	Lobed-incised half to midrib, V shaped sinus	Entire	Present abaxially	Absent	Brownish/ long/scattered
3	*A. scortechinii*	Lobed-incised down to midrib, narrow U-shaped sinus	Entire	Present both side	Brownish/Long/scattered	Brownish/Long/scattered
4	*A. camansi*	Lobed-incised down to midrib, broad U-shaped sinus	Lobed-incised down to midrib, broad U-shaped sinus	Present both side	White/long/dense	White short/scattered
5	*A. altilis*	Lobed-incised down to midrib, broad U-shaped sinus	Lobed-incised down to midrib, broad U-shaped sinus	Present abaxially	Absent	White short scattered
6	*A. rigidus*	Entire	Entire	Present both side	Brownish/short/rarely	Brownish/short/rarely
7	*A. nitidus*	Entire	Entire	Present abaxially	Absent	White/very short/rarely
8	*A. lanceifolius*	Lobed-incised half to midrib, V shaped sinus on apex only.	Entire	Present both side	White/very short/rare	White/very short/rare
9	*A. teysmanii*	Entire	Entire	Absent both side	Absent	Absent
10	*A. integer* var. *silvestris*	Lobed-incised half to midrib, broad V shaped sinus on apex only.	Entire	Present both side	Brownish/long/rare	Brownish/short//rare
11	*A. integer*	Entire	Entire	Present abaxially	Absent	White/very short/rare
12	*A. glaucus*	Entire	Entire	Present both side	White/short. Scattered	White/short. Scattered
13	*A. kemando*	Entire	Entire	Absent both side	Absent	Absent
14	*A. dadah*	Entire	Entire	Present abaxially	Absent	White, short, scattered
15	*F. hispida*	Entire	entire	Present both side	White long scattered	White, short, scattered

Table 4. Venation of studied species I

No	Species	Primary vein				2nd vein			
		Type	Width (mm)	Basal lateral	Apical lateral	Diameter (mm)	Pair	Spacing	Visibility
1	*A. heterophyllus*	Pinnate simple	8-15	Decurrent	Weak brochidodromous	0.2-0.5	6-9	Uniform	Slightly
2	*A. elasticus*	Pinnate simple	9-10	Excurrent	Weak brochidodromous	0.8-1.0	18-20	Increasing toward center	Slightly
3	*A. scortechinii*	Pinnate simple	3-5	Decurrent	Weak brochidodromous	2-5	10-14	Increasing toward center	Slightly
4	*A. camansi*	Pinnate simple	60-80	Decurrent	Weak brochidodromous	20-40	15-17	Uniform	Not prominent
5	*A. altilis*	Pinnate lobed	40-60	Decurrent	Weak brochidodromous	1.0-1.5	12-15	Irregular	Prominent
6	*A. rigidus*	Pinnate simple	2-3	Excurrent	Weak brochidodromous	0.5-1.0	12-14	Decreasing towars base	prominent
7	*A. nitidus*	Pinnate simple	1.0-1.5	Excurrent	Weak brochidodromous	0.5-0.8	11-12	Uniform	Prominent
8	*A. lanceifolius*	Pinnate simple	35-40	Decurrent	Weak brochidodromous	0.5-1.0	10-11	Increasing toward base	Slightly
9	*A. teysmanii*	Pinnate simple	1.0-1.5	Decurrent	Weak brochidodromous	0.25-0.4	8-9	Uniform	Prominent
10	*A. integer* var.*silvestris*	Pinnate simple	0.5-0.7	Excurrent	Weak brochidodromous	0.2-0.3	11-12	Increasing toward center	Prominent
11	*A. integer*	Pinnate simple	1.0-1.5	Decurrent	Weak brochidodromous	0.3-0.5	8-9	Irregular	Slightly
12	*A. glaucus*	Pinnate simple	4-6	Decurrent	Weak brochidodromous	0.5	10-12	Uniform	Prominent
13	*A. kemando*	Pinnate simple	2.5-2.7	Excurrent	Weak brochidodromous	0.55-0.58	13-15	Decreasing towars base	Slightly
14	*A. dadah*	Pinnate simple	1.0-1.5	Excurrent	Weak brochidodromous	0.5	16-17	Uniform	Prominent
15	*F. hispida*	Pinnate simple	1.0-1.5	Decurrent	Weak brochidodromous	0.3-0.5	5-7	Increasing toward center	Slightly

Table 5. Venation of studied species II

No	Species	Inter-secondary vein	Agrophic (Simple/ Compound)	3rd vein category	3rd vein course	3rd vein visibility from above	4th vein category	Ultimate marginal vein
1	*A. heterophyllus*	present	Simple	Mix opposite alternate percurrent	Sinuous	Slightly	Mix opposite alternate percurrent	Looped
2	*A. elasticus*	present	Simple	Mix opposite alternate percurrent	Sinuous	Not obvious	Mix opposite alternate percurrent	Looped
3	*A. scortechinii*	present	Simple	Mix opposite alternate percurrent	Sinuous	Not obvious	Alternate percurrent	Looped
4	*A. camansi*	present	Simple	Mix opposite alternate percurrent	Sinuous	Slightly	Mix opposite alternate percurrent	Looped
5	*A. altilis*	present	Simple	Opposite percurrent	Sinuous	Not obvious	Opposite percurrent	Looped
6	*A. rigidus*	present	Simple	Mix opposite alternate percurrent	Sinuous	Slightly	Mix opposite alternate percurrent	Looped
7	*A. nitidus*	present	Simple	Opposite percurrent	Sinuous	Prominent	Opposite percurrent	Looped
8	*A. lanceifolius*	present	Simple	Alternate percurrent	Sinuous	Slightly	Mix opposite alternate percurrent	Looped
9	*A. teysmanii*	Typically, absent	Simple	Alternate percurrent	Sinuous	Not obvious	Opposite percurrent	Looped
10	*A. integer* var.*silvestris*	present	Simple	Alternate percurrent	Sinuous	Not obvious	Opposite percurrent	Looped
11	*A. integer*	present	Simple	Alternate percurrent	Sinuous	Not obvious	Opposite percurrent	Absent
12	*A. glaucus*	Present	Simple	Opposite percurrent	Sinuous	Prominent	Alternate percurrent	Looped
13	*A. kemando*	Present	Absent	Opposite percurrent	Sinuous	Not obvious	Reticulate	Absent
14	*A. dadah*	present	Simple	Alternate percurrent	Sinuous	Absent	Alternate percurrent	Looped
15	*F. hispida*	present	Simple	Mix opposite alternate percurrent	Sinuous	Not obvious	Mix opposite alternate percurrent	Looped

Broch=Brochidodromous.Unif=Uniform, Irre=Irregular, Dtb=Decreasing towars base, Itb=Increasing toward base.Alt=Alternate, Prec=percurrent, Op=Opposite, Mx=mix.Cvx=Convex, Str=Straight, Sin=Sinous, Sht=Short,VSht=Very Short ,Lg=long, Dns=Dense, Sctr=Scattered.Areaolar venation: Nil=No veinlet, Svnt=Simple veinlet, Bvnt=Bi-veinlet, Tvnt=Triveinlet.Marginal venation: Cmplt=complete, NCmplt=Non-completeCategory 2nd vein- brochidodromous (single loop) : weak brochidodromous, brochidodromous -Double or mor set of loop : Festooned brochidodromous.

Table 6. Petiole of studied species

No	Species	Size			Petiole feature		Petiole indumentum		
		Width (mm)		Length (mm)	Petiole base swollen	Geniculate (Bend-like)	Trichome present	Trichome color	Trichome features
		Base	Apex						
1	*A. heterophyllus*	1.5-2	1.5-2	18-22	Normal	Absent	Present	Whitish	Sparsely
2	*A. elasticus*	10-18	4-5	65	Base swollen	Absent	Present	Brownish	Appressed
3	*A. scortechinii*	5	3	50-65	Base swollen	Absent	Present	Brownish	Scattered
4	*A. camansi*	6		60	Base swollen	Absent	Present	Short white	Dense
5	*A. altilis*	10	5	50	Base swollen	Absent	Absent	N/A	N/A
6	*A. rigidus*	3-5	3-5	30-35	Normal	Absent	Present	Long brown	Long/ Dense
7	*A. nitidus*	1-1.5	1-1.5	8-10	Normal	Absent	Present	Short white	Short/Scattered
8	*A. lanceifolius*	3-4	3-4	19-21	Normal	Absent	Present	Short white	Short/ Scattered
9	*A. teysmanii*	1.5-3	1.5-3	36-41	Normal	Absent	Present	White	Very short/ Scattered
10	*A. integer* var.*silvestris*	1-1.5	1-1.5	14-24	Normal	Absent	Present	Brownish	Long/ scattered
11	*A. integer*	1-2	1-2	10-17	Normal	Absent	Present	White	Long/ scattered
12	*A. glaucus*	1-5-2	1-5-2	18-22	Normal	Absent	Present	White	Short/ Scattered
13	*A. kemando*	1	1	14-17	Normal	Absent	Present	Brownish	Short/dense
14	*A. dadah*	2-3	2-3	6-8	Normal	Absent	Present	Brownish	Short/dense
15	*F. hispida*	1-1.2	1-1.2	25-30	Normal	Absent	Present	White	Short/scattered

Table 7. Stem (twig) of studied species

No	Species	Lenticel	Trichome	
			Presenting	features
1	*A. heterophyllus*	Present	Absent	N/A
2	*A. elasticus*	Present	Present	Short brown
3	*A. scortechinii*	Present	Present	Short brown
4	*A. camansi*	Present	Present	Short white
5	*A. altilis*	Present	Present	Short white
6	*A. rigidus*	Absent	Present	Short brown
7	*A. nitidus*	Absent	Present	Short white
8	*A. lanceifolius*	Present	Present	Short white
9	*A. teysmanii*	Absent	Present	Short white
10	*A. integer* var.*silvestris*	Present	Present	Long white/Long yellowish
11	*A. integer*	Present	Present	Very short
12	*A. glaucus*	Absent	Present	Short white
13	*A. kemando*	Absent	Present	Long scattered intermixed dense short
14	*A. dadah*	Absent	Present	Short white
15	*F. hispida*	Present	Present	White/long/ scattered

3.6. Dichotomous Key

Key provided by morphological character is sufficient to construct general key in term of common criteria shared by all the studied species. Leaf and bark characters also provided enough data to carefully delineate each member of the genus at species level. The following field guide are constructed key based on morphological characteristics.

Field guide key (Habitat, texture, lamina shape & phyllotaxy) key guide for *Artocarpus* species

a. Milky latex
…… **Moraceae**
b. Non-Milky latex …….. **Other than Moraceae**

***Artocarpus* subgenus key**

a. Phyllotaxy alternate spiral, intercostal vein not distinctly or slightly visible above ……..... **Subgenus Artocarpus (A)**
b. Phyllotaxy distichous, intercostal vein distinctly visible above ……
……..…. **Subgenus Pseudojaca (B)**

(A) Subgenus *Artocarpus*

1a. Cultivated…… **2**
b. Grow wild…… **4**

2a. Leaves abaxial smooth, trichome absent; 2nd venation uniform, 3rd vein category mix opposite alternate percurrent ……..... ***A. heterophyllus***
b. Leaves abaxial scabrous, trichome present; 2nd venation irregular, 3rd venation category not mix opposite alternate percurrent ……..... **3**

3a. Leaves blade elliptic, apex acute, margin lobed-incised down to midrib with broad U shape sinus; primary vein pinnate lobed, 3rd vein opposite percurrent, marginal veins ultimate looped; petiole indumentum absent…… ***A. altilis***
b. Leaves blade elliptic to ovate, apex short acuminate, margin entire; primary vein pinnate simple, 3rd vein alternate percurrent, marginal veins ultimate absent; petiole indumentum presence……..... ***A. integer***

4a. Lowland area…… **5**
b. Hillside or Swampy……..... **6**

5a. Leaves blade elliptic to sub-ovate, apex acuminate, margin lobed-incised down to midrib with broad U shape sinus, scabrous adaxial and abaxial; bole lenticel absent……..... ***A. camansi***
b. Leaves blade elliptic, apex acute, margin entire, adaxial scabrous and abaxial leathery; bole lenticel presence……..……. ***A. scortechinii***

6a. Hillside……. **7**
b. Swampy area…….…… **9**

7a. Bark greyish, bole lenticel less or equal to 3mm; leaves blade abaxial leathery, abaxial with indumentum ……..……. ***A. elasticus***
b. Bark grey brownish, bole lenticel absent; leaves blade abaxial not leathery, abaxial and adaxial with indumentum ……. **8**

8a. Leaves blade adaxial scabrous, abaxially scabridulous, apex acute, basal lateral excurrent; 2nd veins spacing decreasing toward base, 2nd veins visibility prominent …..... ***A. rigidus***
b. Leaves blade adaxial and abaxial smooth, apex acuminate, basal lateral decurrent; 2nd veins spacing increasing toward base, 2nd veins visibility slightly prominent …….. ***A. lanceifolius***

9 a. Bark dark grey; leaves blade elliptic to ovate, indumentum present on both surfaces; 2nd veins increasing toward center……. ***A. integer* var. *silvestris***
b. Bark not grey; leaves blade not elliptic to ovate, indumentum absent on both surfaces; 2nd veins not increasing toward center……..… **10**

10 a. Leaves blade elliptic to sub obovate, abaxial scabridulous; 2nd veins spacing decreasing toward base, 2nd veins visibility slightly, 4th veins category reticulates, veins margin ultimate absent……..……..…. ***A. kemando***
b. Leaves blade oblong or ovate, abaxial scabrous or smooth; 2nd veins uniform, 2nd veins visibility prominent, 4th veins category alternate or opposite percurrent, veins margin ultimate loop……..… ***A. teysmanii***

(B) Subgenus *Pseudojaca*

1a. Bark grey brownish; leaves blade ovate, abaxial smooth; 4th veins category opposite percurrent, petiole indumentum short white ……..……..…… ***A. nitidus***
b. Bark greyish; leaves blade not ovate, abaxial glaucous or scabrous; 4th veins category alternate percurrent, petiole indumentum white or brownish ……..……. **2**

2a. Leaves blade elliptic to sub obovate, apex acuminate, adaxial and abaxial glaucous, indumentum present on both surfaces, basal lateral decurrent; petiole indumentum white ……. ***A. glaucus***
b. Leaves blade oblong, apex acute, adaxial smooth, abaxial scabrous, indumentum present abaxially, basal lateral excurrent; petiole indumentum brownish …..…… ***A. dadah***

3.7. Characters Evaluated and Scoring

Among 39 characters of the gross morphology (Appendix A), eight characters were obtained from the habitat type and general characteristics of the studied species were buttress and sap features. Twelve (12) characters were obtained from leaves of the studied species, twelve (12) characters were obtained from venation of the studied species, and seven (7) characters were obtained from the petiole and stem of the studied species. Nineteen (19) characters were identified as binary discrete qualitative character i.e. character 2, 4, 5, 6, 7, 8, 9, 12, 21, 22, 23, 27, 29, 32, 33, 34, 35, 37 and 38. Discrete qualitative with multi-state condition involve 20 characters i.e. character 1, 3, 10, 11, 13, 14, 15, 16, 17, 18, 19, 20, 24, 25, 26, 28, 30, 31, 36 and 39. Morphological numerical dendrogram analysis obtained from MVSP is shown in figure 4.4. Gower's General Similarity Coefficient (GGSc) is scored based on 3 categories. GGSc with values above 0.65 is considered high, while GGSc with values between

0.3 – 0.65 is considered moderate. GGCs with a value lower than 3.0 is considered very low in term of similarity coefficients. The morphological dendogram obtained had an overall GGSc of 0.60 to – 0.84. The data show a clear morphological separation in both genus and species levels. Based on the data obtained, *Artocarpus* can be divided into two clusters (Figure 1), with *Artocarpus kemando* resolving the earliest without belonging to any cluster. This might be due to *A. kemando* having multiple unique characters that differentiate itself from the rest of the members.

Cluster I consisted of *A. teysmanii*, *A. glaucus*, *A. dadah*, *A. nitidus*. *A. integer* var. *silvestris*, and *A. rigidus*. Cluster II consist of *A. altilis*, *A. lanceifolius*, *A. camansi*, *A. scortechinii*, *A. elasticus*, *A. integer* and *A. heterophyllus*. Each cluster shows high similarity indicating that the species within the genus shared many characteristics. The highest GGSc scored between clusters is cluster II which shows GGSc higher than 0.89.

The Neighbor-joining tree had a minimum evolution score of 3.01039 in accordance with the branch length between the in-group and out-group taxa. The pairwise distance between the in-group was between 0.07164 to 0.25194. The neighbour-joining trees were constructed with medium bootstrap support (Figure 2). The major clade branched into two clusters. Ficus elasticus resolved the earliest, Cluster 1 consisted of *A. heterophyllus*, *A. altilis*, *A. integer*, *A. nitidus*, *A. glaucus*, *A. dadah*, *A. teysmanii*, *A. kemando*, *A. integer* var. *silvestris*, *A. rigidus* and *A. lanceifolius*. Cluster II consist of *A. elasticus*, *A. scortechinii*, and *A. camansi*. The majority of the clusters were supported by average bootstrap value (54), whilst the sub-cluster between *A. elasticus* and *A. scortechinii* showed the highest bootstrap value (71).

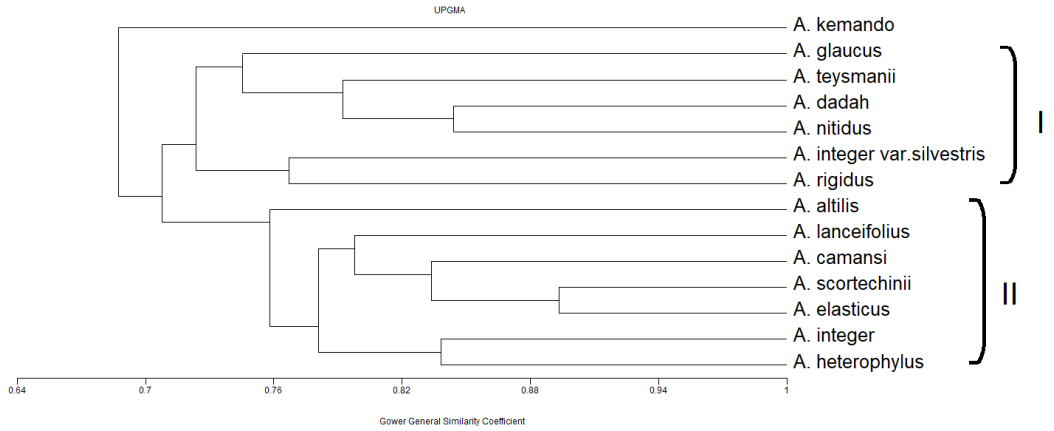

Figure 1. Morphology Gower General Similarity Coefficient Dendrogram

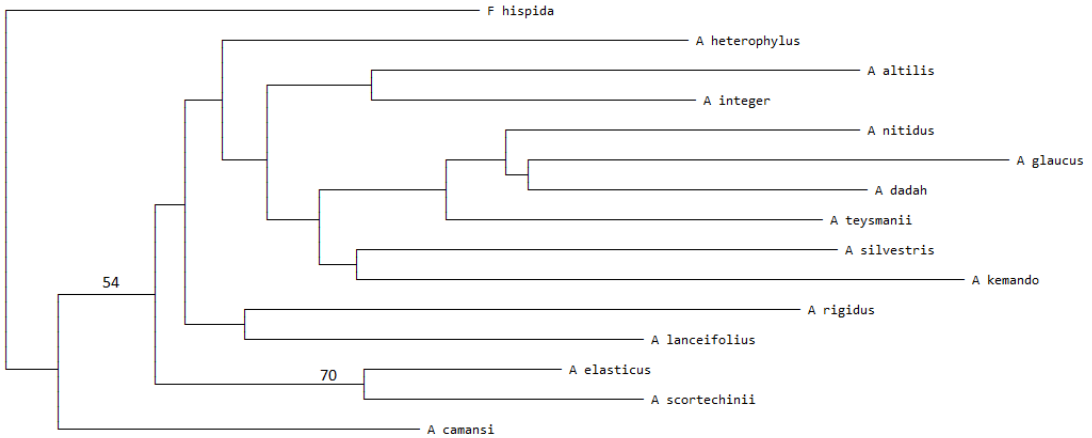

Figure 2. Neighbor-joining tree based on morphological characters

3.8. Artocarpus diversity and its distribution in Perak Province

Perak forest reserves are preferred based on their richness in species diversity which are affected by its unique phytogeography position. In addition, the state of Perak being the location for many important mountains in Peninsular Malaysia namely Titiwangsa mountain (Banjaran Titiwangsa), Bintang mountain (Banjaran bintang) and Keledang mountain (Banjaran Keledang). Some of the samples were obtained from arboretum of Forest Research Institute Malaysia (FRIM). Details information about the characters that can be obtained only from fresh sample in the field were recorded during the fieldwork. This is important to avoid any mistake from occurring. For each sample species, three to five samples were collected. The important data were recorded during the process of collecting sample, such as collection number, area, date and plant characters. Perak sub-province are divided into smaller manageable district in order to properly distinguish *Artocarpus* distribution within its designated location. Table 8 depicts each district having a forest or an eco-park that the researcher visited.

Table 8. List of districts and its respective forest and eco types

District	Forest / Eco Park	Forest type
Northern part	Bukit Relau F.R., Kedah	Lowland Dipterocarp Forest - Tropical
	Lata Bukit Hijau Forest Kedah	
Hulu Perak	Papulut F.R., Gerik and its surrounding area	Hill Dipterocarp Forest - Tropical
Matang District	Bukit Jana Eco Park and its surrounding area	Lowland Dipterocarp Forest – Tropical
Kuala Kangsar	Bukit Sapi Forest and its surrounding area	Hill Dipterocarp Forest – Tropical
	Ulu Kenas Forest and its surrounding area	Lowland Dipterocarp Forest - Tropical
Kinta District	Sungai Salu Eco Park and its surrounding area	Lowland Dipterocarp Forest – Tropical
Batang Padang	Kuala Woh Forest and its surrounding area	Hill Dipterocarp Forest – Tropical
Perak Tengah District	Papan F.R., and its surrounding area	Lowland Dipterocarp Forest – Tropical
Hilir Perak District	Sentosa Eco Park and its surrounding area	Lowland Dipterocarp Forest – Tropical
Muallim District	Sg Dara F.R.,	Lowland Dipterocarp Forest – Tropical
Southern Part	Commonwealth Forest Park and its surrounding area	Lowland Dipterocarp Forest – Tropical
	FRIM Arboretum	

Specimen diversity is thoroughly defined as seen on Table 2. There were three type of forest type in which *Artocarpus* specimens were collected in Perak sub-province namely Lowland Dipterocarp Forest, Hill Dipterocarp Forest and Forest Park in which encompasses of swampy / wet area. Cultivated *Artocarpus* such as *Artocarpus heterophyllus* and *Artocarpus integer* were found mainly on lowland with proximity to settlement area. The highest number of collected *Artocarpus* species, *Artocarpus scortechinii* were mainly found on Lowland Dipterocarp Forest or lowland area. *Artocarpus camansi* could also be found within this locality. Four of the collected specimens were found in Hill Dipterocarp Forest namely *Artocarpus elasticus, Artocarpus rigidus, Artocarpus lanceifolius* and *Artocarpus glaucus.* Majority of *Artocarpus* species were found in lowland swampy areas.

3.9. Frequency of Species

Wild species of *Artocarpus* such as *A. scortechinii* (n=342) are well distributed in all Perak district, followed by *A. rigidus* (n=13), *A. elasticus* (n=10), *A. lanceifolius* (n=7), *A. integer* var. *silvestris* (n=6), *A. nitidus (n=6), A. kemando* (n=5), *A. dadah (n=3), A. teysmanii* (n=3), *A. camansi* (n=1), *A. glaucus (n=1).* Wild species of *Artocarpus* are well distributed in Perak sub-province in comparison to cultivated species.

3.10. Diversity of subgenus

Batang Padang district has the highest number of *Artocarpus* species where four wild species were found namely *A. rigidus, A. elasticus, A. scortechinii* and *A. lanceifolius*. Matang

district has the second highest number of *Artocarpus* species where three species were found namely *A. glaucus*, *A. integer* var. *silvestris* and *A. scortechinii*. The least number of *Artocarpus* species recorded in Perak are Hulu Perak, Kinta & Muallim districts, where only *A. scortechinii* was found. Among Perak sub-province, Southern part which cover Selangor area has the most diverse *Artocarpus* species recorded at five species. Northern part of Perak sub-province which cover Kedah area has the least diverse number of *Artocarpus* species recorded where only two species could be found. Interestingly, *A. camansi* which originated from Papua New Guinea could be found in Hilir Perak scattered around a few villages namely Kampung Kebun Limau, Kampung Bahagia in Teluk Intan (Figure 3).

Figure 3. *Artocarpus camansi* at Kampung Kebun Limau, Teluk Intan, Hilir Perak District

3.11. Habitat (Ecological Area) Pattern

This study concluded that there are four types of *Artocarpus* habitat that could be associated with *Artocarpus* which are cultivated at lowland area, growth wild at lowland area or roadside, hillside and wetland area. *A. heterophyllus, A. altilis* and *A. integer* vast cultivated throughout Perak area at its nearest area. *A. scortechinii* or Terap hitam found grow wildly at road side at lowland area. *A. dadah, A. nitidus, A. kemando* and *A. teysmanii* found grow wildly in swampy area. *A. lanceifolius* found in hillside such as Kuala Woh recreational area, Tapah, Perak and Hillside of Commonwealth Forest Park Fall at Rawang, Selangor. *A. glaucus* also found at hillside area of Bukit Jana recreational area.

Figure 4. *Artocarpus* distribution in Perak Province of Malaysia (Recorded Sample)

Table 9. List of Artocarpus specimens and taxa studied

No	Species	Native Name	Locality				Habitat	No of Tree (Spotted)	Voucher	Collector	Collection date
			District	Spotted Area	GPS Location						
					Latitude	Longitude					
1	*A. glaucus*	Nangka pipit	Matang	Bukit Jana, Kamunting	4.8969658	100.7539426	Hillside	1	MA 009 – MA 015	Ismail, Hishamsudin	6/6/2018
2	*A. dadah*	Keledang tampang bulu		Puncak Alam, Selangor	3.248347	101.438694	Swampy	1	MA 076-MA 083	Angan	2018
				Hutan Relau, Kedah	5.2360865	100.5689948	Swampy	2		Abu Husin	2018
3	*A. nitidus*	Keledang tampang		Hutan Bkt Hijau, kedah	5.642636	100.905876	Swampy	3	MA 070, MA 084-MA 085	Abu Hussin	2018
				Kepong, Selangor	3.231114	101.63317	Swampy	3	MA 071-MA 075	Ismail, Angan	2018
4	*A. heterophylus*	Nangka (Keledang)	Hilir Perak	Kg. Bahagia	4.024313	101.0439619	Cultivated	100	MA 058	Ismail	3/6/2018
			Kepong	FRIM	3.235339	101.634269	Cultivated	10	MA 059	Angan	2018
			Matang	Bkt. Jana, Kamunting	4.896752	100.748149	Cultivated	50	MA 060	Ismail	6/6/2018
			Muallim	Behrang	3.806935	101.425532	Cultivated	50	MA 061	Ismail	7/7/2018
5	*A. integer*	Cempedak (Keledang)	Batang padang	Simpang Sg Kelah	3.980289	101.320586	Cultivated	10	MA 025, MA 055, MA 056	Ismail, Jamilah	7/7/2018
			Hilir Perak	Kg. Bahagia	4.024313	101.0439619	Cultivated	50	MA 026	Ismail	1/4/2018
			Kepong Selangor		3.235339	101.634269	Cultivated	1	MA 027	Angan	2/12/2017
			Muallim	Behrang	3.806935	101.425532	Cultivated	10	MA 028	Ismail, Jamilah	2/2/2018
			Matang	Bkt. Jana kamunting	4.896752	100.748149	Cultivated	20	MA 057	Ismail, Hishamsudin	6/6/2018
6	*A. integer* va *silvestris*	Bangkong	Matang Bkt jana	Kamunting	4.8969658	100.7539426	Swampy	2	MA 022-MA 024	Ismail,Hishamsudin	6/6/2018
			Rawang	Commonwealth Forest Park	3.2941218	101.6119532	Swampy	6		Ismail,Ahusin,Atul	
7	*A. teysmanii*	Cempedak air (Terap)	Perak tengah	Kg.Teluk Sareh	3.740762	101.448469	Swampy	3	MA 006-MA 008	Ismail, A Rahman	2/3/2018
			Muallim	Behrang Stesen	4.242485	100.915793	swampy	1		Ismail, Jamilah	22/11/2019
8	*A. rigidus*	Temponek	Kuala kangsar	Bukit Sapi,lenggong	5.1368	101.076285	Hillside	10	MA 016-MA 018	Ismail,Abdullah	13/5/2018
			Batang Padang	Tapah-Cameron road	4.3162506	101.3303931	Hillside	3	(MA 001, MA 002, MA 004.) (MA 003, MA 005) MA 019 - MA 021	Ismail	3/3/2018
9	*A. altilis*	Sukun (Terap)	Hilir Perak	Taman Intanova			Cultivated	5	MA 062	Ismail	1/2/2018
			Kepong, Selangor				Cultivated	1	MA 063	Angan	3/32018
10	*A. camansi*	Marang	Hilir Perak	Kg. Kebun Limau	4.0195437	101.0367857	Lowland	1	MA 029-MA 035	Ismail, Jamilah	2/2/2018
11	*A. elasticus*	Terap nasi	Batang Padang	Tapah Cameron road	4.222818	100.9268441	Hillside	7			2019
			Rawang	Commonwealth Forest Park	3.2941218	101.6119532	Hillside	2			2019
			Kepong, Selangor		3.235339	101.634269	Hillside	1	MA 053, MA 054	Angan	2019
12	*A. scortechii*	Terap hitam	Kinta valley	Simpang Kuala Dipang	4.37729	101.152926	Roadside	20	MA 049	Ismail	6/2/2018
			Matang	Jln Kamunting Taiping	4.8956717	100.7031206	Roadside	30		Ismail,Hishamsudin	2018
			Kuala kangsar	Manong	4.608809	100.9061605	Roadside	30	MA 046	Ismail,Jamilah	3/4/2018
			Hulu perak	Gerik	5.2784329	101.0583541	Roadside	40	MA 038, MA 047	Ismail	1/4/201
			Muallim	Slim River	3.8600874	101.3849002	Roadside	20		Ismail	2018

				Behrang	3.7350793	101.4589244	Roadside	10	MA 039	Ismail	2/6/2018
			Batang padang	Tol Tapah area	4.2206494	101.2662638	Roadside	15	MA 041	Ismail, Jamilah	3/6/2018
				Bidor	4.115719	1.1.280168	Roadside	30	MA 042	Ismail	3/6/2018
				Sungkai	3.98777	101.314895	Roadside	50	MA 043	Ismail, Jamilah	3/6/2018
			Hilir Perak	Taman Impiana	4.007994	101.032926	Roadside	5	MA 040	Ismail	2/1/2018
				Sg.Manik	4.118375	101.120062	Roadside	20	MA 044	Ismail	2/1/2018
			Perak tengah	Bota Kiri	4.3654382	100.8826482	Roadside	50		Ismail	2/1/2018
				Kg. Gajah	4.203073	100.917556	Roadside	10	MA 045	Ismail	2/1/2018
13	*A. lanceifoliu*	Keledang-keledang	Batang padang	Kuala Woh rec. area	4.2430184	101.3226104	Hillside	5	MA 064-MA 069	Ismail	6/2/2018
			Rawang	Common wealth Forest Park	3.17529	101.36408	Hillside	2		Ismail,A husin,Atul	2018
			Batang padang	Tapah Cameron road	3.2941218	101.6119532	Hillside	3			2019
14.	*A. kemando*		Rawang	Common wealth Forest Park	3.2941218	101.6119532	Swampy	5		Ismail,A husin,Atul	2019
15	*F. hidpida*		Perak tengah	Kg. Tersusun Tg. Sareh			Roadside	20		Ismail	19/11/19
			Muallim	Behrang-Tg. Malim road			Roadside	15		Ismail	22/11/19

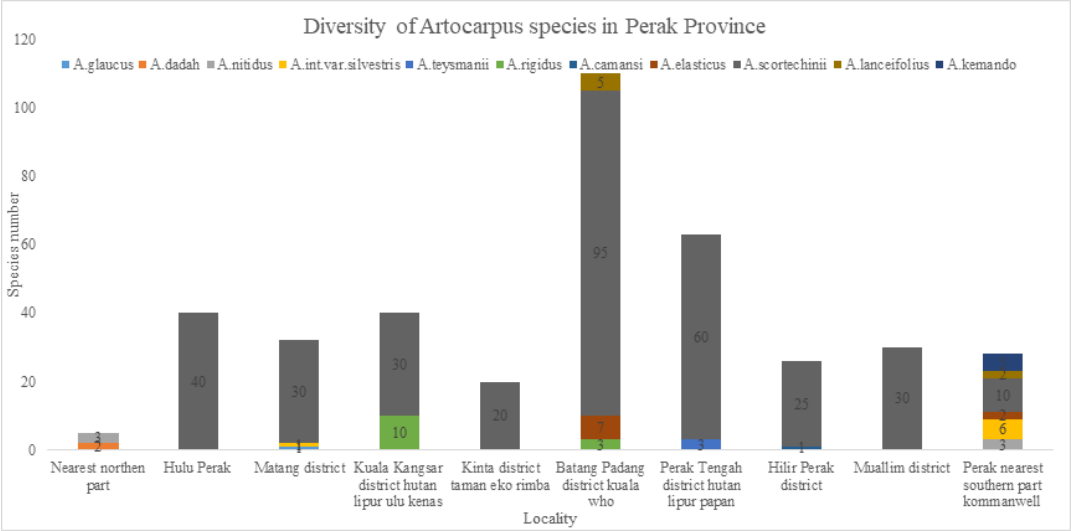

Figure 5. Diversity of *Artocarpus* species in Perak Province

4. CONCLUSION

The thirty-nine vegetative morphological characters evaluated using Multi-Variate Statistical Package (MVSP) and Phylogeny Analysis Using Parsimony (PAUP) are found to be of taxonomic significance at all genus, tribe and species levels. The developed field guide using these characters is workable for species identification. Bole lenticel and bark colour prove to be of taxonomic significance at subgenus level, whilst-leaf shape, texture, latex, and venation can lead to species identification. It also shows that vegetative characters are useful as guides to determine *Artocarpus* genus and subgenus in the field. The habit of growth is another useful character in the field. It is concluded that the findings from this research were in agreement to Berg et al. (2006) which found that the morphological characters are very useful and highly significant taxonomically.

Among all 14 species within 350 of *Artocarpus* samples collected, *A. nitidus* has the widest distribution. It is widely distributed to all across ten studied areas in Perak Province and most abundant in Batang Padang. This study also found that southern Perak Province has the highest diversity of *Artocarpus* members. The discovery of *Artocarpus camansi* or Keluih in Perak Tengah and Muallim is a surprising as it is known as a Philippines species.

Declaration of Interest
I declare that there is no conflict of interest.

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Appendix A: Key scoring character

Key	**Character**
1. General feature	
Habitat	Cultivated (0), Lowland (1), Hillside (2), Swampy (3) Butress
Butress	Absent (0), Present (1) Bark Color Greyish (0), Greyish brownish (1)
Bark Color Greyish (0), Greyish brownish (1)	Color Greyish (0), Greyish brownish (1)
i. Bole	
ii. Bark texture	Smooth (0), Rough (1)
ii. Lenticel	Absent (0), Present (1)
iii. Special character	N/A (0), New leaves at syncarp (1)
Sap feature	Ssw (0), Vsw (1)
Armed Absent (0), Present (1)	Absent (0), Present (1)
2. Leaves	
Leaves types	Compound (0), Simple (1)
Texture	
Adax	Scabrous (0), Smooth (1)
Abax	Scabrous (0), Smooth (1)
Lamina symmetry Asymmetry (0), Symmetry (1)	Asymmetry (0), Symmetry (1)
Phylotaxy	Opposite (0), Distichious (1), Alternate spiral (2)
Leaf shape	Sub-obovate (0), Elliptic (1), Elliptic to sub-ovate (2), Elliptic to ovate (3), Ovate (4), Oblong (5),
Leaf apex	Acuminate (0), Acute (1), Short acuminate (2),
Leaf base	Cuneate (0), Round (1), Cordate (2),
Leaf margin	
Matured leaf	Entire (0), Lobed incised down (1),
Trichome	Absent (0), Present abaxially (1), Present (2),
Adax indumentum	Absent (0), Brownish-long (1), Brownish short (2), white long (3), White short (4),
Abax indumentum	Absent (0), Brownish-long (1), Brownish short (2), white long (3), White short (4)
3. Venation	
Primary vein	
Type	Pinnate simple (0), others (1),
Basal lateral	Excurrent (0), Decurrent (1),
Apical lateral	Weak brochidodromous (0), Others (1),
Spacing	Uniform (0), Increasing toward center (1), Decreasing toward base (2),
2 nd vein visibility	Not prominent (0), Slightly (1), Prominent (2),
Inter secondary vein	Absent (0), Present (1), Agrophic Absent (0), Simple (1),
3 vein category	Alternate percurrent (0), Opposite percurrent (1), Mix opposite alternate percurrent (2),
3 vein course	Sinuous (0), Other (1),
3 vein visibility	Not prominent (0), Slightly (1), Prominent (2),
4 vein category	Alternate percurrent (0), Opposite percurrent (1), Mix opposite alternate percurrent (2), Reticulate (3),
Marginal ultima	Absent (0), Looped (1),
4. Petiole	
Base	Normal (0), Swollen (1),
Geniculate	Absent (0), Present (1),
Petiole indumentum	
Trichome	Absent (0), Present (1),
Trichome color	White (0), Brown (1),
5. Stem	
Lenticel	Absent (0), Present (1),
Trichome	Absent (0), Present (1),
Features	Absent (0), Short brown (1), Short white (2), Long white (3)