CHAPTER 3.0

ECOLOGICAL STUDIES OF *Amorphophallus* spp. IN PENINSULAR MALAYSIA

3.1 INTRODUCTION

The genus *Amorphophallus* belongs to the Araceae family and it was recorded that there were 12 species found in Peninsular or West Malaysia. They form an attractive plant group of which the corms of several species are edible. Some species are restricted to certain regions in various habitat. This is the case of Peninsular Malaysia, whereby some areas in the north like Perlis and Kedah which have distinct dry period from January till March, while most parts of the country do not have a long dry period. Similarly, the highland regions, for example, Cameron Highlands, experience higher rainfall, cooler climate and different vegetation. The difference in environmental conditions can influence the types of plant dominance in a particular area.

However, little information is available with regards to the ecology of *Amorphophallus* species in Peninsular Malaysia. This study involved:

i) Herbarium studies which involve detailed examination of herbarium specimens from Forest Research Institute Malaysia (FRIM), University Malaya (UM), Kew Botanical Garden (KBG), Sarawak Forest Center (SFC), University Malaysia Sarawak (UNIMAS) and Singapore Botanical Garden (SING) to

determine the distribution and identification of *Amorphophallus* spp. in Peninsular Malaysia.

ii) Field survey and documentation of *Amorphophallus* spp. in Peninsular Malaysia based on data from herbarium studies.

iii) Ecological studies of *A. paeoniifolius* and *A. prainii* in two selected locations in Jerantut, Pahang and Kuala Kangsar, Perak.

3.2 MATERIALS AND METHOD

3.2.1 Distribution of *Amorphophallus* species in Peninsular Malaysia

3.2.1.1 Sample Collections and Survey

The initial identification and collection of data were based on herbarium specimens from Forest Research Institute Malaysia (FRIM), University Malaya (UM), Kew Botanical Garden (KBG), Sarawak Forest Center (SFC), University Malaysia Sarawak (UNIMAS) and Singapore Botanical Garden (SING) in order to determine the locations and abundance of species studied. The above data was used as a guide for the field studies which were carried out throughout Peninsular Malaysia.

3.2.2 Studies on Morphological and Life Cycle

Samples of *Amorphophallus* species found at various locations were brought back to University Malaya for species identification. Herbarium specimens were prepared in replicates and deposited as voucher specimens in University Malaya KLU

herbarium for future record. The morphological characteristics of the plant collected in the field were documented. Specimens were compared with herbarium specimens at FRIM, subsequently were identified and verified by taxonomists at FRIM. The life cycle of *A. paeoniifolius* was observed and recorded starting from March 2009 until May 2010.

3.2.3 Ecological Parameters

Data on the ecological parameters where *Amorphophallus* species prevailed were collected and analyzed for the following parameters,

i) Soil Characteristics
ii) Forest Type
iii) Global Positioning System (GPS)
iv) Altitude
v) Temperature
vi) Humidity
vii) Light intensity

3.2.4 Soil Characteristics: Physical

3.2.4.1 Soil Texture

The surface soil texture was determined in the field. The soil texture which is the percentages of sand, silt, and clay particles in a soil was estimated by feel. The soil was rubbed between the fingers and the thumb and an estimate of the amount of the various separates present was made based on the degree to which the characteristic properties of each were expressed (Figure 3.1).

The soil was moistened when making field estimates of soil texture. The more important characteristics of the various textural classes of soils which were of value and which could be recognized by feel follow the guidelines as in the flowchart of Figure 3.1.

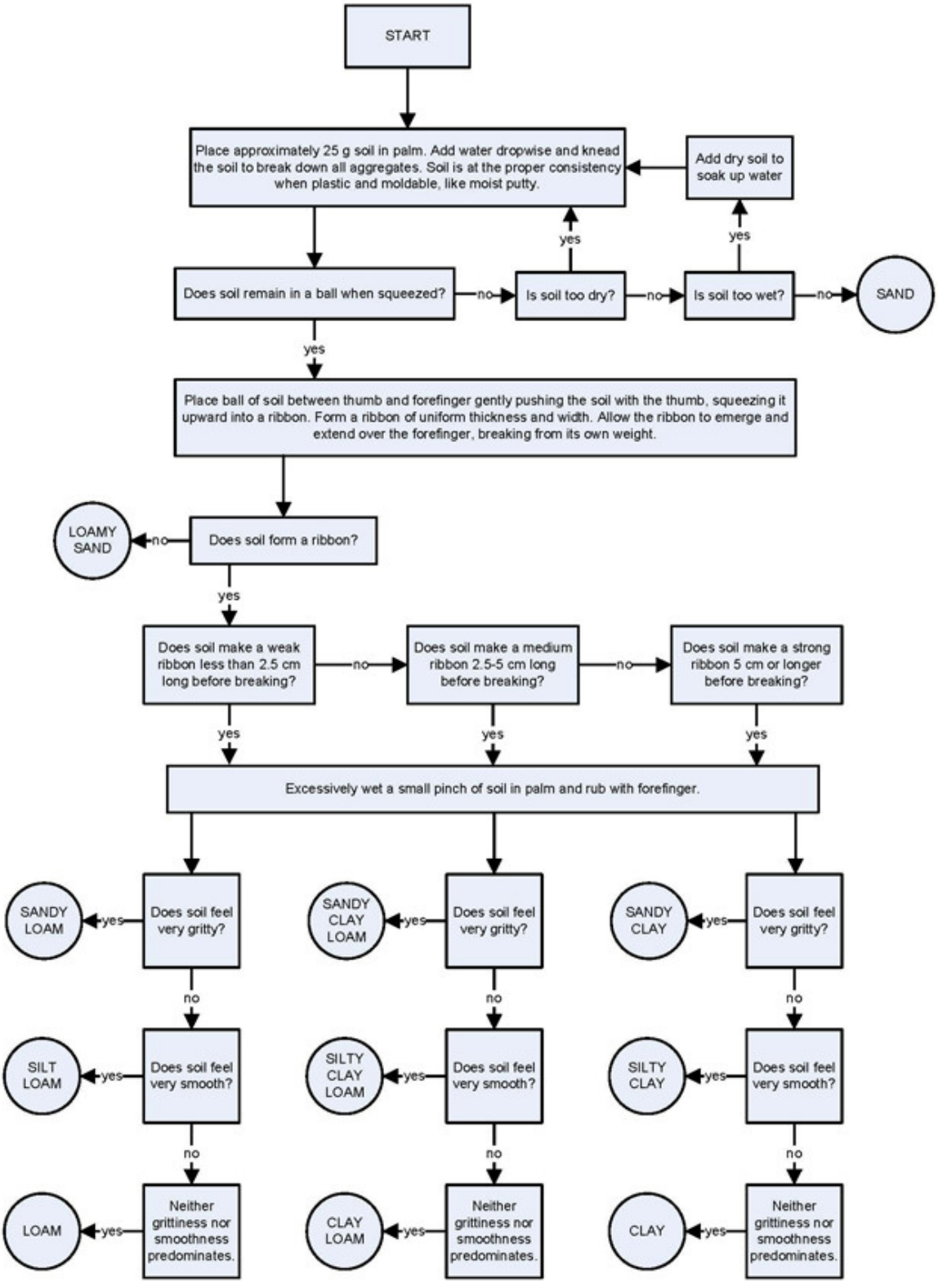

Figure 3.1: The flowchart for estimating the soil texture by feel (Modified from Thien, S. J. 1979)

3.2.4.2 Soil Moisture Content

The mass of moisture can and lid was initially weighed (MC), then the moist surface soil sample was placed in the can, the lid secured and weighed (MCMS). The lid was removed and was placed in a drying oven that was set at 105 °C. The oven was left overnight. It was then allowed to cool to room temperature. The mass of the moisture can and lid (containing the dry soil) was determined and recorded (MCDS).

The soil moisture content (MC) was determined as follows:

$$MC\ (\%) = \frac{MCMS - MCDS}{MCDS - MC} \times 100$$

(Adopted from Kenneth I. P. et al. 1999)

3.2.5 Soil Characteristics: Chemical

3.2.5.1 Soil pH

A ten (10) g of soil was suspended in 25 ml distilled water in a plastic vial. The soil was then stirred for 5 seconds and the sample was left standing for 24 hours. After 24 hours, the pH of the soil samples were measured using a pH meter (pH meter were calibrated using buffer solutions of pH 7 and pH 4). The result was reported as water pH (pH_W). (Adopted from Marion L. et al. 2005)

3.2.5.2 Soil Mineral Content: Potassium (K), Calcium (Ca), and Magnesium (Mg)

A 1M ammonium acetate (pH7) was used in leaching of a 5 g of soil sample for at least 6 hours with 1M NH_4Ac buffered at pH 7. The leachate was collected for determination of exchangeable bases, namely K, Ca and Mg. Potassium (K) was determined by the use of an Auto Analyzer (AA), while Ca and Mg were determined by the Atomic Absorption Spectrophotometer (AAS). (Adopted from Marion L. et al. 2005)

3.2.5.3 Total Nitrogen (N)

Nitrogen was determined using a Kjeldahl Method. A 1 g soil was weighed and put into a 100 mL digestion tube. A ten (10) mL of concentrated sulphuric acid was added onto the tube and the mixture was shaken. Then, 0.3 g $Na_2S_2O_3$ was added into the tube and the mixture was heated. After cooling the tube, 1 g of a mixed catalyst was added and digested until the mixture became grayish white. The digestion tube was then allowed to cool. A 5 mL of deionized water was added before it was filtered and put onto Auto Analyzer (AA) to determine the N value. (Adopted from Marion L. et al. 2005)

3.2.5.4 Total Phosphorus (P)

Phosphorus was determined using a Shaking Method that is, by preparing the extracting solutions consisting of 0.03 N NH_4F and 0.1 NH_4Cl with pH 1.8. A two (2) g of soil was filled into a 20 mL test tube. Fourteen (14) mL of the extracting solution was poured onto the tube. Then, the tube was closed and shaken for 45 seconds. The extract was then filtered before it was put into Auto Analyzer to determine the P content. (Adopted from Marion L. et al. 2005)

3.2.5.5 Total Organic Carbon (TOC)

Total Organic carbon was determined by using the rapid dichromate method. A 1 g of finely ground soil sample was used. The soil organic carbon was oxidized with 10 ml $K_2Cr_2O_7$ (0.5 M) air dry soil in a 500 mL Erlenmeyer flask. The flask was gently swirled to disperse the soil in the solution. Twenty (20) mL of concentrated H_2SO_4 was added to the mixture, swirled for 1 minute and the flask was allowed to stand for about 30 min. Two hundred (200) mL distilled water was added to the mixture and organic carbon was determined by filtration back the excess $K_2Cr_2O_7$ with ferrous ammonium sulphate (0.5 N) by adding 5 ml of concentrated H_2SO_4 and 3-4 drops of orthophenol indicator. (Adopted from Marion L. et al. 2005)

3.2.6 Ecological Studies: Quantitative Analysis

The studies were conducted in two separate locations, namely,

i) Kg. Gintong, in the District of Jerantut, Pahang. GPS: N 3°56.003' E 102°22', and
ii) Ulu Jeliang, in the District of Kuala Kangsar, Perak. GPS: N 4°32.435'E 100°46.073'.

These were repeated during three consecutive seasons and the durations are as shown in Table 3.1

Table 3.1: The three consecutive seasons selected for the ecological studies

Season	Duration (Year 2009)
Season 1	January-April
Season 2	May-August
Season 3	September-December

Data for the monthly rainfall, relative humidity, minimum, maximum and average daily temperature were also collected for comparison purposes.

3.2.6.1 Estimates of Abundance of *Amorphophallus* spp.

In order to determine the abundance estimate of a particular plant species in an area, the density-frequency-dominance measure, the Point Centered Quarter Method was used. A combined abundance estimate used is usually expressed as relative values, relative density is the number of a given species expressed as a percentage of all species present, relative frequency is the frequency of a given species expressed as a percentage of the sum of frequency values for all species present, and relative dominance is the basal area of a given species expressed as a percentage of the total basal area of all species present.

In the selected area for each location, transects were made throughout the area. Random number determined points were selected in the area to be sampled. Each point represented the centre of the measurement area. From the centre, a compass was used to define four quadrants. Distance of the closest plant from the point for each quadrant was measured. Diameters covered by the closest plant were measured. All the information was then transferred to a data sheet.

The quantitative indices represent the coverage area percentage, existence percentage, relative density, relative dominance, relative frequency, relative patchiness and importance value (IV), whereby:

i) Density = individual species number/ sample area (m^2),

ii) Relative density (x) = density for each species/ total densities,

iii) Dominance = coverage area percentage/ total sampling area,

iv) Relative dominance (y) = dominance for each species,

v) Frequency = number of block with the existence species/ total block,

vi) Relative frequency (z) = frequency for each species/ total frequency, and

vii) Importance value (IV) index = (x) + (y) + (z)

(Adopted from Muhamad Shakirin M., 2008)

3.3 RESULTS

3.3.1 Distribution of *Amorphophallus* species in Peninsular Malaysia from Herbarium Records.

From references and records of the herbarium materials stored in the herbarium of UM, FRIM, KEW, SFC, UNIMAS and SING, it was noted that 12 species had been identified to be present in various regions of Peninsular Malaysia. The species were:

i) *Amorphophallus bufo,*

ii) *Amorphophallus carnosus* syn. *carneus,*

iii) *Amorphophallus elatus* syn. *variabilis,*

iv) *Amorphophallus elegans,*

v) *Amorphophallus haematospadix,*

vi) *Amorphophallus longituberosus* syn.*viridis,*

vii) *Amorphophallus minor,*

viii) *Amorphophallus oncophyllus* syn. *muelleri,*

ix) *Amorphophallus paeoniifolius* syn. c*ampanulatus,*

x) *Amorphophallus perakensis,*

xi) *Amorphophallus prainii, and*

xii) *Amorphophallus sparsiflorus.* .

The distribution of various species found from the herbarium records are as shown in Table 3.2.

Table 3.2: Distribution of *Amorphophallus* spp. in Peninsular Malaysia from herbarium records.

Species	Collector/ Date Collected	Collection No.	Locality
A. bufo	Meekiong, Isa Ipor 2007	NA	Cameron Highlands, Pahang
A. carnosus	R. Kiew 1994	RK2884	Bukit Lagi, Kangar, Perlis
A. carnosus	NA 2004	04778	Gua Musang, Kelantan
A. elatus	NA 1804	NA	Johor
A. elatus	NA 1889	NA	Perak
A. elatus	NA 1994	NA	Penang
A. elegans	NA 4/2/1922	NA	Senawang, Negeri Sembilan
A. elegans	Sam Y. Y 17/8/2002	KBG 2002-0656	Endau-Rompin, Sg Salai, Johor
A. haematospadix	NA 1902	NA	Langkawi
A. haematospadix	Saw L. G. 1/6/1999	FRI44960	Bukit Lagi, Kangar, Perlis
A.haematospadix	Saw L.G., Howard A, & Mc Laughin M 3/5/1996	FRI44578	Kaki Bukit, Gua Kelam, Perlis
A. minor	NA 12/1895	22725	Air Itam,Penang
A.minor	M.C. Woods & N.G. Bisset 23/2/1925	1738	Kuala Krai, Kelantan
A. oncophyllus	Saw L.G., Howard A, & Mc	FRI44568	Kaki Bukit,Gua Kelam,Perlis

	Laughin M 3/5/1996		
A. paeoniifolius	NA 1892	NA	Bukit Payong, Melaka
A. paeoniifolius	Hanne Cristinsen & Mr. Rozidan 06/08/1999	2062	Krau Wildlife, Pahang
A. paeoniifolius	NA 1921	NA	Tembeling, Pahang
A. paeoniifolius	F. Ed. Ahmad 15/2/1922	6921	Kuala Krai, Kelantan
A. paeoniifolius	NA 28/4/1994	NA	Sungkai, Perak
A. paeoniifolius	A. H Millard 8/5/1958	326	National Park, Pahang
A. perakensis	NA 5/1889	NA	Perak
A.prainii	NA 6/2/1998	3963	Bukit Kinta, Perak
A.prainii	E. J. Strugnell 8/4/1932	27854	Frasers Hill, Pahang
A. prainii	NA 1916	NA	Kedah
A. prainii	NA 16/4/1917	NA	Tampin, Negeri Sembilan
A. prainii	NA 1919	NA	Penang
A. prainii	NA 1927	NA	Tioman Island, Pahang
A. prainii	R. Kiew 28/4/1987	RK2592	Perak
A.prainii	3/5/1970	NA	Labis, Johor
A.prainii	NA 24/11	NA	Jerantut, Pahang
A. sparsiflorus	NA 16/7/1980	NA	Taiping Hill, Perak

A. variabilis	NA 3/1892	NA	Langkawi
A. variabilis	NA 1902	NA	Langkawi
A. variabilis	NA 1904	NA	Castlewood, Penang
A. variabilis	Gadah anak Umbai& A. H. Millard 8/6/1958	399	Kuala Panson, Hulu Langat, Selangor
A. viridis	NA 17/6/1913	NA	Bukit Galing, Pahang
A. viridis	I. Biggs 24/61922	47	Gombak, Selangor
A. viridis	NA 7/11/1945	NA	Kemaman, Bkt Kajang, Terengganu

Note: NA = not available

3.3.2 Distribution of *Amorphophallus* species in Peninsular Malaysia from Survey Conducted.

Several expeditions were conducted to determine the diversity of *Amorphophallus* species in various parts of Peninsular Malaysia between 2009 and 2011. Species collected for this study are shown in Table 3.33. It clearly indicated that the number of *Amorphophallus* species sampled was not as many as were recorded in the depositories from herbaria in Malaysia and Singapore. This was partly due to the limitation of time in conducting the survey at various locations throughout the country and also due to the fact that when the plant is in dormancy stage at the time of the survey, it is impossible to locate the plant shoots.

Nonetheless, the number of species encountered and collected was only six, namely *A. bufo, A. elatus, A. elegans, A. oncophyllus, A. paeoniifolius,* and *A. prainii.*

It was very obvious that *A. paeoniifolius* and *A. prainii* were the most common species found in Peninsular Malaysia. They were encountered in various parts of the country irrespective of the highland region or the dry region in the north. Other species, such as, *A. bufo, A. elatus, A. elegans* and *A. oncophyllus*, are limited in distribution and were restricted to certain areas of the country.

The distribution of *A. bufo* for instance, was restricted only to the wet and cooler areas of Cameron Highlands. It was not found in other parts of the country during the course of this study.

Similarly, the distribution of *A. oncophyllus* was restricted only to the northern parts of Peninsular Malaysia. This particular species is not native to our country. It is indigenous to Thailand and it is commercially being planted in that country for its glucomannan content. States like Perlis and Kedah bordering Thailand could have possibly acquired this species via human transfer of the corm across the border.

Table 3.3: Distribution of *Amorphophallus* spp. recorded from the field survey.

No	Name of species	Col. No./ Date Collected	Location/ District/ State	Altitude (m, a.s.l)/ Latitude/ Longitude
1	*Amorphophallus elegans*	DS12 20/04/2009	H.S Bkt Bauk Dungun Terengganu	129 N4°41.911' E103°25.015'
2	*Amorphophallus elegans*	DS13 20/04/2009	H.S Bkt Bauk Dungun Terengganu	89 N4°22.105' E103°25.013'
3	*Amorphophallus prainii*	DS17 20/04/2009	H.S Bkt Bauk Dungun Terengganu	65 N4°42.287' E103°25.015'
4	*Amorphophallus paeoniifolius*	DS18 20/04/2009	H.S Bkt Bauk Dungun Terengganu	65 N4°42.287' E103°25.015'
5	*Amorphophallus prainii*	DS21 21/04/2009	H.S Jengai Kemaman Terengganu	7 N4°39.572' E103°67.068'

6	*Amorphophallus prainii*	DS23 21/04/2009	H.S Jengai Kemaman Terengganu	7 N4°39.572’ E103°67.068’
7	*Amorphophallus prainii*	DS26 23/04/2009	H.S Sg. Nipah Kemaman Terengganu	30 N4°17.103’ E103°14.027’
8	*Amorphophallus prainii*	DS28 23/04/2009	H.S Sg. Nipah Kemaman Terengganu	30 N4°17.103’ E103°14.027’
9	*Amorphophallus prainii*	DS32 7/05/2009	Genting-Janda Baik Janda Baik Pahang	467 N3°25.271’ E101°47.055’
10	*Amorphophallus prainii*	DS35 7/05/2009	Genting-Janda Baik Janda Baik Pahang	467 N3°21.035’ E101°49.073’
11	*Amorphophallus prainii*	DS40 12/06/2009	FRIM Kepong Selangor	44 N3°14.011’ E101°37.052’

12	*Amorphophallus paeoniifolius*	DS43 18/06/2009	Kg. Gintong Jerantut Pahang	35 N3°56.003’ E102°22.
13	*Amorphophallus paeoniifolius*	DS45 18/06/2009	Kg. Gintong Jerantut Pahang	32 N3°56.003’ E102°22.
14	*Amorphophallus elegans*	DS51 19/06/2009	Gunung Tunggul Manong Perak	45 N4°23.503’ E100°41.001’
15	*Amorphophallus elegans*	DS53 19/06/2009	Ulu Licin Kuala Kangsar Perak	94 N4°32.435’ E100°46.073’
16	*Amorphophallus prainii*	DS58 26/10/2009	Ulu Kenas Kuala Kangsar Perak	103 N4°41.321’ E100°53.003’
17	*Amorphophallus prainii*	DS60 26/10/2009	Hutan Simpan Bubu Beruas Perak	139 N4°41.177’ E100°52.009’

18	*Amorphophallus prainii*	DS 61 26/10/2009	Hutan Simpan Bubu Beruas Perak	123 N4°41.177’ E100°52.009’
19	*Amorphophallus elegans*	DS 63 26/10/2009	Hutan Simpan Bubu Beruas Perak	117 N4°41.177’ E100°52.009’
20	*Amorphophallus prainii*	DS65 17/11/2009	Bukit Bendera Air Hitam Penang	292 N3°29.021’ E101°27.093’
21	*Amorphophallus bufo*	DS67 19/11/2009	Cameron Highlands Cameron Highlands Pahang	839 N5°24.927’ E100°16.045’
22	*Amorphophallus paeoniifolius*	DS 69 3/06/2011	Wang Kelian Padang Besar Perlis	179 N6°41.590’ E100°11.502’
23	*Amorphophallus oncophyllus*	DS 70 3/06/2011	Wang Kelian Padang Besar Perlis	179 N6°41.590’ E100°11.502’

24	*Amorphophallus elatus*	DS 72 4/06/2011	Gua Kelam Kaki Bukit Perlis	160 N6°38.710’ E100°12.115’

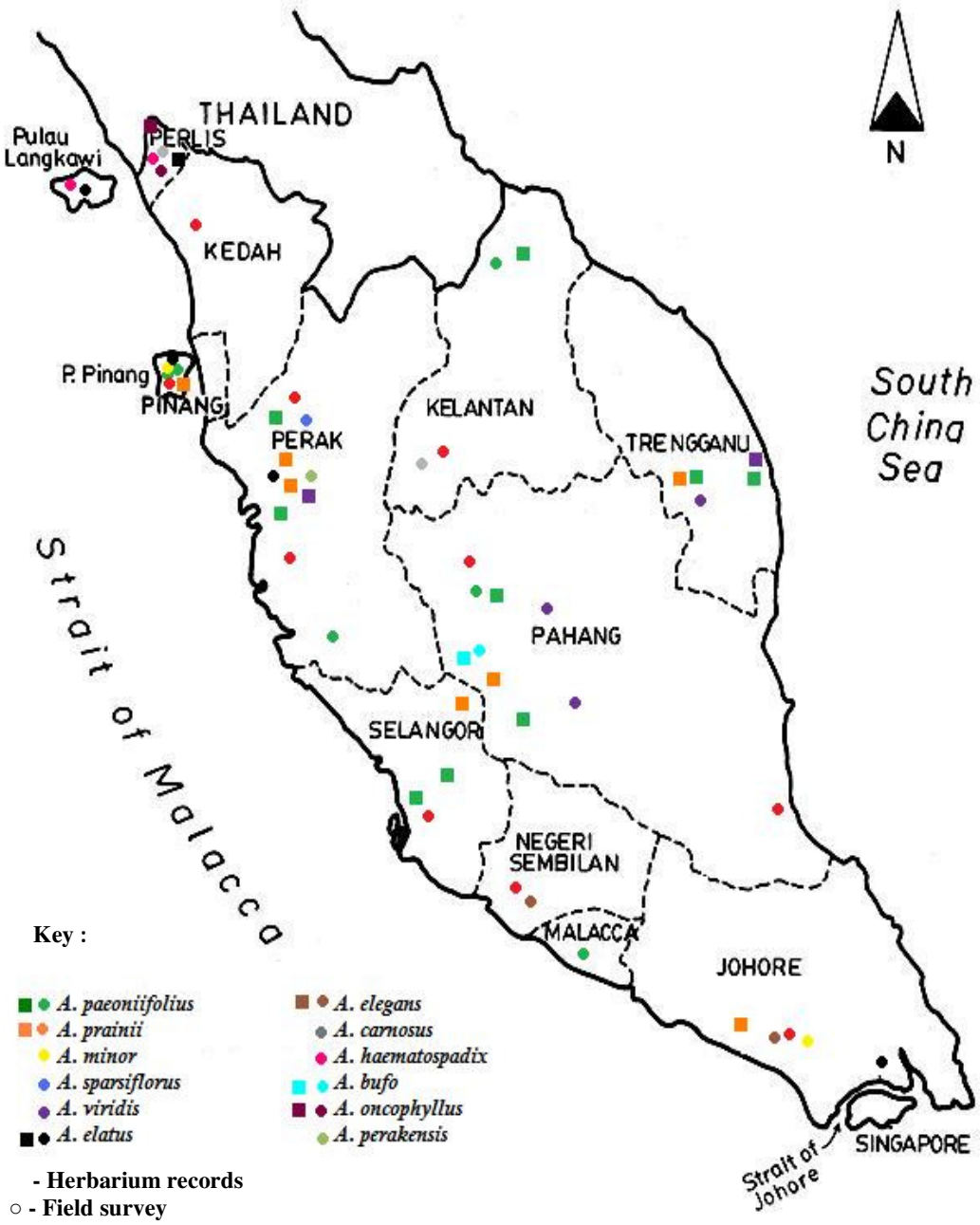

Figure 3.2: The distribution of *Amorphophallus* species in Peninsular Malaysia from herbarium records and field survey

3.3.3 Morphological Observations

The morphological characteristics were evaluated and measured for the six species collected, namely *A. bufo*, *A. elatus, A. elegans, A. oncophyllus, A. paeoniifolius,* and *A. prainii* are distinguishable for each species. The inflorescence characters are more useful in species identification, as the leaf characters are rather similar except for *A. oncophyllus* which has a small button-like bulbil at the middle of the leaf.

3.3.3.1 Morphological Characteristics of *Amorphophallus bufo* Ridl.

Corm globose, not so many rootscars present, size was about 3-5 cm in diameter having a light brown colour. **Leaf** solitary (sometimes with an inflorescence), *petiole* 25-100 cm long, spotted grey and dark green, or dark reddish brown in several shades. *Lamina* was 40-80 cm in diameter. Anterior part was less developed and shorter than posterior. *Leaflets* elongate-elliptic 8-25 cm long, upper surface glossy dark green, lower surface reddish brown when young. **Inflorescence** solitary, flowering without foliage leaves, long *peduncle* 60 cm long 1.5 cm in diameter, *spathe* about 25 cm long, 10 cm in diameter, color olive green with creamy white spots outside and brownish with creamy spots inside, hooded in large specimens, apex acute, basal margins strongly reflexed, auriculate. *Spadix* sessile, shorter than spathe, 12 cm long, female zone slightly conic, 2 cm long, 1.3 cm in diameter, flowers slightly distant, both separated by sterile zone 0.4 cm long male zone obconic, 2 cm long, 1 cm in diameter, flower congested at the top except at the base.

Habitat: Secondary forest in highland area, near human habitation

3.3.3.2 **Morphological Characteristics of *Amorphophallus elatus* Hook.f.**

Corm elongate, brown, light brown inside, 12 cm long 3 cm in diameter, no offsets development. **Leaf** solitary, *petiole* 75 cm long, 2 cm in diameter, smooth, dark green, with many blackish green spots, brown with dark reddish brown spots when young; *lamina* 75 cm in diameter; leaflets elongate elliptic, 20 cm long, acuminate, upper side dark green. **Inflorescence** solitary, flowering without foliage leaves, long peduncled; *peduncle* as petiole 40 cm long 1.5 cm in diameter; *spathe* ovate-triangular, tubular, 20 cm long 7 cm in diameter, outside light green, inside pale green with few blackish green and white spots. *Spadix* longer than the spathe, 35 cm long. Male and female zone flowers congested.

Habitat: Found in disturbed primary forest, on steep hillside, in secondary growth and edges of forest.

3.3.3.3 Morphological Characteristics of *Amorphophallus elegans* Ridl.

Corm subglobose or globose, brown ouside light brown inside, 4 to 10 cm in diameter, 4-7 cm high, weighing 70 to 450 g. No offset development. **Leaf** solitary, *petiole* smooth but slightly rough at the base, 1.5 -3.5 cm diameter, very turgid, background color dull midgreen with many shades of dark green, the base with grey and brown spots. *Lamina* 30-100 cm in diameter, rachises unwinged but for the distalmost parts; *leaflets* elongate elliptic or long acuminate, the basal ones petiolate, base not decurrent when sessile, 8 - 22 cm long, 3-6 cm in diameter, upper surface glossy green, main vein impressed, lower surface pale green. **Inflorescence** solitary, long peduncled; *peduncle* 70 cm long, 1.5 cm in diameter, mottled grey at the base, green, brown and pink with scaterred pale green spots; *spathe* erect, elongate triangular, outside base grayish

green with small dark green, inside base off-white. *Spadix* longer than spathe, 20 cm long; female zone cylindrical.

Habitat: Common in rather open places in the lowlands, in disturbed primary forest, on limestone hills, and near river at rocky area

3.3.3.4 Morphological Characteristics of *Amorphophallus oncophyllus* Blume

Corm globose, light brown, light cream inside, 10 cm in diameter, no offsets development, rootscars annuliform. **Leaf** solitary, sometimes two on one tuber. The leaf deeply dissected into numerous segments. *Petiole* smooth light green with light brown spots, 30-150 cm long, 1-5 cm in diameter, light green or olive green, brownish green or dark brown, with numerous stripe-like or green spots. *Laminar* highly dissected, 20-45 cm in diameter, in the centre, carrying epyphyllar bulbils on the major branchings and on the most distal branches; *leaflets* elongate. Upper surface green or light green with red margin (clearly seen when young). *Bulbils* rounded or elongate, brown 0.5-3 cm in diameter. **Inflorescence** not available. Identification of species based on comparison with herbarium specimen at FRIM, subsequently species were identified and verified by taxonomist at FRIM.

Habitat: Secondary forest near border Malaysia-Thailand in lowland forest in shady area

3.3.3.5 Morphological Characteristics of *Amorphophallus paeoniifolius* (Dennst.) Nicolson

Corm depressed globose, huge in size, from 15-30 cm in diameter, 10-15 cm high, weighing to 10 kg, dark brown outside, light brown inside with many rootscars, produced off-set, 5-8 offsets each season, root 2-5 mm thick. **Leaf** solitary or paired, 0.5-2.0 m in height, diameter 2.5-10 cm, rough *petiole* surface, corrugate to verrucate,

laminar is highly dissected, light green to dark green in color, light green from above and paler below, rounded ovate, elongate elliptic, elliptic-oblong, acuminate. **Inflorescence** solitary, flowering without foliage leaves, short *peduncle*, 7-10 cm long, 3 cm in diameter, usually paler and smoother than *petiole*; *spathe* campanulate, broader than long 13-40 cm long 15-25 cm in diameter, base and limb always separated by a shallow constriction, limb spreading strongly undulate, background color dark green, pale green to reddish brown with round dark spots, base lower inside dark maroon, upper zone off-white or pale pinkish, limb outside as base with maroon flushes, especially near the margin, limb inside glossy dark maroon. *Spadix* sessile, longer but sometimes shorter than spathe, 9-25 cm long; female zone cylindric 4-12 cm long 2-7 cm in diameter, *flowers* congested; male zone cylindric or strongly obconic 3-8 cm long, 2-6 cm in diameter, at the top, flowers congested; *appendix* variable, inflated 5- 18 cm long, 5-12 cm in diameter, oval, or triangular, smooth, base often with flattened, glossy dark maroon, emit a strong smell of rotting meat. **Infructescence** long peduncle 75-120 cm, diameter 4.2 cm upper, 5.1 cm middle, 5.4 cm base; *berry* oval elongate, clavate, red when ripens, orange when nearly ripens, 0.7-1.0 cm long, 0.7-1.2 cm diameter.

Habitat: In orchard, abandoned orchard, oil palm and rubber plantations, near paddy field, in evergreen primary forest, secondary forest in Peninsular Malaysia. Common in lowland forest in open moist area and near human habitation.

Note: The tuber is used to accelerate wound healing by rubbing the wound with tuber that were burned until soft. (Amandus, 1989).

Local name: Ubi kekek (Mat-Salleh & Latiff, 2002), loki (Ridley,1925), lekir, teliga potato (Datta, 1988) and hakai (orang asli)

3.3.3.6 Morphological Characteristics of *Amorphophallus prainii* Hook. f.

Corm globose, 4-7 cm in diameter, 5-10 cm thick in vegetative phase, 6-8 cm in diameter thick in reproductive phase. Has numerous roots 2-3 mm diameter, colors of corm light brown with many rootscars, got button orangish in color at bottom of the corm. Corm multiplying by offsets. **Leaf** solitary, sometimes paired leaf 22-23 cm, 77-74 cm, height 20-70 cm diameter 2.5-5 cm. The leaf deeply dissected into numerous segments. Smooth, slightly rugulose at the bottom, soft and turgid petiole. Variety of background color, dark green, green brownish, dark brown with light green or light brown spots, *leaflets* linear to lanceolate, color light to dark green base on maturity. **Inflorescence** not available during fieldwork. Identification of species based on comparison with herbarium specimen at FRIM. **Infructescence** long subglobose, height 0.5-1.2 m. *berries* green when young, orange when nearly ripens and red at maturity 0.8-1.2 cm long, 0.5 cm in diameter. Dispersed by birds.

Habitat: In orchard, abandoned orchard, oil palm and rubber plantations, in evergreen primary forest, secondary forest in Peninsular Malaysia. Commonly found in lowland forest in open moist area and near human habitation.

Local name: Keladi ular (Perak)

3.3.4 Life Cycle of *Amorphophallus paeoniifolius*

In this study the life cycle of *A. paeoniifolius* was investigated starting from March 2009 until May 2010. *A. paeoniifolius* undergoes 3 phases in its life cycle. Firstly, is the vegetative growth phase, followed by a dormant phase and thirdly the generative growth phase. The dormant phase is a resting period, when the plant becomes inactive

and will not develop any leaf even when the environmental condition is favorable. The generative growth phase normally only occur on mature tuber.

The vegetative growth starts when the tuber is developing young shoots. Usually, the first vegetative phase starts when the tuber start to produce a slightly small petiole. This is due to the limited energy and ability from the young plant. The process of photosynthesis is still not very active due to inadequate chlorophyll content in the young plant. The potential of this plant to grow well is dependent on its environment. The first vegetative growth phase occurs in the first 5-6 months, then it will go through a first dormant phase. This happened just after the last leaf of the plant wilted and died. During this dormant phase one will not see any trace of the plant. When there is no leaf, no photosynthesis occurs at this stage. The plant is undergoing its resting period in the soil for about 2-3 months and most of the time this happens during the dry season.

The second vegetative phase starts when the tuber develops a new shoot. The second shoots will always be larger than in the first growth. This is due to the ability to produce a high level energy by the corm. Next, the growth rate will be determined by the root spreading system, photosynthetic activity and environmental condition surrounding the plant for the next 5-6 months. If one corm produces more than 1 shoot, it might affect the growth development and become less productive. This is because they are sharing the energy from the same tuber. One way to overcome the situation is to cut the offset and grow it upside down. At this stage, the tuber size is larger than in the first vegetative phase.

The second dormant phase occurs just after the second foliage dies off. There is no part of the plant emerging from the soil and no photosynthesis at this stage. At a glance it

looks like the plant is dead, but actually the plant is undergoing its resting period. This phase usually happens during the dry season.

The third vegetative phase starts when the tuber starts to develop a new shoot. The new shoots will develop a larger leaf compared to the previous growth phase. This is due to the ability to produce a high level energy by the corm. Next, the growth rate will be determined by the root spreading system, photosynthetic activity and environmental conditions surrounding the plant for the next 5-6 months. At this stage, the tuber size is large enough and can be used as a planting material.

The vegetative phase and the dormant period will be repeated several times before becoming matured and subsequently ready to proceed to the generative phase. The generative phase will last for 1-2 months until flowering is complete. This full growth process will take quite a long time until 3-4 years to produce an inflorescence.

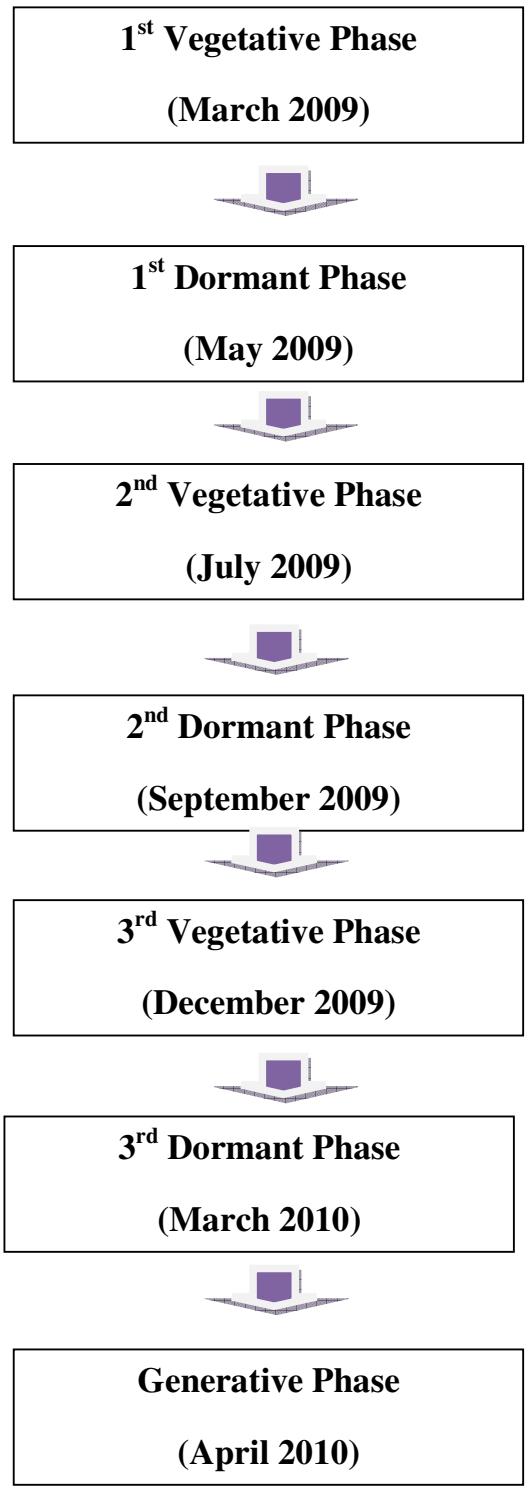

Figure 3.3: The life cycle of *Amorphophallus* species (March 2009-April 2010).

3.3.4.1 *Amorphophallus paeoniifolius* Flowering Period

The plant only blooms when it is mature. It would take a few years for the tuber to reach the size when flowering will occur. The flowers are monoesious, individual flowers, either male or female, but both sexes can be found on the same plant (Figure 3.14).The flowers only last about 5 to 7 days. The inflorescence is fully open when the cataphyll enclosing the spathe splits and is lying at the base of the inflorescence. Then the plant generates heat and releases an awful odor. This is believed to attract flies, the primary pollinator to pollinate the flowers. The female flowers of the spadix are at their peak receptivity for pollination. After a successful pollination, the spathe and appendix surface become dull, rougher in appearance and wilt before it dies and drop off.

Figure 3.4: Variations in leaf shapes of *Amorphophallus* species collected from different locations in Peninsular Malaysia **A**. *A. paeoniifolius* (Jerantut, Pahang); **B**. *A. elatus* (Kaki Bukit, Perlis); **C**. *A. bufo* (Cameron Highlands, Pahang); **D**. *A. oncophyllus* (Padang Besar, Perlis); **E**. *A. prainii* (Kuala Kangsar, Perak); **F.** *A. elegans* (Gombak, Selangor).

Figure 3.5: Leaf samples of *A. prainii* from Ulu Kenas, Kuala Kangsar, Perak. (**A, B, C, D**. represent the variations of petiole pattern and color, **E** represents the leaflets).

Figure 3.6: Leaf samples of *A. prainii* from Maxwell Hill, Perak. (**A, B, C, D**. represent the variations of petiole pattern and color, **E** represents the leaflets).

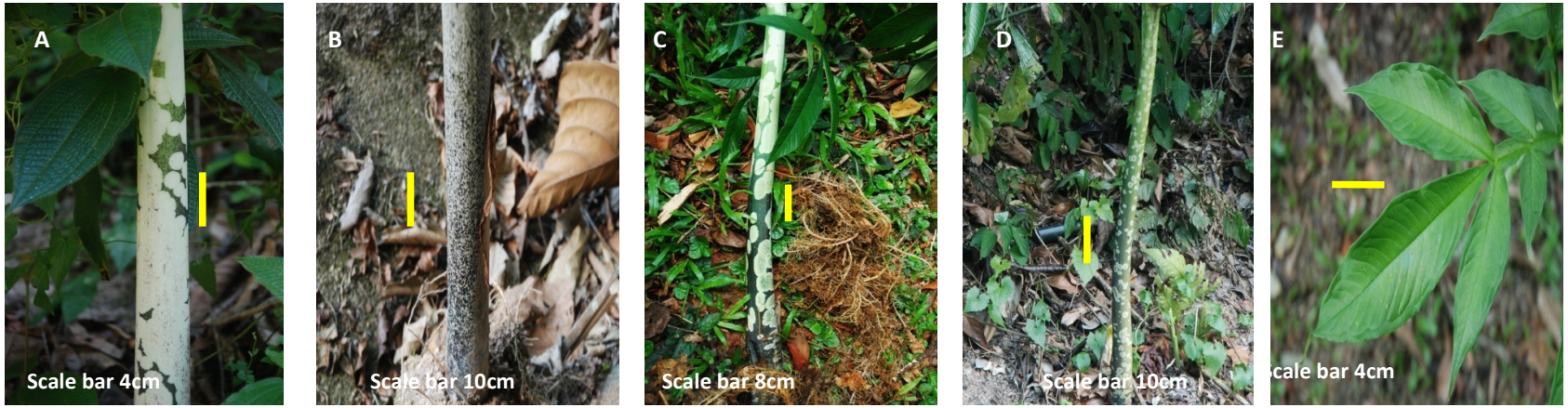

Figure 3.7: Leaf samples of *A. prainii* from Janda Baik, Pahang. (**A, B, C, D**. represent the variations of petiole pattern and color, **E** represents the leaflets).

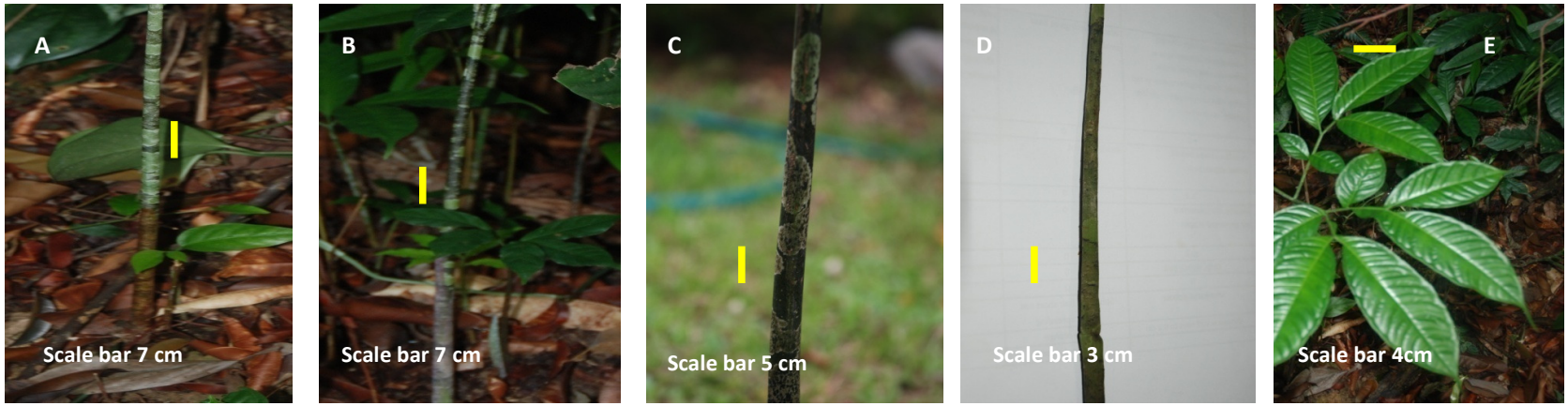

Figure 3.8: Leaf samples of *A.elegans* from Gombak, Selangor. (**A,B,C,D**. represent the variations of petiole pattern and color, **E** represents the leaflets.)

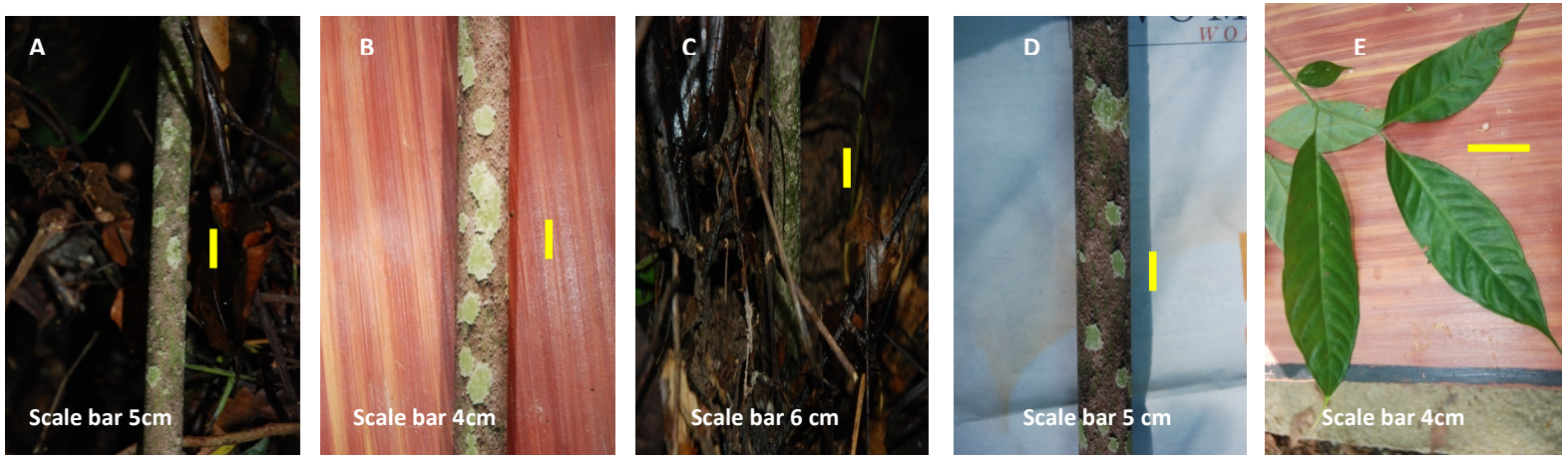

Figure 3.9: Leaf samples of *A. elegans* from Hutan Simpan Bukit Bauk, Terengganu. (**A, B, C, D**. represent the variations of petiole pattern and color, **E** represents the leaflets).

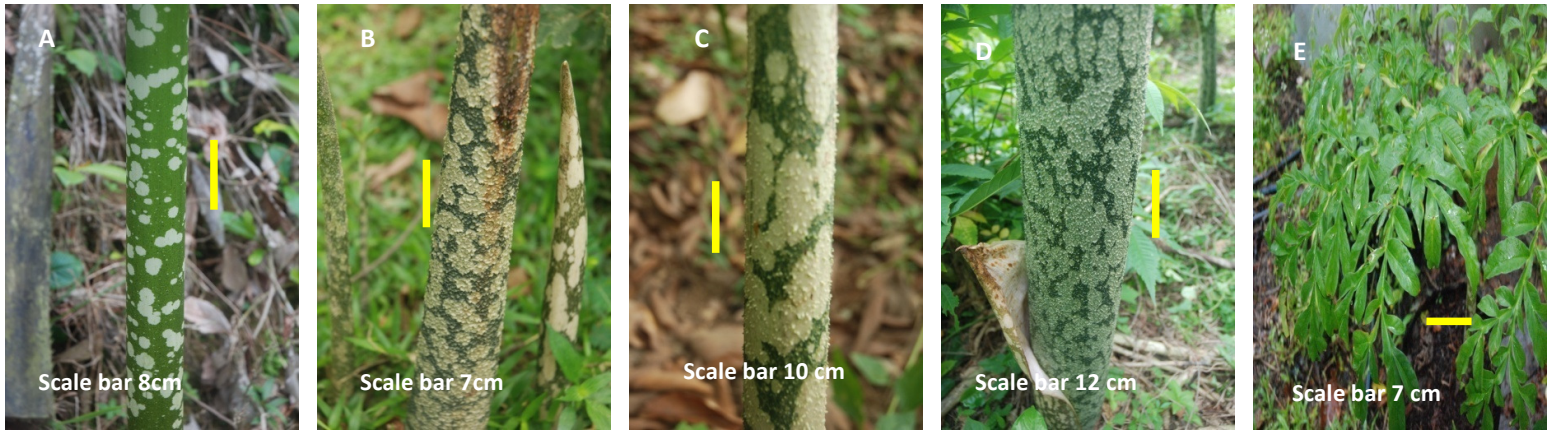

Figure 3.10: Leaf samples of *A. paeoniifolius* from Kg. Gintong, Jerantut, Pahang. (**A, B, C, D**. represent the variations of petiole pattern and color, **E** represents the leaflets).

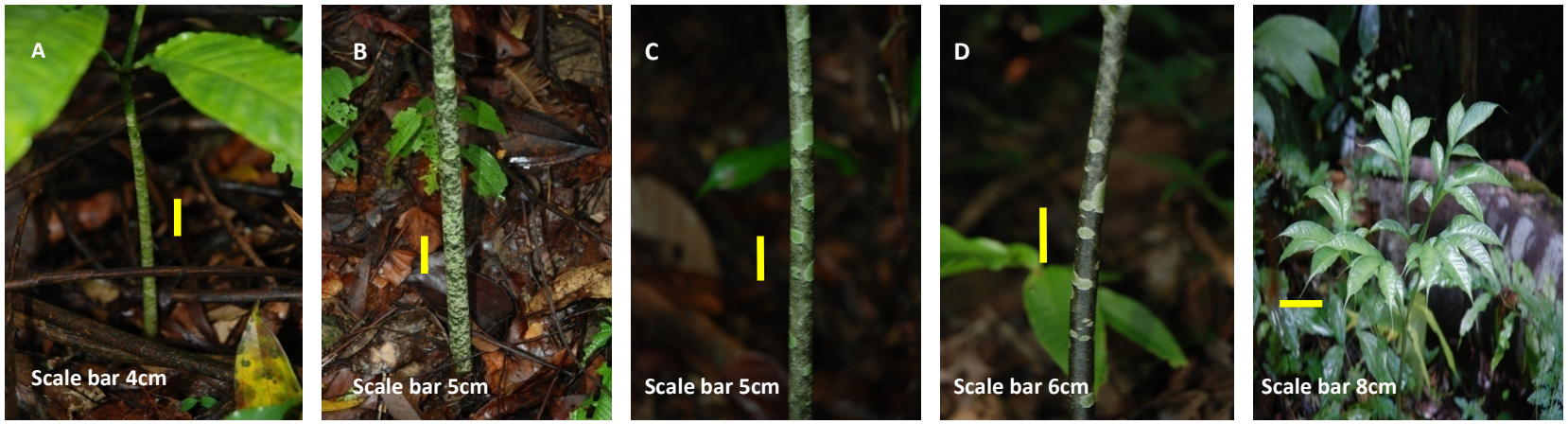

Figure 3.11: Leaf samples of *A. elegans* from Hutan Lipur Ulu Licin, Beruas, Perak. (**A, B, C, D**, represent the variations of petiole pattern and color, **E** represents the leaflets).

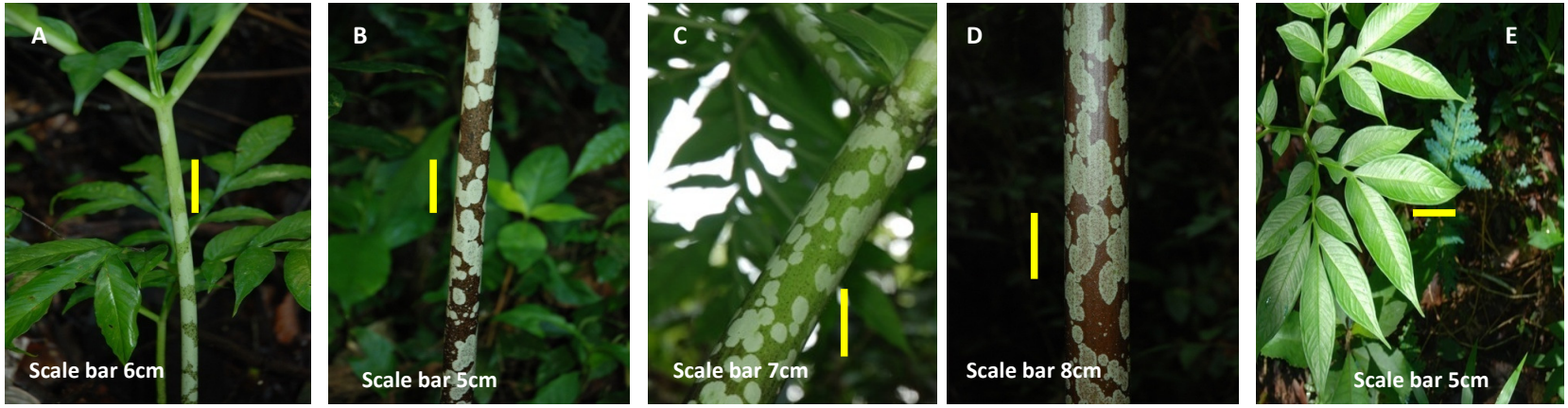

Figure 3.12: Leaf samples of *A. prainii* From Hutan Lipur Ulu Licin, Beruas, Perak. (**A, B, C, D**, represent the variations of petiole pattern and color, **E** represents the leaflets).

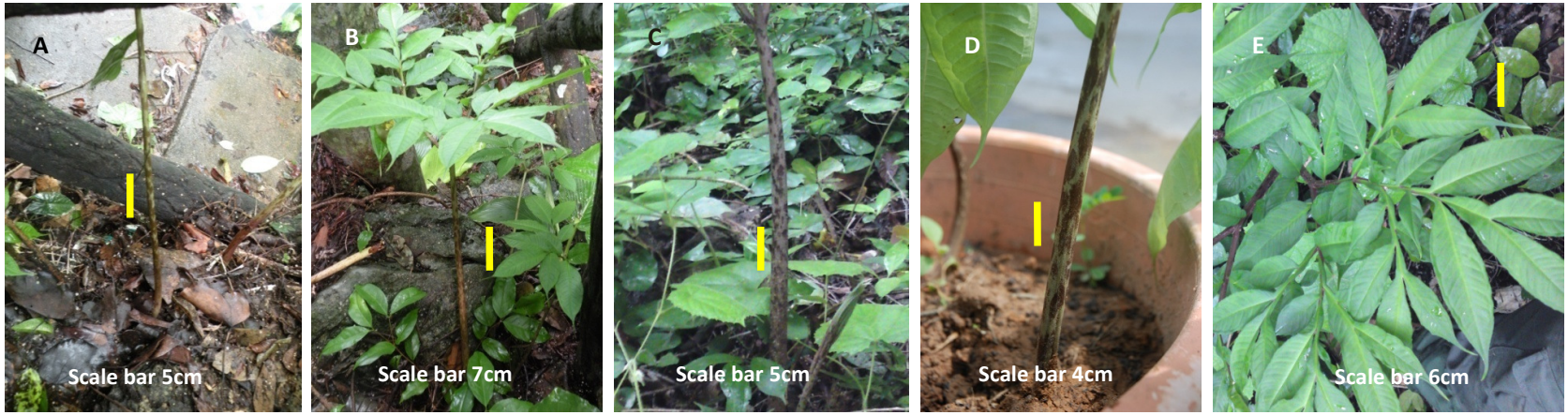

Figure 3.13: Leaf samples of *A. elatus* from Wang Kelian, Perlis. (**A, B, C, D**, represent the variations of petiole pattern and color, **E** represents the leaflets).

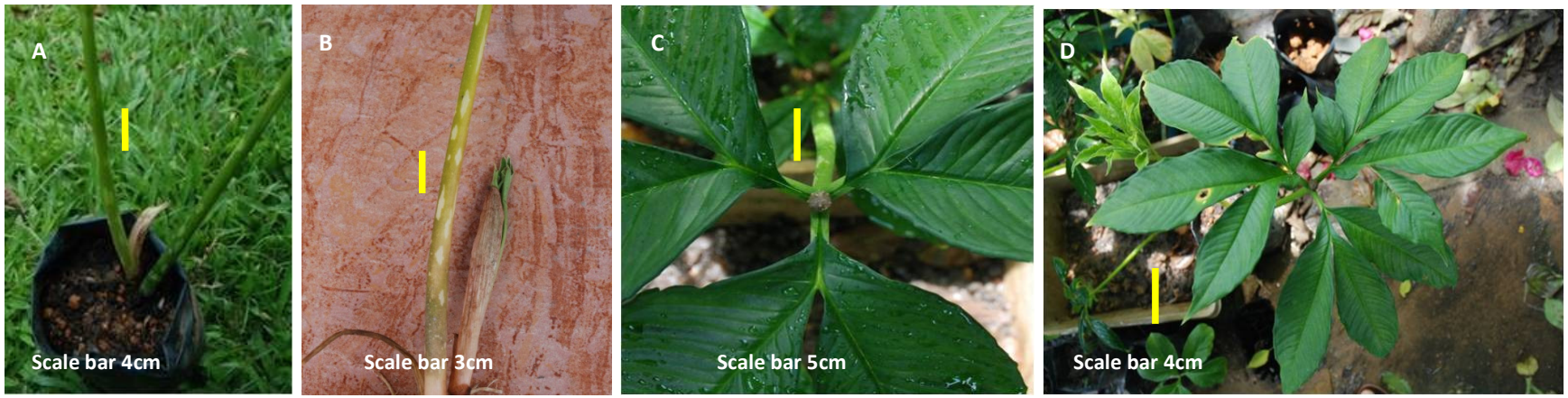

Figure 3.14: Leaf samples of *A. oncophyllus* from Padang Besar, Perlis. (**A, B**, represent the variations of petiole pattern and color, **C** and **D** represent the leaflets).

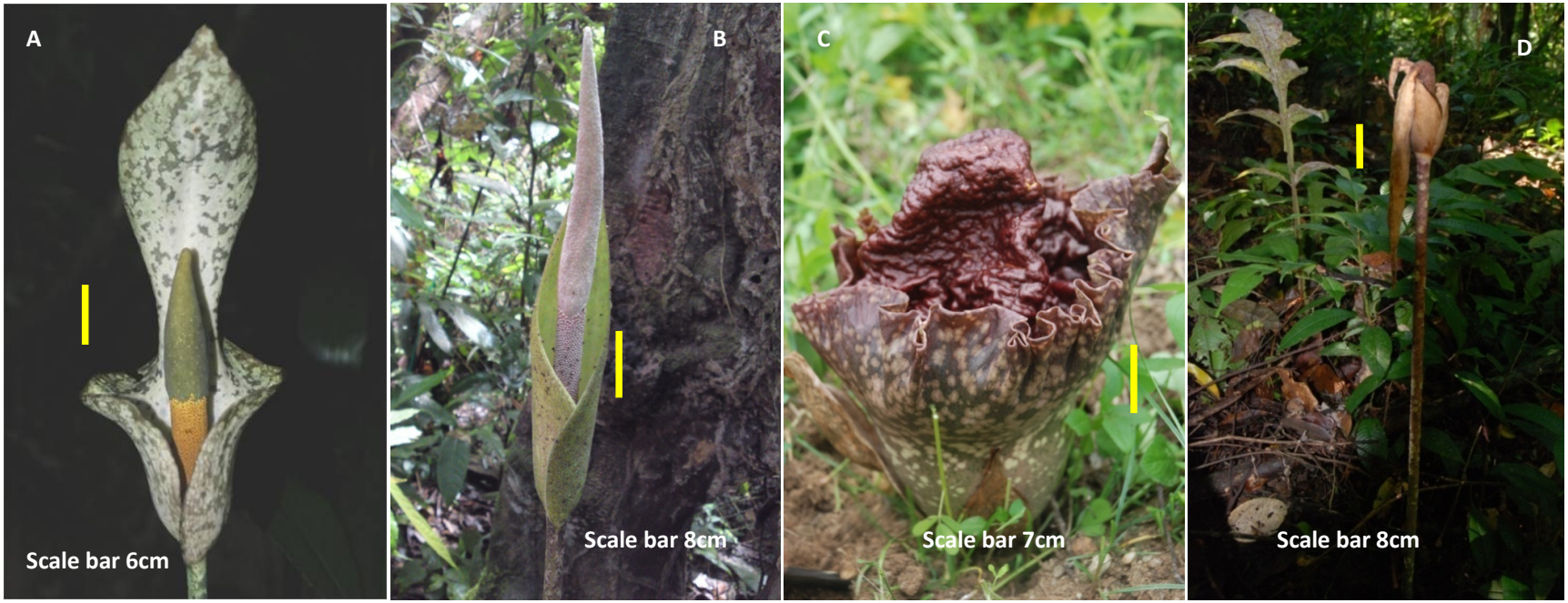

Figure 3.15: *Amorphophallus* species flowering in their natural habitat. Leaves are absent during flowering. **A**. *A. bufo* (Cameron Highlands, Pahang); **B**. *A. elatus* (Kaki Bukit, Perlis); **C**. *A. paeoniifolius* (Jerantut, Pahang); **D**. *A. elegans* (H.S. Bkt Bauk, Terengganu).

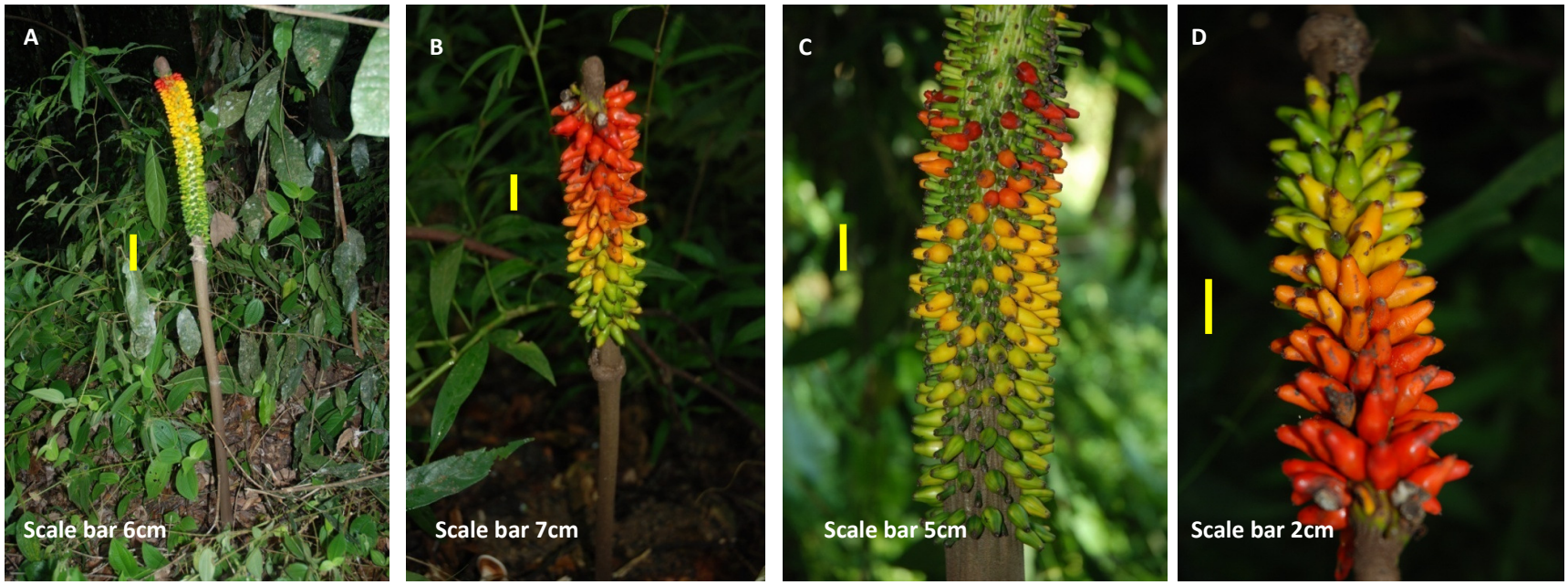

Figure 3.16: Infructescence of *Amorphophallus* spp. from different locations in Peninsular Malaysia. **A**. Infructescence of *A. prainii*, (Kuala Kangsar, Perak); **B**. Close-up of infructescence of *A. prainii* (Kuala Kangsar, Perak); **C**. Infructescence in ripening stage of *A. paeoniifolius* (Jerantut, Pahang); **D** Infructescence (close up) of *A. paeoniifolius* (Jerantut, Pahang).

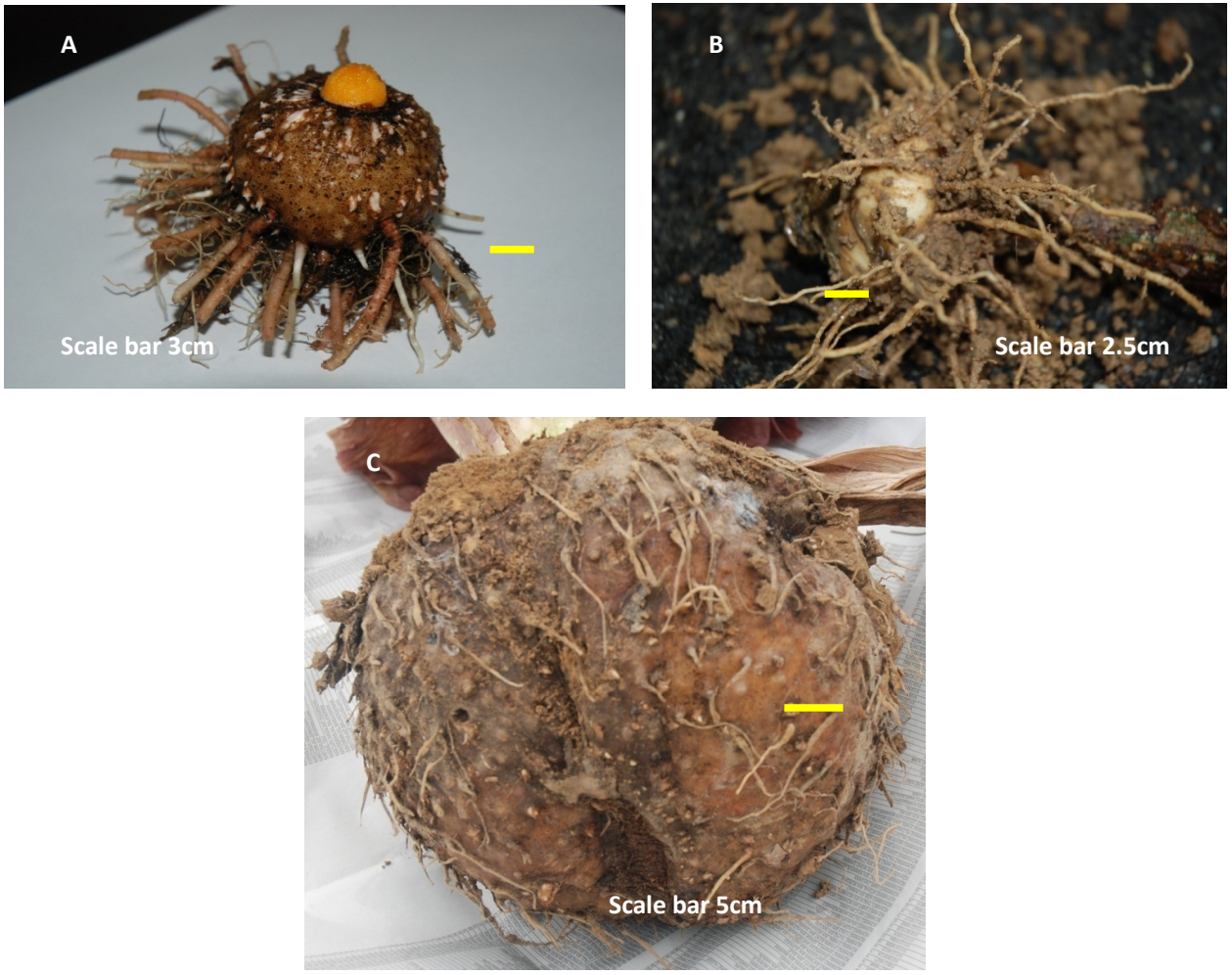

Figure 3.17: Tubers of *Amorphophallus* species collected from different sites in Peninsular Malaysia. **A.** *A. prainii* (Kuala Kangsar, Perak); **B**. *A. elegans* (H.S. Bkt. Bauk, Terengganu); **C**. *A. paeoniifolius* (Jerantut, Pahang).

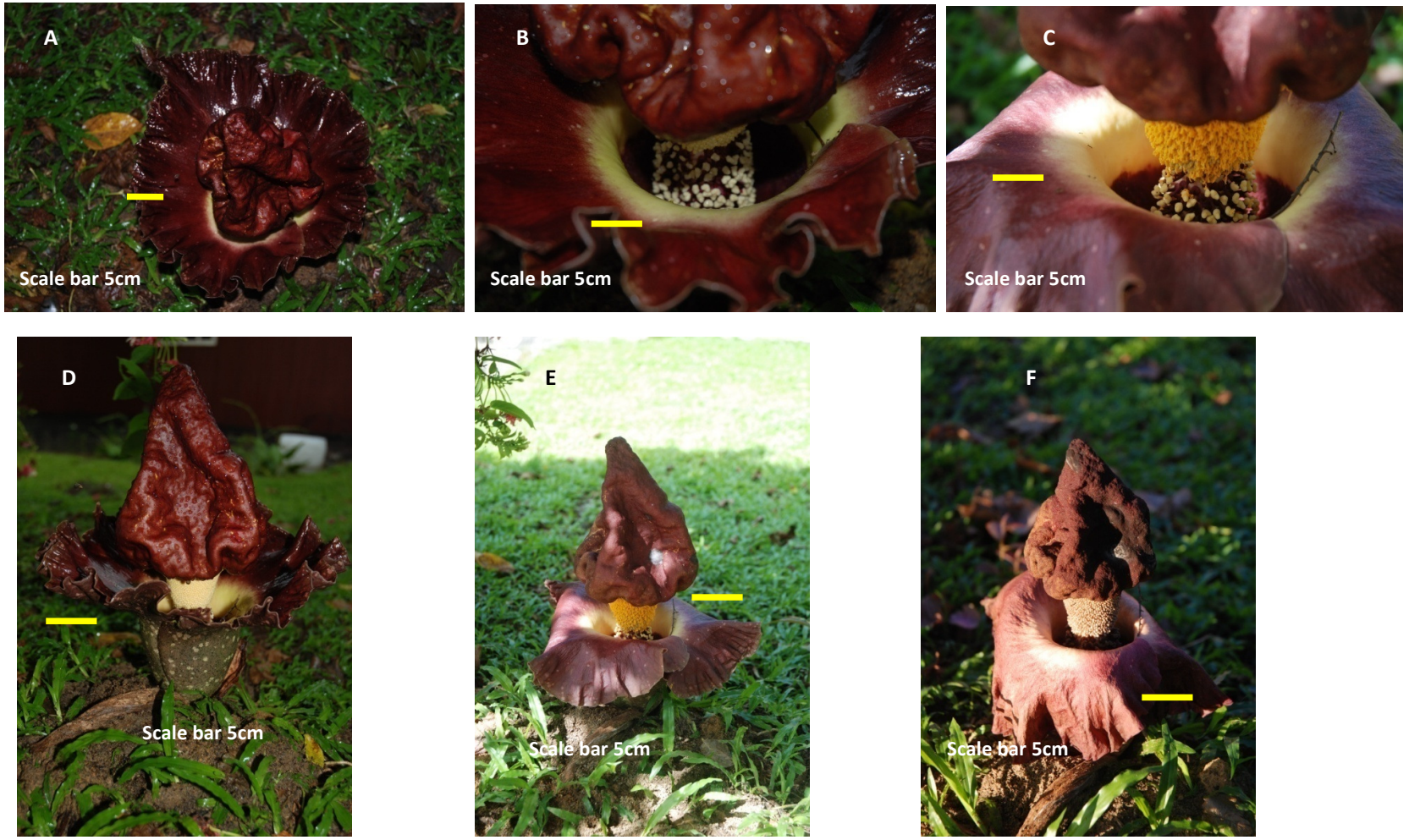

Figure 3.18: Flowering Period of *Amorphophallus paeoniifolius*. Leaves are absent during flowering, flowering lasts a week.(**A**. upper view, **B**. female flower, **C**. male flowers at anthesis, **D** side view of spathe, **E** appendage and spathe become dull after pollination, **F**. flower dies off).

3.3.5 Ecological Parameters

3.3.5.1 Types of Forest and Altitude

In Peninsular Malaysia, *Amorphophallus* can be found in all states, such as Johor, Kedah, Kelantan, Melaka, Negeri Sembilan, Pahang, Perak, Perlis, Penang, Selangor, and Terengganu. It can also be found at elevations of 5 - 850 metres (Table 3.4). It is commonly regarded as weeds by the local people because it is abundant in disturbed primary and secondary forests. The plant is well adapted to damp, shady floors of open disturbed secondary forests, under oil palm or rubber trees, near the river banks, and near human habitation.

Table 3.4: Location and types of forest, of *Amorphophallus* species surveyed.

Location	Species	Forest Type	Alt	Latitude	Longitude
Bukit Bauk, Terengganu	*A. Elegans* Ridl.	Disturbed Primary Forest	129	N4°41.911’	E103°25.2’
Jengai, Terengganu	*A. prainii* Hook. f.	Secondary Forest	7	N4°39.572’	E103°06.7’
Bukit Kajang, Terengganu	*A. prainii* Hook. f.	Disturbed Primary Forest	30	N4°17.103’	E103°14.3’
Janda Baik, Pahang	*A. prainii* Hook. f.	Disturbed Secondary Forest	250	N3°19.57’	E101°51.33’
Genting, Pahang	*A. prainii* Hook. f.	Disturbed Secondary Forest	467	N3°25.271’	E101°47.6’
Gombak, Selangor	*A. paeoniifolius* (Dennst.) Nicolson	Disturbed Secondary Forest	56	N3°18.469’	E101°44.93’
Kepong, Selangor	*A. elegans* Ridl.	Disturbed Secondary Forest	44	N3°14.11’	E101°37.5’
Jerantut, Pahang	*A. paeoniifolius* (Dennst.) Nicolson	Disturbed Secondary Forest	35	N3°56.003’	E102°2.2’
Kuala Kangsar, Perak	*A. prainii* Hook. f.	Disturbed Secondary Forest	103	N4°41.321’	E100°5.33’
Beruas, Perak	*A. elegans* Ridl.	Disturbed Secondary Forest	110	N4°5’	E100°78.3’
Air Hitam.	*A. prainii*	Disturbed	292	N5°42.490’	E100°26.9’

Penang	Hook. f.	Secondary Forest			
Cameron Highlands, Pahang	*A. bufo* Ridl.	Disturbed Secondary Forest	839	N5°24.927'	E100°16.5'
Gua Musang, Kelantan	*A .paeoniifolius* (Dennst.) Nicolson	Disturbed Secondary Forest	134	N3°51.565'	E102°26.44'
Kota Bahru, Kelantan	*A. prainii* Hook. f.	Disturbed Secondary Forest	40	N6°06.787'	E102°14.77'
Gunung Pulai, Johor	*A. prainii* Hook. f.	Primary Forest	136	N5°03.059'	E100°56.66'
Gunung Angsi, Negeri Sembilan	*A. paeoniifolius* (Dennst.) Nicolson	Disturbed Primary Forest	462	N2°43.644'	E102°03.38'
Jitra, Kedah	*A. prainii* Hook. f.	Disturbed Secondary Forest	36	N6°2.67'	E100°4.17'
Padang Besar, Perlis	*A. elatus* Hook. f.	Disturbed Secondary Forest	140	N6°38.71'	E100°12.12'
Endau- Rompin, Pahang	*A. prainii* Hook. f.	Primary Forest	76	N2°43.895'	E103°31.25'

3.3.5.2 Temperature, Humidity and Light Intensity

Records of the annual mean temperature indicated that the range of temperature for the growth of *Amorphophallus* species in various locations in Peninsular Malaysia was between 25 - 31°C (Figure 3.19). The lowest temperature recorded was 25°C in Cameron Highlands, Pahang, while the highest temperature recorded was in Jitra, Kedah, at 29.2°C. The range of temperature was considered small and not extreme at all. Although 12 *Amorphopallus* species occur in various parts of Peninsular Malaysia, *A. paeonifolius* and *A. prainii* were the two most common species that thrive well under this temperature regime. However, a perculiar observation was noted for *A. bufo,*

that is, this is the only species that was adaptable to the cooler and high moisture environment of the highland.

The humidity recorded was between 58 - 83% in all localities. The highest humidity was recorded in Jerantut, Pahang while the lowest was recorded in Beruas, Perak (Table 3.2).

The range of the light intensity recorded at various locations where sampling of *Amorphophallus* species was done varied from 500 to 2800 lux. The highest light intensity recorded, with a reading of 2800 lux was in Bukit Kajang, Terengganu while the lowest light intensity recorded, with a value of 500 lux was in Bukit Bauk, Trengganu. However, most locations where *Amorphophallus* species were sampled had light intensities in the lower range of 550 - 600 lux. This indicated that this particular understorey plant species thrive well under low light intensity. At high light intensity and high temperature, the leaves tended to scortch and died off. This was particularly true during the warm drier months when it was difficult to sample the plant because leafy portions of the plant died off leaving only the tubers in the ground. The plant reappeared when the weather was favourable during the wet and cooler months.

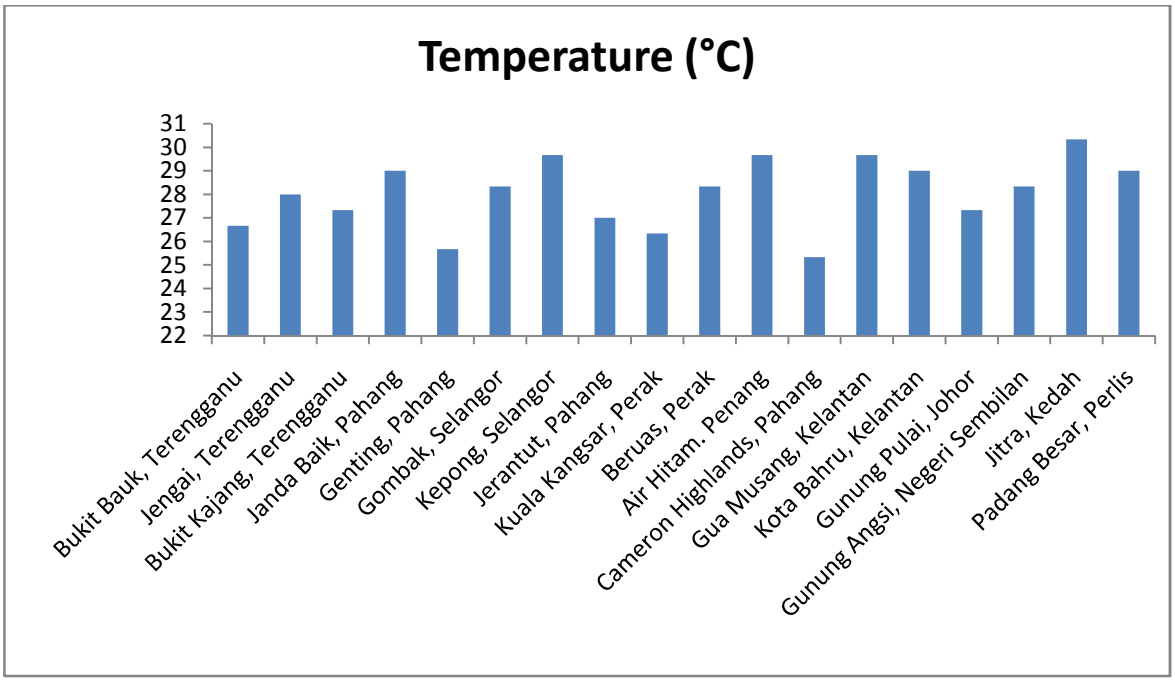

Figure 3.19: The mean temperature of locations where *Amorphophallus* spp. were sampled

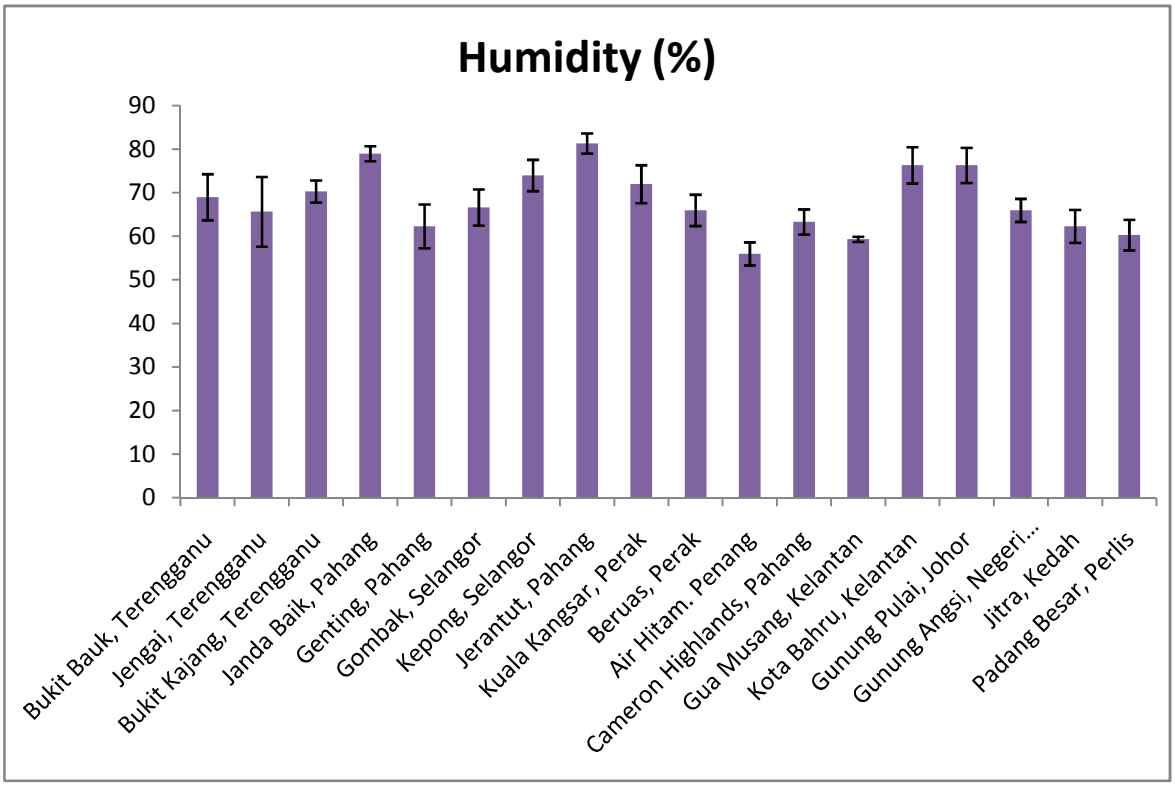

Figure 3.20 : The mean humidity of locations *Amorphophallus* spp. were sampled

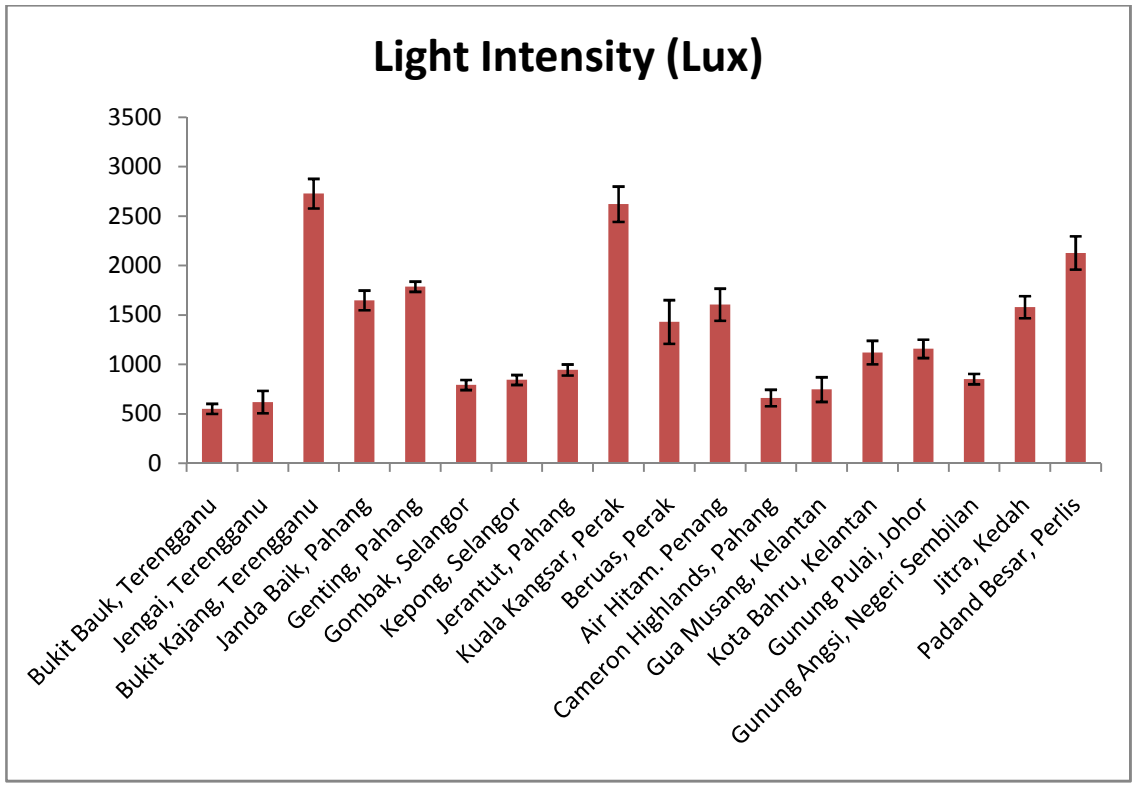

Figure 3.21: The mean light intensity where *Amorphophallus* spp were sampled

3.3.6 Soil Characteristics : Physical

3.3.6.1 Soil Texture

Results from the texture analysis estimates of the soil sampled indicated that the soil can generally be divided into 3 textural classes, namely, silt loam, clay loam and sandy loam.

The majority of the soils sampled had a silt loam soil texture. A silt loam soil consists rather small amounts of sand and clay and is composed mostly of silt-sized particles. When dry, it was often rather cloddy in the field; but the lumps were easily broken between the fingers, and the soil then feels soft and floury. Either moist or dry,

casts can be formed which can be handled somewhat freely without breaking. When moistened and squeezed between the fingers it feels soft and smooth. It will not "ribbon out"; but will break into small bits. This included soils of Bukit Bauk, Kepong, Jerantut, Air Hitam, Cameron Highlands, Kota Bahru, Gunung Angsi and Padang Besar.

Several soils had a clay loam in texture. A clay loam soil consists of soil material having the most even distribution of sand, silt, and clay of any of the soil textural grades. But it feels as though it possesses more clay than sand or silt. Sticky and plastic when wet, it forms casts that are firm when moist and hard when dry. The moist soil will form a thin ribbon that will barely sustain its own weight when squeezed carefully between the thumb and fingers. Soils with a clay loam texture were obtained from Jengai, Bukit Kajang, Janda Baik, Kuala Kangsar and Gua Musang.

Some soils are sandy loam in texture**.** A sandy loam soil is not dominated by any particular size of sand particle. It contains 30% or more very coarse, coarse, and medium sand (but less than 25 % very coarse and coarse sand), and less than 30 % either fine sand or very fine sand. Soils with this textural class included those from Genting, Gombak, Beruas, Gunung Pulai and Jitra.

3.3.6.2 Soil Moisture Content

Results indicated that the highest soil moisture content recorded was at Cameron Highlands where the average content was 22 % while the lowest moisture content recorded was at Kepong with an average of 14% (Figure 3.22).

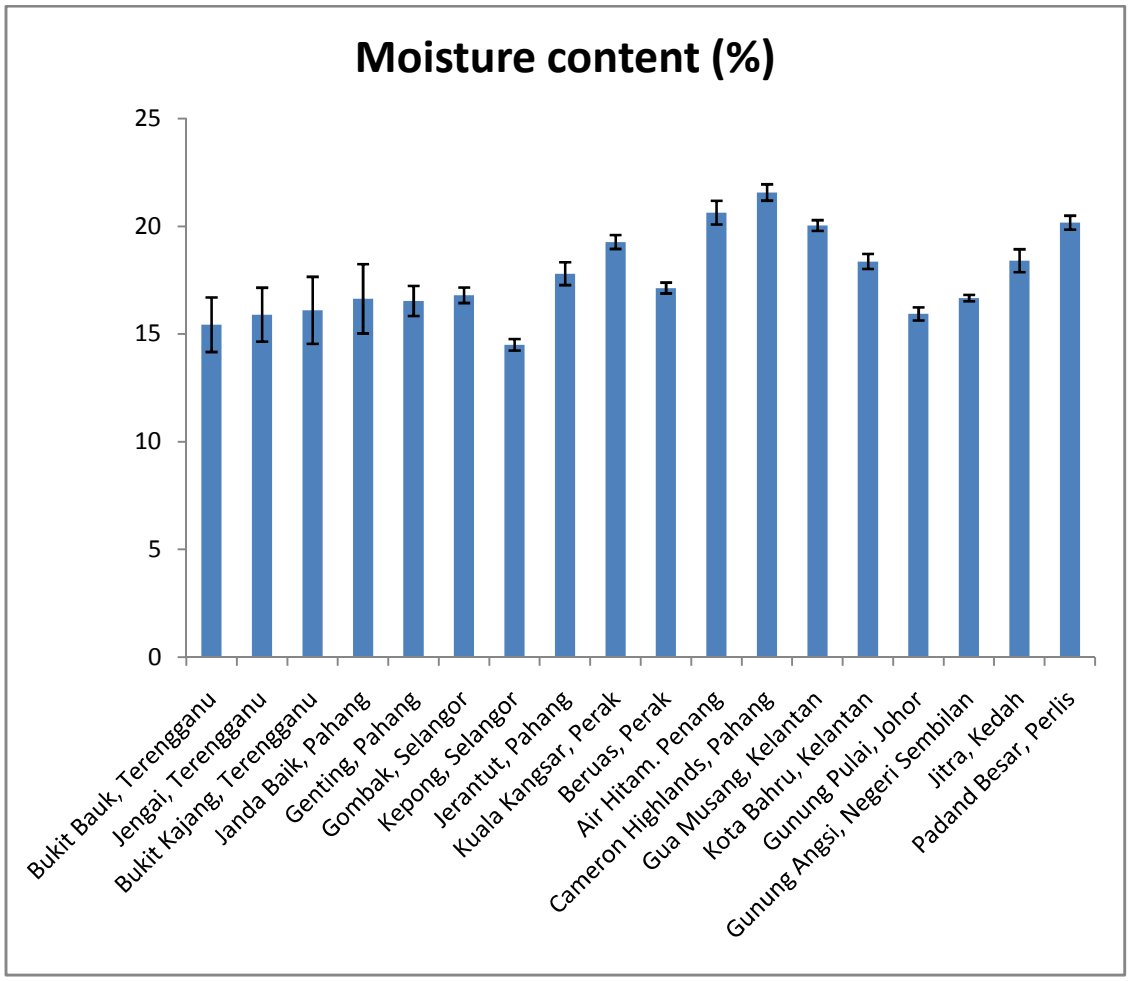

Figure 3.22 : The mean moisture content recorded from various localities where *Amorphophallus* spp. were sampled

3.3.7 Soil Characteristics : Chemical

3.3.7.1 Soil pH

All the soils were acidic in nature and were within the range of pH 4.7- 6.9. The highest acidity was recorded from Gombak, Selangor with pH value of 4.7. The lowest acidity was soil from Bukit Kajang, Terengganu with a pH value of 6.9 (Figure 3.23).

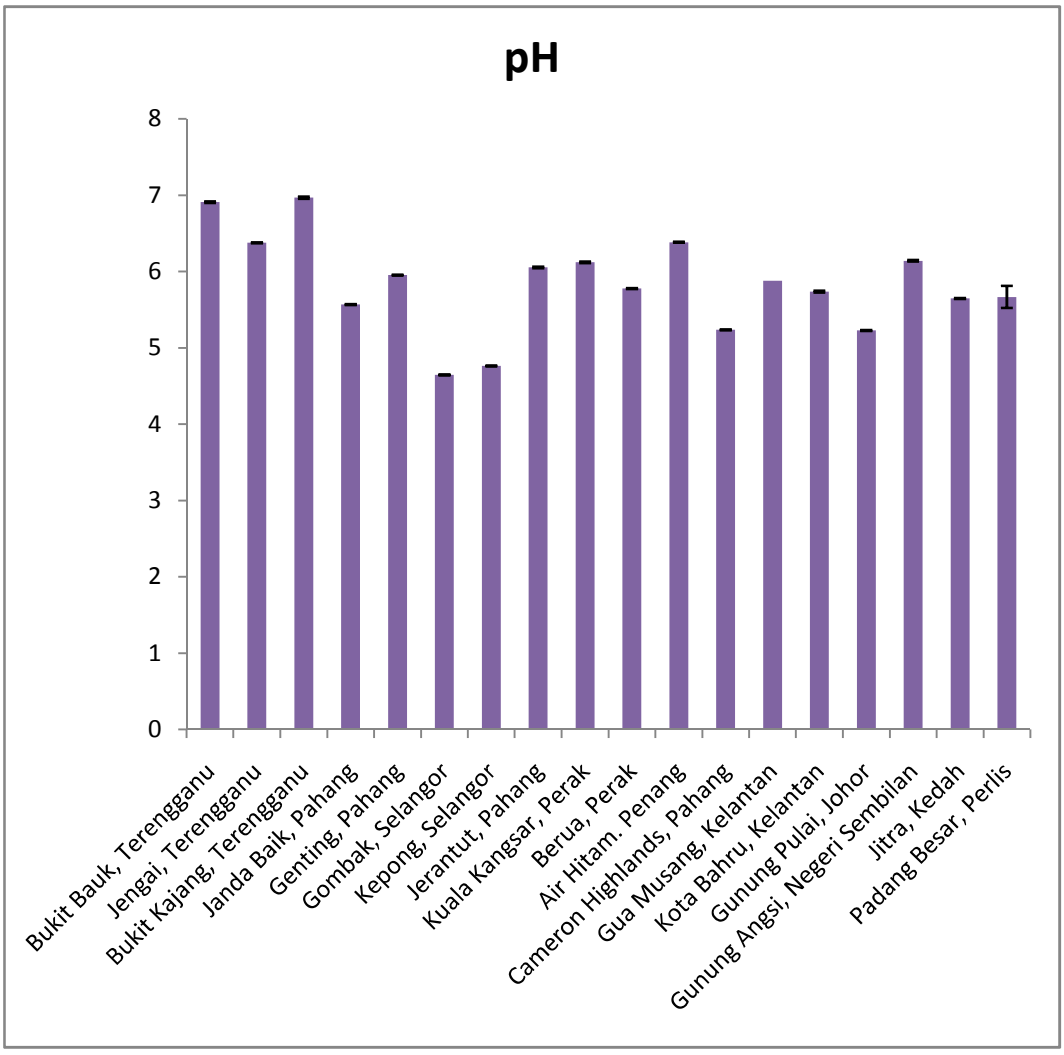

Figure 3.23: Soil pH of several soils where *Amorphophallus* spp. were sampled

3.3.7.2 Soil Mineral Content (Ca, Mg, K, Total N and P), and Organic Matter

All of the soil samples collected from all localities showed a high amount of potassium (K), Magnesium (Mg) and Calcium (Ca) with a variety of readings. The highest K was recorded at Gunung Angsi, Negeri Sembilan with 250 $\mu g\ g^{-1}$ and the lowest was recorded at Kota Bahru, Kelantan with 98 $\mu g\ g^{-1}$ (Figure 3.24). Soils from Kepong, Selangor recorded the highest amount of Ca whereas soils from Gua Musang recorded the lowest with 25 $\mu g\ g^{-1}$ (Figure 3.25). The highest amount of Mg was recorded from soils at Padang Besar, Perlis with 140 $\mu g\ g^{-1}$ and the lowest was recorded at Air Hitam, Penang with a value of 17 $\mu g\ g^{-1}$ (Figure 3.26).

The highest amount of N was recorded from soils of Jitra, Kedah with sampled at a value of 0.24% while the lowest was from soils of Gua Musang, Kelantan at 0.1% (Figure 3.27).

The amount of Phosphorus (P) from all the soil samples taken were in the range of 25 - 60 $\mu g\ g^{-1}$ (Figure 3.28). The highest amount of P was recorded at Jitra, Kedah with a value of 60 $\mu g\ g^{-1}$ while the lowest was recorded at Padang Besar, Perlis with a value of 25 $\mu g\ g^{-1}$.

The highest amount of organic matter was recorded from soils at Janda Baik, Pahang with 3.9 % and the lowest was recorded from Beruas, Perak with a value of 1.9 % (Figure 3.29).

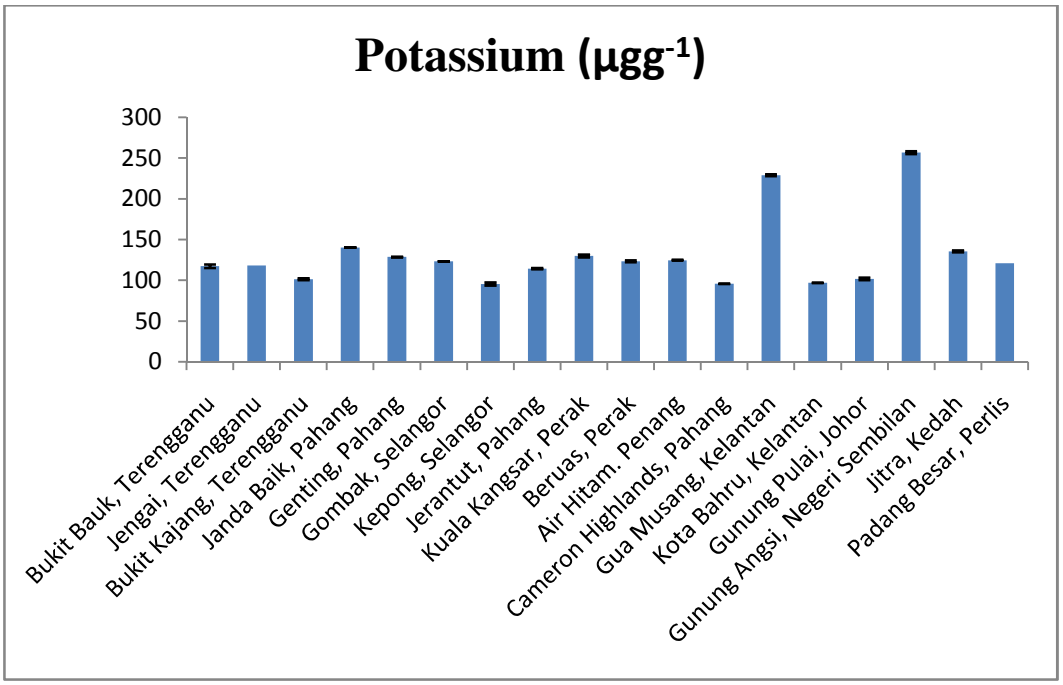

Figure 3.24: Potassium (K) content of soils where *Amorphophallus* species were sampled.

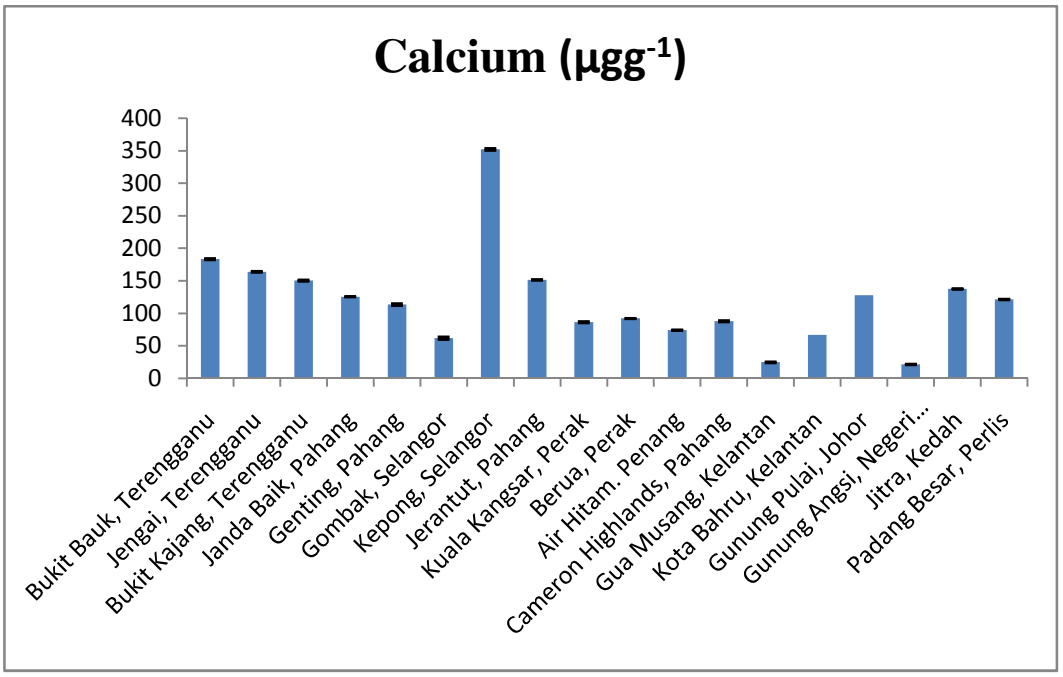

Figure 3.25 : Calcium content of soils where *Amorphophallus* species were sampled

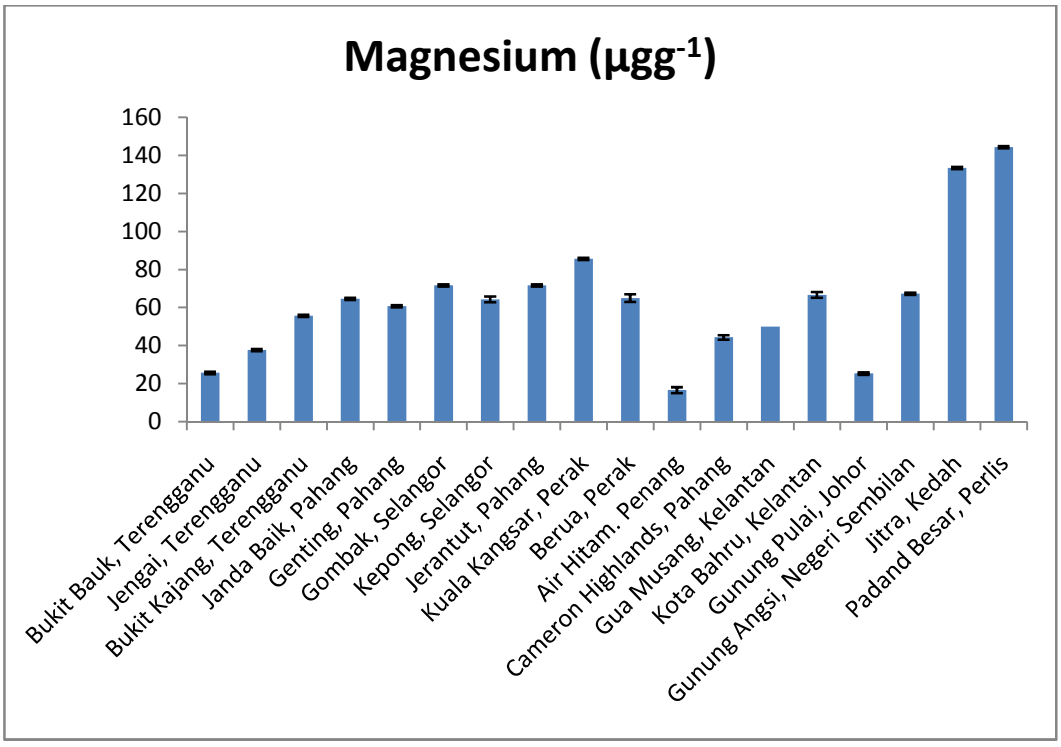

Figure 3.26: Magnesium content of soils where *Amorphophallus* species were sampled.

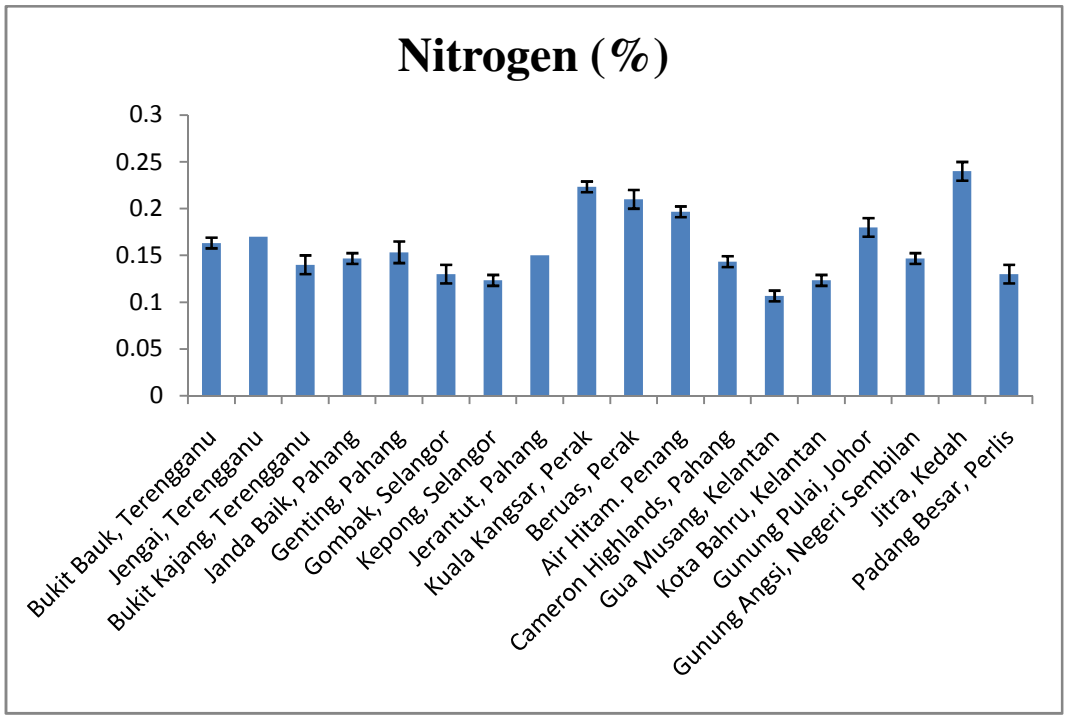

Figure 3.27: Nitrogen content of soils where *Amorphophallus* species were sampled

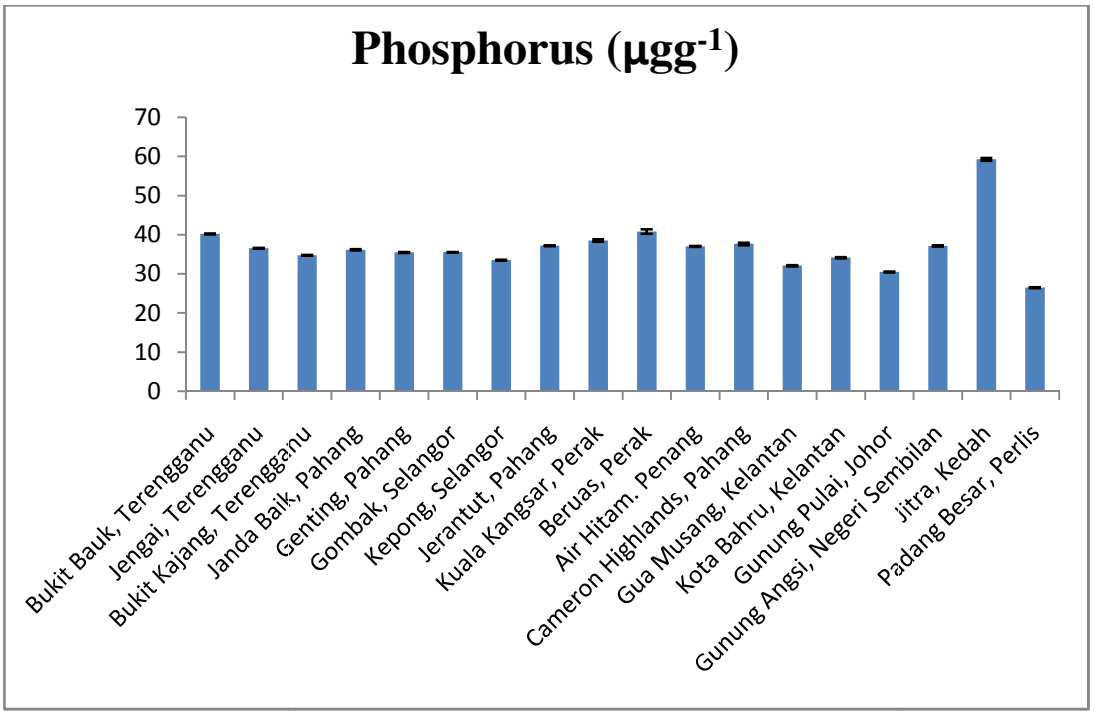

Figure 3.28 : Phosphorus content of soils where *Amorphophallus* species were sampled.

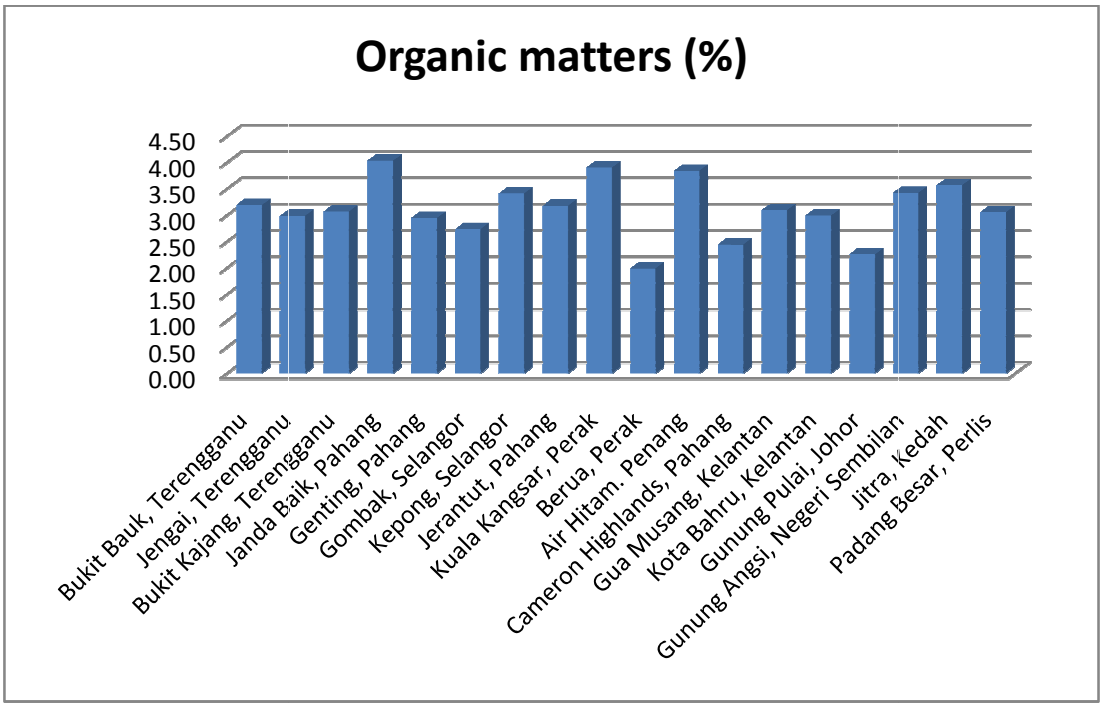

Figure 3.29: Organic Matter content of soils where *Amorphophallus* species were sampled.

3.3.8 Ecological Studies: Quantitative Analysis

3.3.8.1 Climatic Records

During the course of the experiment, it was recorded that the range of monthly rainfall was between 118 - 310 mm and 162 - 325 mm in Pahang and Perak respectively (Table 3.5). The minimum, maximum and mean temperature for both locations were quite similar to each other, with a difference of only 1^{o} C for the minimum, maximum and mean temperatures (Table 3.6). The range of mean temperature varied from 26^{o}C to 29^{o}C. However, Kuala Kangsar had a very slightly higher relative humidity when compared to Jerantut throughout the three seasons of the study period (Table 3.7). The range of relative humidity in Kuala Kangsar was between 78 – 83 % while that of Jerantut was between 74 – 82%.

Table 3.5 : Monthly rainfall records for sampling sites in Pahang and Perak for three consecutive seasons in 2009.

Season (2009)/ Site	Pahang (Jerantut)		Perak (Kuala Kangsar)	
	Monthly Rainfall (mm)	Average (mm)	Monthly Rainfall (mm)	Average (mm)
Season 1 (Jan-Apr)	118-320	228	162-260	202
Season 2 (May-Aug)	240-283	259	186-320	266
Season 3 (Sept-Dec)	150-310	270	196-324	292

Table 3.6 : Minimum, maximum and average daily temperatures for sampling sites in Pahang and Perak for 3 consecutive seasons in 2009.

Season (2009) /Site	Pahang (Jerantut)			Perak (Kuala Kangsar)		
	Daily Temperature			Daily Temperature		
	Min (°C)	Max (°C)	Average (°C)	Min (°C)	Max (°C)	Average (°C)
Season 1 (Jan-Apr)	25	33	28	24	34	29
Season 2 (May-Aug)	24	32	26	22	32	27
Season 3 (Sept-Dec)	24	31.5	27	23	30	26

Table 3.7 : Mean relative humidity for sampling sites in Pahang and Perak for 3 consecutive seasons in 2009.

Season (2009) /Site	Pahang (Jerantut)	Perak (Kuala Kangsar)
	Mean Relative humidity (%)	Mean Relative humidity (%)
Season 1 (Jan-Apr)	74	78
Season 2 (May-Aug)	77	81
Season 3 (Sept-Dec)	82	83

3.3.8.2 Abundance Estimates of *Amorphophallus* spp.

To determine the abundance estimate of *Amorphophallus* species in the two locations studied, namely Jerantut, Pahang and Kuala Kangsar, Perak, i.e., the density-frequency-dominance measure, the Point Centered Quarter Method was used. A combined abundance estimate used is usually expressed as relative values, relative density is the number of a given species expressed as a percentage of all species present, relative frequency is the frequency of a given species expressed as a percentage of the sum of frequency values for all species present, and relative dominance is the basal area of a given species expressed as a percentage of the total basal area of all species present.

The importance value of a species is defined as the sum of the three relative measures :

Importance value = Relative density + Relative cover + Relative frequency.

Importance value (IV) is a measure of dominance of species in an area. The higher the IV, the more dominant is the plant species (Mitchell, 2007). Figures 3.30 - 3.35 show IV indices for three seasons. Importance Value (IV) was used to compare the dominant stature of *Amorphophallus* spp. in each season.

It was observed that the IV of *Amorphophallus* species varied considerably with season for both locations. This implied that the *Amorphophallus* species could appear dominant during the favourable period of the year and hibernate when adverse condition prevailed. However the pattern of IV was similar for both locations. The IV

was highest during Season 3 (September-December), followed by Season 2 (May-August) and lowest during Season 1 (January-April) in both locations. This pattern of IV coincided well with the climatic conditions, when *Amorphophallus* species go through the dormancy period in Season 1 (dry season). Whereby the IV was highest in Season 3 when both the locations were experiencing slightly lower temperature, slightly higher humidity and rainfall during the North East Monsoon period at the end of the year. In this season, many *Amorphophallus* species grow well and easy to be seen in both locations in Jerantut and Kuala Kangsar.

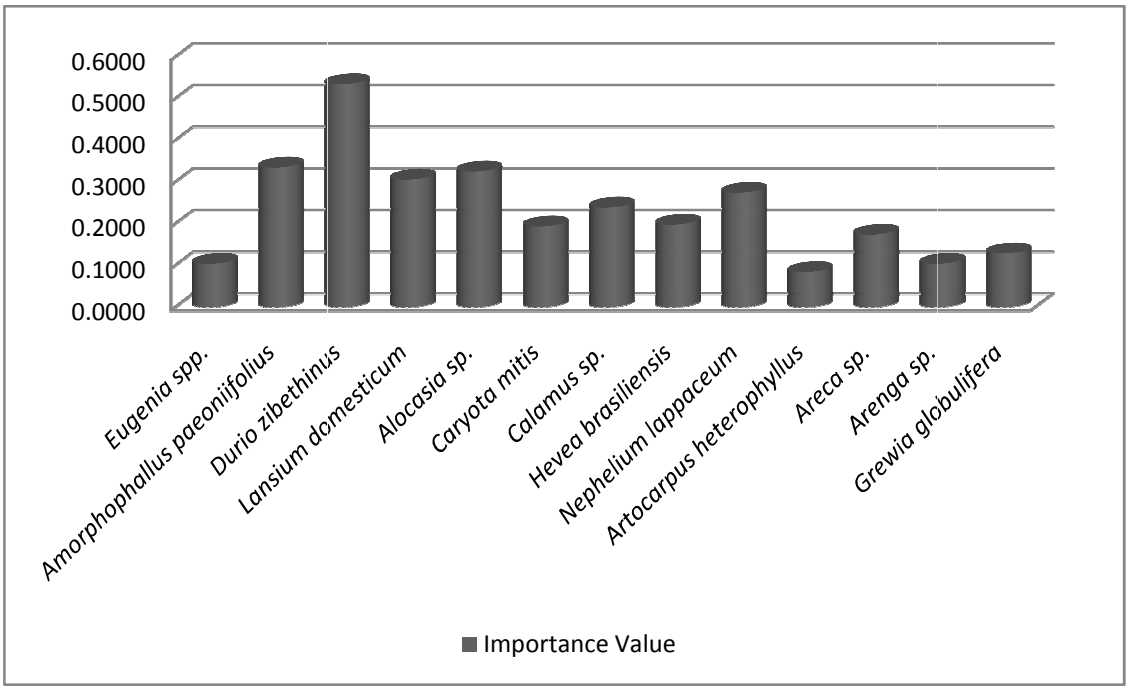

Figure 3.30: Importance Value (IV) of *Amorphophallus paeoniifolius* and associated species for season 1 in Jerantut, Pahang

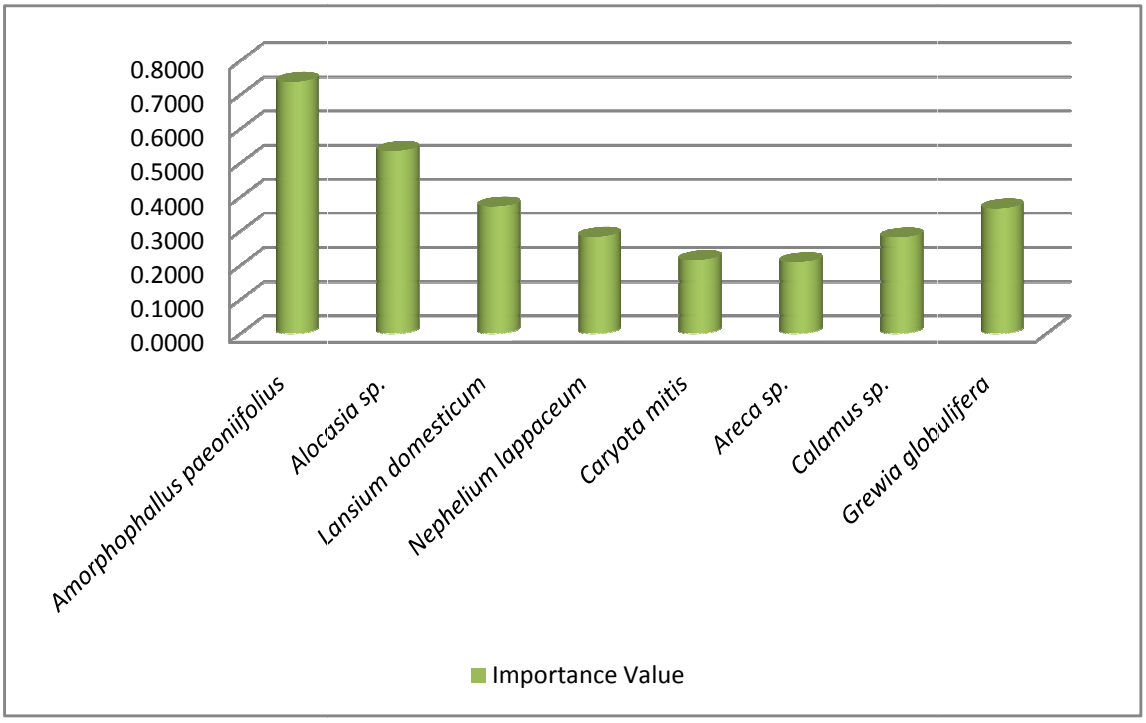

Figure 3.31: Importance Value (IV) of *Amorphophallus paeoniifolius* and associated species for season 2 in Jerantut, Pahang

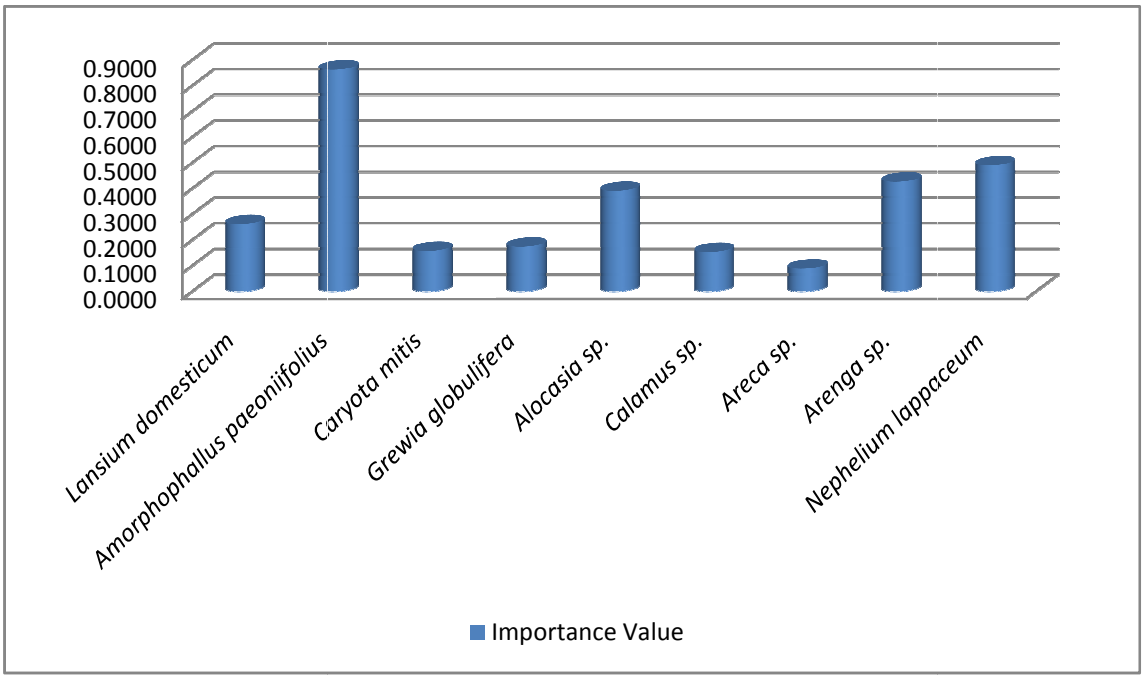

Figure 3.32 : Importance Value (IV) of *Amorphophallus paeoniifolius* and associated species for season 3 in Jerantut, Pahang

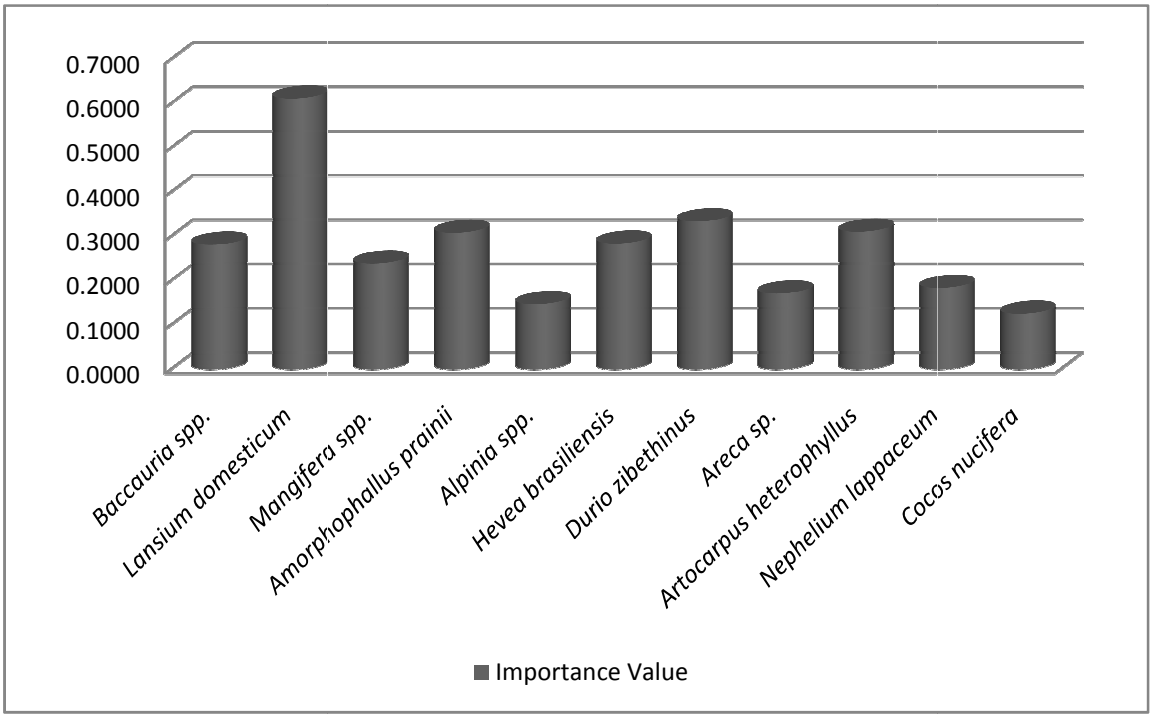

Figure 3.33: Importance Value (IV) of *Amorphophallus prainii* and associated species for season 1 in Kuala Kangsar, Perak

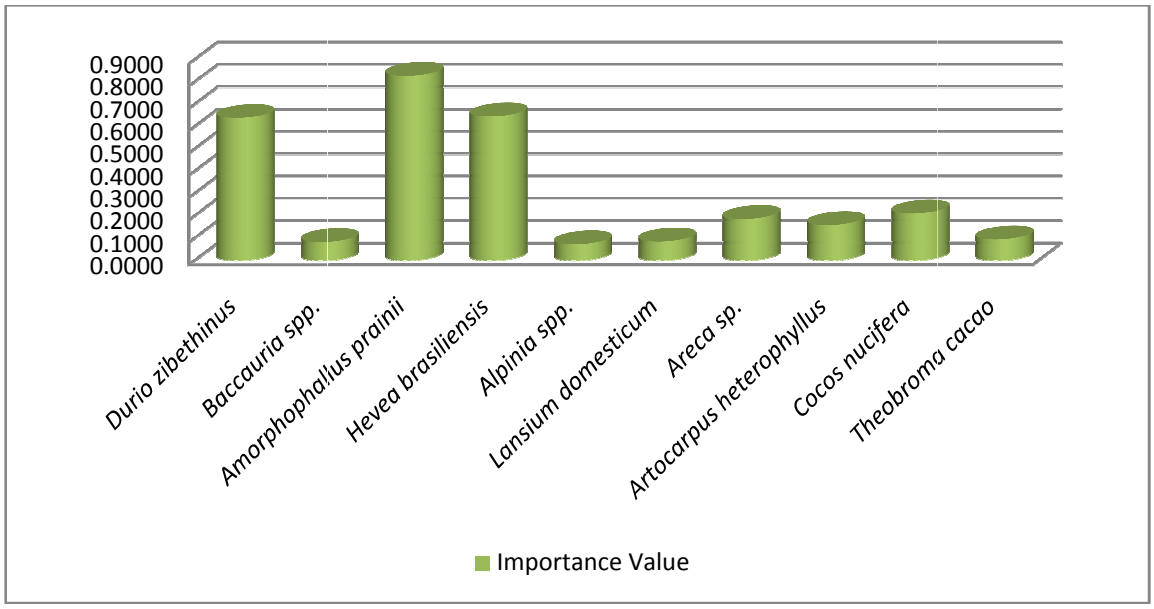

Figure 3.34: Importance Value (IV) of *Amorphophallus prainii* and associated species for season 2 in Kuala Kangsar, Perak

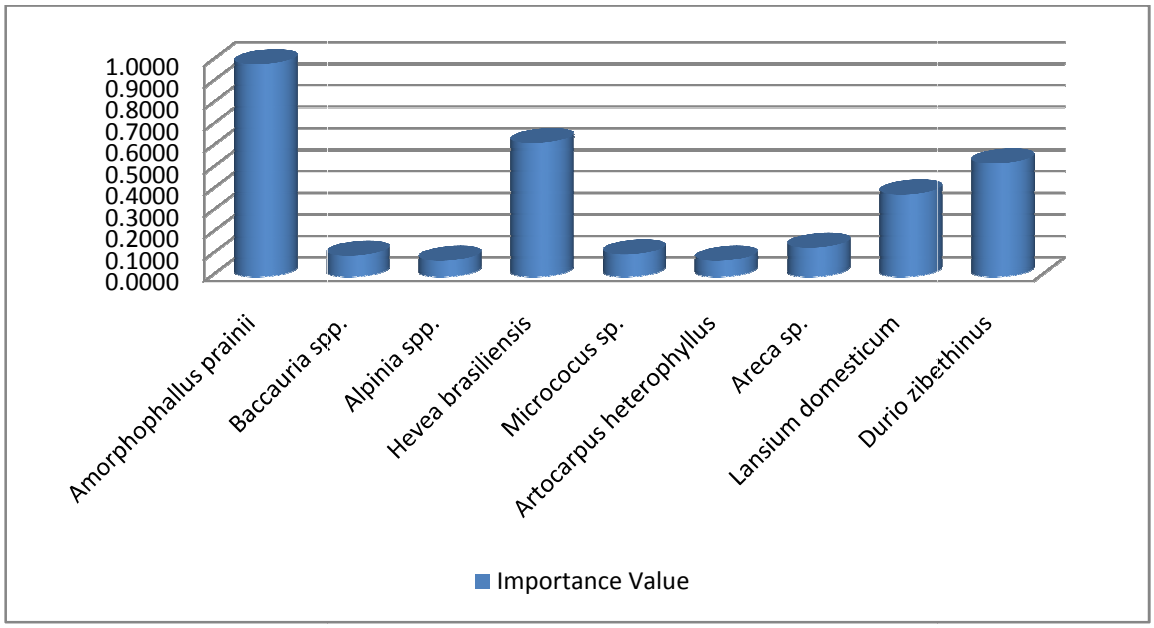

Figure 3.35: Importance Value (IV) of *Amorphophallus prainii* and associated species for season 3 in Kuala Kangsar, Perak

3.3.8.3 Total Density (TD) of Vegetation in Site 1 and Site 2

The Total Density of Vegetation for both locations is as shown in Figure 3.36. It was observed that the TD varied with seasons for both locations. For site 1 (Jerantut, Pahang), The TD values were highest (0.4402) in Season 3, followed by Season 1 (0.3804) and lowest in Season 2 (0.2991) (Figure 3.36). However, in site 2 (Kuala Kangsar, Perak), the TD was highest (0.3854) in Season 1, followed by Season 2 (0.2885) and lowest in Season 3 (0.2709) (Figure 3.37).

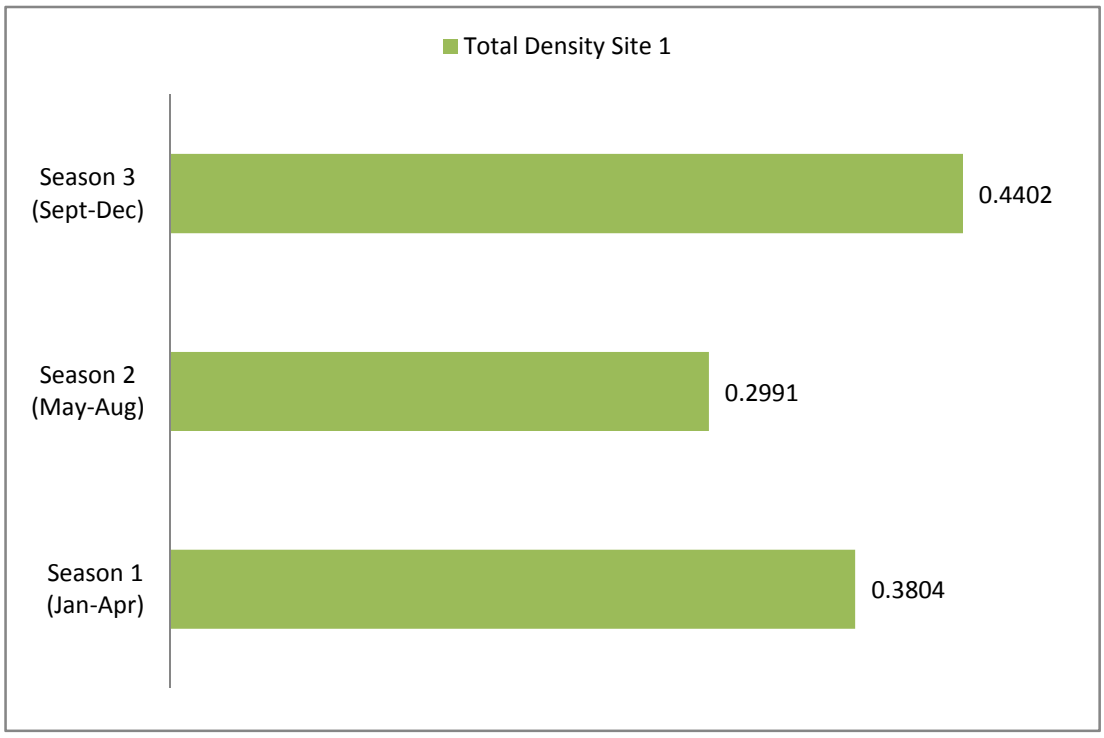

Figure 3.36 : Total density of vegetation in site 1 (Jerantut, Pahang) during the growth season in 2009.

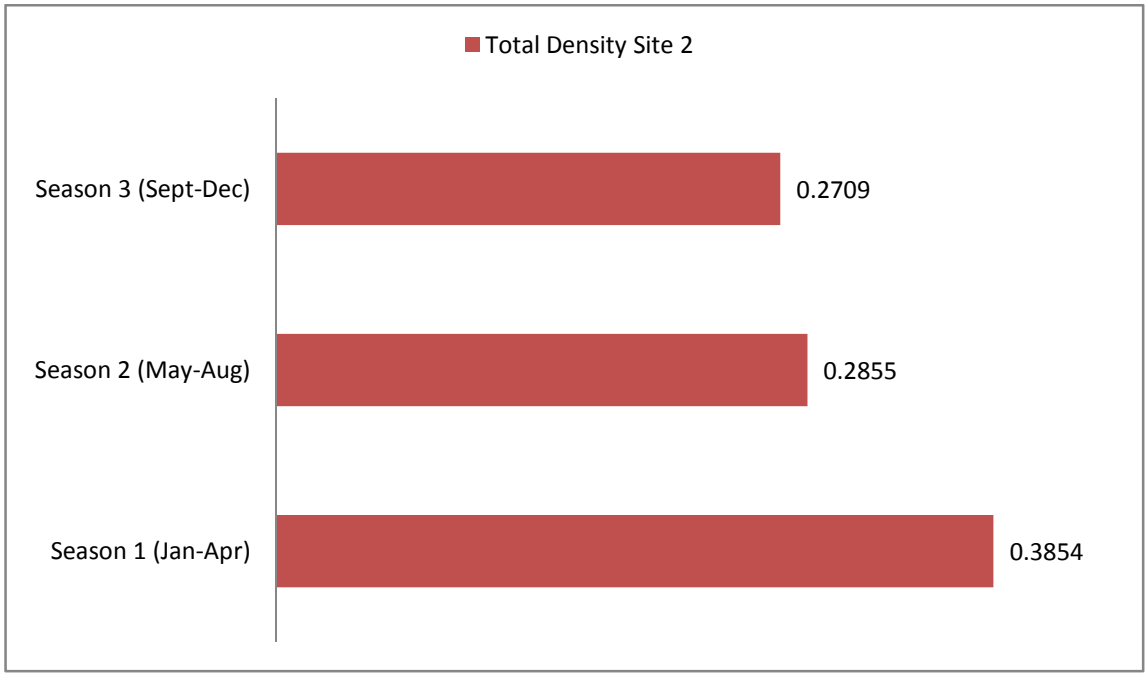

Figure 3.37: Total density of vegetation in site 2 (Kuala Kangsar, Perak) during the growth season in 2009.

3.4 DISCUSSION

It was noted that based on records and references, 12 species had been identified to be present in various parts of Peninsular Malaysia. The species were *A. bufo, A. carnosus* syn. *carneus, A. elatus* syn. *variabilis, A. elegans, A. haematospadix, A. longituberosus* syn.*viridis, A. minor, A. oncophyllus* syn. *muelleri, A. paeoniifolius* syn. c*ampanulatus, A. perakensis, A. prainii,* and *A. sparsiflorus.* However, from the field survey conducted, only six species were successfully collected, identified and documented from several areas in Peninsular Malaysia. The species sampled were *A. bufo, A. elatus, A. elegans, A. oncophyllus, A. paeoniifolius,* and *A. prainii.* Sampling of specimens is quite difficult because of the limited time to cover a large area and also the nature of the plant whereby during certain period of the year especially during the hot and dry period, the plant shoot did not appear above the ground hence it was almost impossible to sample the species that was supposed to be present at that particular area.

It was very obvious that *A. paeoniifolius* and *A. prainii* were the most common species found in Peninsular Malaysia. They were sampled in various parts of the country irrespective of the highland region or the dry lowland region in the north. This could imply that the two species can adapt to all kinds of environmental conditions including the different soil types of Peninsular Malaysia.

Other species, namely, *A. bufo, A. elatus, A. elegans* and *A. oncophyllus*, were restricted in their distribution to certain areas of the country. The distribution

of *A. bufo* was restricted only to the wet and cooler area of Cameron Highlands. It was not found in other parts of the country during the course of this study.

Similarly, the occurrence of *A. oncophyllus* was restricted only to the northern parts of Peninsular Malaysia. This particular species is not native to our country (Hetterscheid & Ittenbach, 1996). It is indigenous to Thailand and it is commercially being planted in that country for glucomannan production. States like Perlis and Kedah bordering Thailand possibly acquired this species via human transfer of the corm through the border.

A. paeoniifolius and *A. prainii* were the most dominant or common *Amorphophallus* species found in Peninsular Malaysia, hence this two species were selected for detailed studies. Site 1 (Jerantut, Pahang) is the selected study site for *A. paeoniifolius* location while site 2 (Kuala Kangsar, Perak) was selected for *A. prainii*. However the vegetation of site 1 and site 2 are representative of an orchard or abandoned orchard, and this heavily anthropogenic regrowth are not indicative of wild habitats for *Amorphophallus* spp. studied.

From the field study, it was observed that the optimum growth of *Amorphophallus* spp. in Peninsular Malaysia could be achieved when the humidity ranged between 53 to 85 %. This result also indicate that *Amorphophallus* species can grow at locations with high light intensity of up to 2780 Lux. *Amorphophallus* spp. appear to thrive best at temperatures between 25 -30°C.

Results of the present study also indicated that both *A. paeoniifolius* and *A. prainii* were dominant during the rainy season (Season 2 and Season 3). The

shoot grew well during this period. This result supports previous studies that showed *Amorphophallus* spp. grows well in the wet season (Hetterscheid & Ittenbach, 1996). However, *Amorphophallus* spp. can also survive the hot and dry season by undergoing dormancy as in Season 1.

It was also observed that all the *Amorphophallus* species investigated had no preference for soil acidity. Since most of the Malaysian soils are acidic in nature, the observation made indicated that all the *Amorphophallus* species sampled were found in soils that were acidic in nature, which is slightly acidic to nearly neutral. Similarly, all species were found in areas with varying soil properties including soil texture, moisture content, available Ca, Mg, K and total P and organic matter. However, as in other plants, *Amorphophallus* species require fertile soil high in available Ca, Mg, K, total P, organic matter and optimum moisture content.

It was observed that the Importance Value (IV) of *Amorphophallus* species varied considerably with seasons for both locations (Jerantut and Kuala Kangsar). This indicated that the *Amorphophallus* species can appear dominant during the implied favourable period of the year and hibernate when adverse conditions prevail.

The pattern of IV was similar for both locations (Jerantut and Kuala Kangsar), that is, the IV was highest during season 3 (September-December), followed by season 2 (May-August) and lowest during season 1 (January-April). This pattern of IV coincided well with the climatic conditions, when *Amorphophallus* species are undergoing dormancy in season 1 in both locations, (Jerantut and Kuala Kangsar), whereby the IV was highest in season 3 when both

the locations were experiencing slightly lower temperatures, slightly higher humidity and rainfall during the North East Monsoon period at the end of the year which favoured the growth of *Amorphophallus* spp.

It was also observed that the *Amorphophallus* species studied was well distributed under the canopy of orchard trees namely, *Durio*, *Nephelium*, *Artocarpus*, and *Lansium* in both locations. It clearly indicated that both species can grow well under the cultivated orchard fruit trees.