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Descriptive analysis on the morphology, growth and branching patterns of Princess-flower (*Tibouchina urvilleana* Cogn.) in Peninsular Malaysia

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Abstract

Princess-flower (*Tibouchina urvilleana* Cogn.) from the family Melastomaceae is a true indigene of Brazil. The plant with attractive purple flowers is a widely cultivated ornamental in the tropics, including Malaysia. We found the plants escaping into the wild in Genting Highlands, Peninsular Malaysia. This shrub or small ornamental tree ranges from 1 to 4.5 m in height, with young quadrate branches. General growth and branching patterns of princess-flower were studied. The ultra-morphological characterization of the leaf and stem was carried out using light and scanning electronic microscope (SEM). Plants of *T. urvilleana* growing singly in pots in the absence of neighbors develop a symmetric crown. The vector arrow projecting from the centre of the distribution of branches represents the mean angles of 140.5^o. Most branches are concentrated in opposite direction and away from each other with mean angles of 135^o and 315^o in a clockwise manner with respect to the mother plant. The relation between days after planting as independent variable with dependent variables are represented by CurveExpert and SPSS examined every possible regression model for the data and selected the best one of regression models such as 3rd degree polynomial, logistic, sinusoidal fit, Gompertz relation and vapor pressure. The relation between plant height and days after planting is represented by a simple linear regression model, $y=8.522+0.301x$ with $R^2=0.97$.

Key words: Princess-flower, *Tibouchina urvilleana,* growth, branching patterns.

Introduction

There are over 300 known species of *Tibouchina* worldwide mostly in the tropics and sub-tropics [1]. Princess-flower (*Tibouchina urvilleana* Cogn.) from the family Melastomaceae is a true indigene of Brazil. The plant with their attractive purple flowers (Fig. 1) is a widely cultivated ornamental in the tropics, especially in warm areas with mild climates, including Malaysia. Princess-flower is a very popular landscape plant in frost-free areas around the world. It is also cultivated in southern parts of the United States, and elsewhere in the Pacific, *viz*. Cook Islands, Hawai'i, Kermadec Islands and Samoa [7]. We found the pockets of *T. urvilleana* escaping into the wild in Genting Highlands, Peninsular Malaysia. Princess-flower is known by other common names, *viz.* Glory bush or Lasiandra [3, 12] and as well as synonym names like *Lisiandra urvilleana* DC, *Pleroma grandiflora* Hort., *P. splendens* Hort. and *Tibouchina semidecandra* non (DC) Cogn. [12]. Almeda and Chuang [2] reported n = 9, 18 in the original meiotic chromosomal counts for *T. urvilleana.*

Princess-flower requires full sun for best flowering and will thrive on any well-drained soil when regularly watered. Its growth habit is somewhat weedy, requiring training and pruning to develop and maintain it as a tree. It is widely cultivated in warm regions for its soft foliage and showy purple flowers and also it is known to form thickets in wet areas of Hawaii from 200 to 1,700 m. Princess-flower is a weed in many tropical areas worldwide, especially in lowland moist disturbed areas. The plant has become naturalized in some areas of Hawai'i, and has a high potential to be as noxious weed in the state of Hawai'i [9, 10, 13].

Princess-flower prefers rich fertile soil but it is able to adapt to other soils as well if mulched, fed and periodically watered. Fertilizer application after each bloom cycle ensures optimum flowering. The plant prefers sunny situations but Princess-flower appreciates afternoon shade in areas with high summer temperatures. Princess-flower likes moisture but not soggy conditions, although the plant will survive short periods of drought. It can be easily propagated from cuttings, softwood cuttings and division of clumps [8]. Princess-flower is ideal for mixed shrubbery border or used in small groupings to compound the impact of bloom time [4]. This paper describes the results of our studies on the general descriptive analysis of *Tibouchina urvilleana*, and its general growth and branching patterns.

Materials and Methods

Six young uniform seedlings of *T. urvilleana* were collected from Genting Highlands, Pahang, Malaysia (3^{o}8'N; 101^o 42'E) in December 2005. These were then transplanted into clay pots measuring 35 cm in diameter and 40 cm high, previously filled with garden soils of Malacca series (Table 1). The plants were watered twice in the morning and in the evening from above with fine rose. The plants were raised in insect-proof house with 12 hr of natural sunlight and mean ambient temperatures of 33^{o}C (day) and 25^{o}C (night) at Rimba Ilmu, University of Malaya, Kuala Lumpur, Malaysia. Growth parameters, namely plant height; primary, secondary and tertiary branch length and numbers; leaf numbers in each category of branches and phenological traits (time and duration of flowering, number of flowers/branch or flowers/plant) were recorded. The ultra-morphological structures of the leaf and stem were examined using light and scanning of electronic microscopy (SEM).

Table 1. Physico-chemical characters of (a) forest soils with prevailing populations of *Tibouchina urvilleana* in Genting Highlands, and (b) garden soils of Malacca series, Malaysia.

Sample	Depth (cm)	pH	EC	SP%	T.N.V. %	N%	P (ppm)	K(ppm)	OM%	Sand%	Silt%	Clay%
a	0-50	5.83	0.44	29.75	0.762	0.82	3.4	50	1.160	84	8	8
b		5.25	0.91	29.61	0.514	0.156	46	75	2.194	78	10	12

As for the branching pattern studies, the plants were progressively divided into 50-cm heights from soil surface, and denoted accordingly. A circle of transparency plastic sheet divided into 8 sectors quadrant with a 45^o degree angle was prepared. With this plastic sheet, overlays were prepared every 4-weekly interval for a period of 24 weeks to assess branching patterns of *T. urvilleana.* With the aid of a compass, the direction and branch angles (primary branches with respect to the mother plant) in each quadrant were recorded. The growth data were analyzed with ANOVA, circular data and regression analyses were performed where appropriate. The process of finding the best fit was done by CurveExpert 1.3. It compares the data to each model to choose the best curve. It is a comprehensive curve fitting system for Windows. XY data can be modeled using a toolbox of linear regression models, non-linear regression models, interpolation or splines. AXIS Version 1.1 was used as a program for the statistical analysis of circular data. Observations on two-dimensional direction are called circular data. Two-dimensional direction can be represented as angles measured with respect to some suitably chosen “zero direction”, i.e., the starting point and “sense of rotation”, i.e., whether clockwise or anti-clockwise is taken as positive direction. The proper use of circular statistical methods could lead to improve the rhythms as well as factors that influence these rhythms [5].

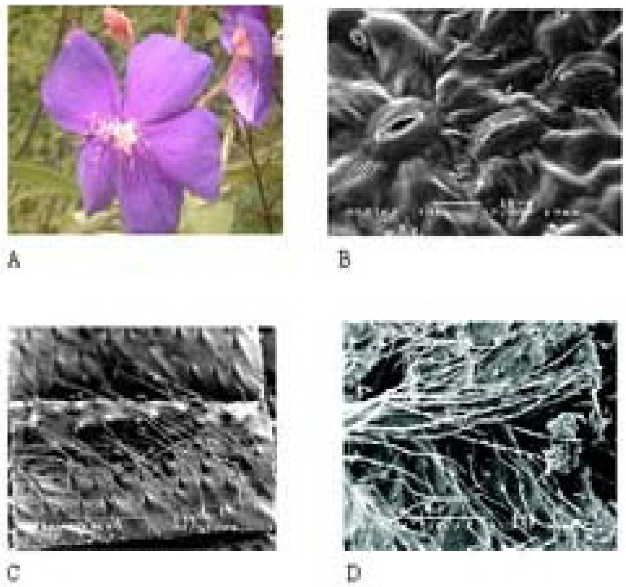

Figure 1. The (a) flower, (b) the stomata in the beneath surface of the leaf, (c) long trichomes on the surface (d) and beneath the leaf in *Tibouchina urvilleana.*

Results and Discussion

Nomenclatural description: The generic name is derived from a native name of the plants in Guiana [12]. This shrub or small ornamental tree ranges from 1 to 4.5 m in height, young branches quadrate, densely villous to hirtellous. Leaves are elliptic-ovate to lanceolate, 4-12 cm long, 2-5 cm wide, 5-7 nerved, upper surface strigose, the hairs not adnate to surface (Fig. 1), lower surface sericerous, margins entire, apex acute to acuminate, base obtuse to rounded, petioles 5-20 mm long. Inflorescences are terminal, 8-15 cm long (incl. peduncle), with 2 bracts elliptic to elliptic-ovate, 2.5-3 cm long, 0.8-1.4 cm wide, deciduous, bracteoles enclosing and concealing floral buds; hypanthium densely strigose; calyx lobes linear-subulate, 12-15 mm long, 3-5 mm wide, deciduous after anthesis; petals 5, purple, 25-40 mm long, 20-40 mm wide; stamens dimorphic; larger anthers 15-16 mm long, connective prolonged 6-7 mm, with an appendage *ca.* 1 mm long, smaller anthers 11-14 mm long, with shorter connective and appendage but otherwise as in larger anthers; filaments glandular puberulent at base. Fruiting hypanthium is 14-15 mm long and 9-10 mm wide. Mature seeds are not seen [12]. In our studies, no mature seeds were observed in the experimental site of Rimba Ilmu, University of Malaya and Genting Highlands, Pahang, Malaysia.

According to Meyer [6], the genus *Tibouchina* is quite different and can be differentiated from their relatives in genera *Tristenma, Melastoma* or *Osbeckia* within the family Melastomaceae. The general keys (Table 2) help to differentiate *Tibouchina vis-à-vis* species from related genera in the family Melastomaceae.

Table 2. Keys to the genera of Melastomaceae family.

1a.	Fruits fleshy	2
b.	Fruits dry capsules	3
2a.	Hypanthium glabrous except for bristles or penicillate emergences arranged in rings	*Tristenma mauritianum* (J.F. Gmelin)
b.	Hypanthium covered with bristles, scales or emergences (not arranged in rings)	*Melastoma* L.
3a.	Flowers > 5 cm in diameter, dark purple	*Tibouchina urvilleana* Cogn.
b.	Flowers smaller, not dark purple	4
4a.	Stamens isomorphic	*Osbeckia* L.
b.	Stamens dimorphic	5
5a.	Creeping shrub or suffrutescent herb, hypanthium covered with stellate emergences	*Dissotis rotundifolia* (Sm.) Triana
b.	Erect shrub, hypanthium covered with simple scales	*Melastoma pellegrinianum* (H. Boissieu, K. Meyer)

Table 3. Model summaries and parameter estimates of the regression relationships between mean branch lengths/plant, plant height, leaf numbers/plant or leaf numbers/branch, and numbers of flowers/plant of *T. urvilleana* as the function of time (for 25 weeks) after transplanting raised in insect-proof house in Peninsular Malaysia.

Dependent variable	Regression model	Standard error	R^2
Plant height	Linear y= 8.522+0.301x	11.28286433	0.97
Total leaf number/plant	Logistic model y= 410.05648/(1+55.504304 *exp(-0.023059267 x)	11.44859073	0.97
Leaf number in B1°	Logistic model y= 141.06562 /(1+43.874747*exp(-0.022563164 x)	2.9317721	0.98
Leaf number B2°	Gompertz Relation y=407.00055*exp(-exp(1.8125139b-0.0069489916x))	2.8940487	0.98
Leaf number B3 °	Sinusoidal Fit: y=10.562953+12.739392*cos(0.024246405x+2.1030641)	3.3091089	0.92
Branch length 1°	Y=3.039+0.220 x	1.744094	0.98
Number of Branch 1°	Sinusoidal Fit: y=4.275149+3.2464155*cos(0.027157668x+2.1871206)	0.7706691	0.94
Number of Branch 2°	Sinusoidal Fit : y=4.5160468+4.07471 *cos(0.019331798x+2.4524794)	0.3737234	0.99
Branch number B3°	Logistic Model: y=6.505/(1+1.8331649e+008*exp(-0.1740421x))	1.1831322	0.89
Number of flower 1°	3rd degree Polynomial Fit: y=0.50171932-0.031116607x+0.00024262686x^2+7.9420466e-007x^3	1.0201916	0.86
Number of flower 2°	3rd degree Polynomial Fit: y=0.20745209 -0.0075926174x-0.000119659x^2+1.9458925e-006x^3	0.9438553	0.83
Number of flower /plant	3rd degree Polynomial Fit: y=1.0653367-0.058326363x+0.0001884567x^2+4.1360732e-006x^3	2.3757120	0.89
Node number /Branch 1⁰	Vapor Pressure Model: y=exp(- 2.4845031+5.2572135/x+0.83678209ln(x))	0.3348995	0.97

General growth and branching patterns: The 3rd degree polynomial regression model in Fig. 2 represents the best one for plant height and the days after planting. The regression models can describe the growth for different plant characters such as plant height, branch number, leaf number/plant or leaf number/branch and flowers/branch or flowers/plant (Table 3). Princess-flower is a perennial shrub and plant height and the length of branch are elongated with increasing plant age, and growth model equations for continuous variables are linear regressions. There was observed some of early beneath branches in the plant canopy died because of light and internal growth competition between different plant parts. The equation for other discrete variables like the number of leaves, branches and flowers is not simple linear regression model. As the number of leaves and flowers are different at various phenological and morphological stages, the trends are non-linear regression models. Here we presented only the relationship between plant height and day after planting as a linear regression model (y=8.522+0.301x, R^2=0.965). The plant height increased linearly up to 25 weeks after transplanting at the rate of 0.301 cm/day (Fig. 2). Most branches and flowers appeared after 150 days from seedling stage (Fig. 3).

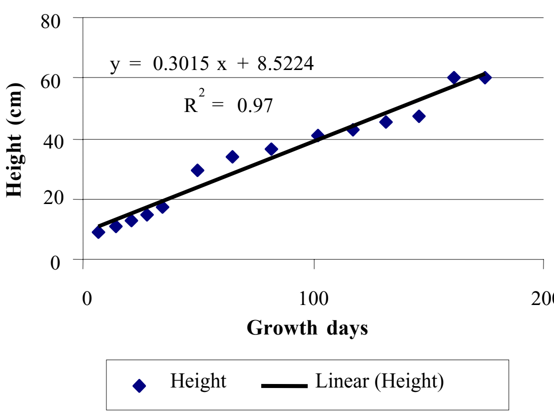

Figure 2. The relationship between plant height of *Tibouchina urvilleana* and time after transplanting.

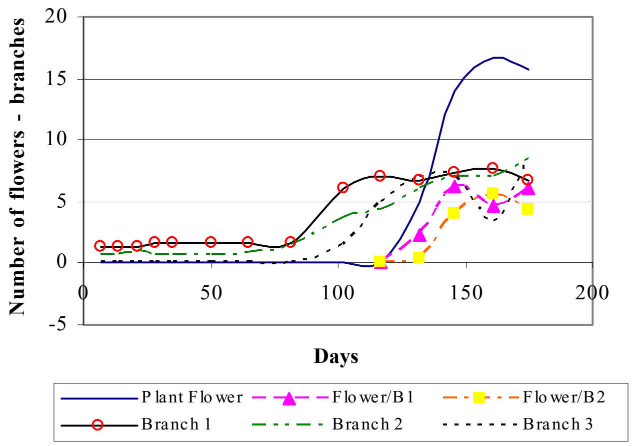

Figure 3. The relationship between the number of flowers and branch type and growth days in *Tibouchina urvilleana*.

Table 4. Analysis of variance of different characters in each branch direction in *Tibouchina urvilleana*.

Source of variations	Degree of freedom	Mean square					
		Length of branch 1° (cm)	Angle of branch 1°	Leaf number of branch 1°	Length of branch 2° (cm)	Angle of branch 2°	Leaf number of branch 2°
Replication	2	1.477 ^{ns}	11.292^{ns}	6.792*	3.135^{ns}	21.875^{ns}	5.167^{ns}
Branch direction	7	159.381**	1419.905**	86.161**	248.167**	1487.946**	163.327**
Error	14	0.977	11.244	1.411	3.850	14.732	2.310
Coefficient of variation		10.44	10.53	18.39	33.16	26.70	34.09

** significant at P<0.01 and ns means non-significant at P<0.05.

Circular distribution had significant effect at α=0.01 on different characters like length, angle and leaf number of branches in each branch dispersion (Table 4).Least significant different test (LSD at α=0.05) showed that the longest 1° branch was in the angle of 180-360°. There was no observation of any branches and leaves as well, in the angles 225° and 270°.The biggest amount of the angle of branch 1° and 2°, leaf number/branch 1°, 2° and the length of branches 1°, 2° were observed in the angle of 180° (Table 5).

The symmetry of growth of the crown and the stem branches in *Tibouchina urvilleana* shows a circular distribution with various amount of dispersion. The blue line or T shape line indicates the mean angle, which is 140.50° the amount of r=0.35 (the length of the mean vector) and circular variance 0.65 (V=1-r).The value of r varies inversely with the amount of dispersion in data. It has no units and it may vary from 0 (when there is so much dispersion that a mean angle cannot be described) to 1.0 (when all the data are concentrated at the same direction) [11]. The shortest arc containing all the data is that running clockwise from 0 to 360°, the range 140.50°, median direction 138°, mean resultant length 0.035 and concentration 0.75 (Fig. 4). The most distribution having opposite modes at 135° and 315°, the distribution is centrally symmetrical because each observation is matched by an observation 180° away. There is a 95% probability that the true mean direction is less than 162.73° and more than 118.28°. Rayleigh's test shows the population is not a uniform circular distribution and therefore there is mean population direction (Fig.4, Tables 3 and 6).

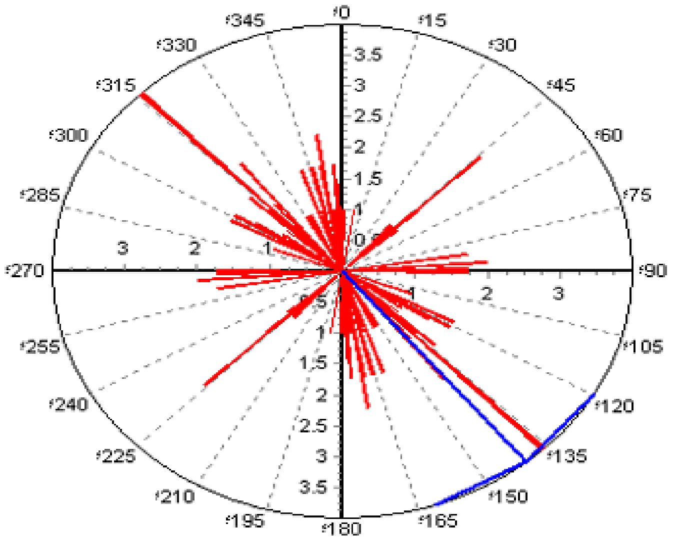

Figure 4. The symmetry of growth of the crown and the circular plot of stem branches in *Tibouchina urvilleana.*

Table 6. Descriptive statistical analysis of circular data of *Tibouchina urvilleana* branches.

Descriptive statistics	
Observations	98
Mean direction	140.50°
Concentration	0.75
Standard error of mean	11.34°
Lower 95% mean	118.28°
Upper 95% mean	162.73°
Mean resultant length	0.35
Circular variance	0.65
Circular std dev.	83.09°
Median direction	138
Lower 95% median	135
Upper 95% median	160
Circular dispersion	183.06
Rayleigh test of uniformity (p= 0.0159557)	4.13794

Table 5. Least significant difference test of branch angles with respect to the mother plant in *Tibouchina urvilleana*.

Direction	Length of Branch 1°	Angle Branch 1°	Leaf number/ Branch 1°	Length of Branch 2°	Angle Branch 2°	Leaf number/ Branch 2°
45°	9.167 c	36.67 c	3.667 d	9.333 c	30 b	7 b
90°	11 b	39.33 c	8.333 c	0.0 d	0.0 c	0.0 c
135°	10.67 bc	47 b	7.333 c	0.0 d	0.0 c	0.0 c
180°	19.50 a	55 a	14.67 a	24 a	60 a	20.67 a
225°	0 e	0 e	0 e	0.0 d	0.0 c	0.0 c
360°	18.50 a	51.67 ab	12.50 b	0.0 d	25 b	8 b
LSD (0.05)		5.872	2.080	3.436	6.722	2.662

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