Leaf morphology and numerical taxonomic evaluation of *Clerodendrum L.* (Lamiaceae)

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Abstract : A total number of 14 species of *Clerodendrum* was investigated using 50 leaf morphological characters. The species studied showed common shared characters of having simple type of leaf, opposite leaf arrangement, sinuous and random reticulate of 3rd vein, absence of free ending ultimate vein, regular polygonal reticulation of 4th vein, looped type of marginal ultimate and swollen petiole with marginal type of petiole position arrangement. Selected characters such as the presence and shape of stipule, vein spacing, leaf venation, 5th vein category, leaf texture, agrophic, leaf shape, presence or absence of hair at the epidermal layers, areolation, petiole outline and presence of hair and leaf texture, can be very useful in species delimitation. Leaf apex, base, margin and most of serration and sinuses features can be used as diagnostic characters to several species identification such as *C. johorensis, C. chinensis* and *C. paniculatum.*

Keywords: Lamiaceae, *Clerodendrum*, morphology, leaf architecture

INTRODUCTION

The genus *Clerodendrum* was first described by Linnaeus (1753), consists of one species, *C. infortunatum.* It was first assigned to Verbenaceae before it was placed into Lamiaceae in accordance to the recircumscription of the family boundaries based on molecular and morphological phylogenetic evidence (Olmstead et al. 1993, Wagstaff et al. 1998, Cantino et al. 1992; Harley et al., 2004). *Clerodendrum* composed of shrubs or small trees which have large inflorescences of white or brightly-coloured zygomorphic flowers. It is also known as glory bower, bag flower and bleeding-heart. Most of *Clerodendrum* are important ornamentals or have medicinal properties whereas, some are pernicious weeds (Neeta and Teja, 2007). It is currently classified in subfamily of *Ajugoidae* based on phylogenetic analysis of morphological and molecular data conducted by Wagstaff et al., (1998). Yuan et al. (2010) stated that there are about 150 species while Harley et al. (2004) cited about 450 species belongs to the genus. The number varies as a result of some of the species which were formerly placed in the genus were transferred to *Rotheca, Volkameria* and *Ovieda* (Yuan et al., 2010). This also showed the uncertainty of total number of *Clerodendrum* which portrays the unclear placement of the members into the right genera by many taxonomists. On the other hand, Turner (2008) stated 11 species of *Clerodendrum* recorded in Peninsular Malaysia.

A repeated study by Steane (1997, 1998) to delimit the group which formerly understood as polyphyletic into monophyletic resulted in numerous changes. Yuan et al. (2010) also try to delimit the genus into monophyletic resulting in the rise of two genera namely *Volkameria* and *Ovieda*. Constant addition and deletion of the species made the genus problematic as stated by Mabberly (2011) as in his finding. He claimed that some of the species are in uncommon position as they were reidentified several times until reaching a nomenclatural 'full circle'.

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MATERIALS AND METHODS

Fresh leaf samples of 14 *Clerodendrum* species were collected through a series of fieldtrips conducted throughout Peninsular Malaysia. These areas were suggested to have high richness in species due to their unique phytogeographical position. Herbarium specimens were prepared and morphological characters were observed thoroughly under dissecting microscope (Leica A60S). Leaf morphological architectures were evaluated under Leica A60S dissecting microscope based on Hickey (1999). Morphological variation of leaf architecture was focussed in this study. Voucher specimens were kept in UPSI herbarium for future reference. *Tectona grandis* served as an out group in this study. Dendrogram was constructed from the data obtained to examine the similarity matrices of the studied genus through morphological analysis.

RESULTS AND DISCUSSION

Leaf architecture attributes including leaf arrangement, leaf shape, apex, base and margin, leaf venation, petiole characters, leaf serration and sinuses, stipule shape, leaf texture and presence of hair on the epidermal surfaces were evaluated based on Hickey (1999) and are summarized in Table 1. Dendrogram was constructed using UPGMA multivariate analysis according to 50 leaves morphological architecture characters within 14 species observed (Appendix A).

General leaf features

All 14 species of *Clerodendrum* studied show some common general morphological features that distinguished the genus from the rest of Lamiaceae genera. The genus has simple leaf, opposite leaf arrangement, randomly reticulate, inconsistent and sinuous course of 3rd vein. 4th vein with regular polygonal reticulate vein, looped ultimate margin, swollen petiole base and marginal position of petiole attachment. Leaf margin characters can be used to subdivide the Peninsular Malaysian *Clerodendrum* into three groups which are entire, lobed and serrate. All species fall in entire margin group except, serrate margin of *C. chinense* and lobed margin found in *C. villosum* and *C. paniculatum*. Leaf venation characters are also useful in delineate to the species into three main catagories namely pinnate, actinodromous and palinactinodroumous.

Leaf blade features varies from elliptic, aristate, cordate, deltoid and linear. Starts with the majority of *Clerodendrum* species share elliptic and aristate leaf blade. *C. laevifolium, C. umbellatum, Clerodendrum* sp1 and *Clerodendrum* sp2 share elliptic leaf blade while *Clerodendrum* sp3, *C. deflexum, C. disparifolium* and *C. phyllamega* share aristate leaf blade. On the other hand, *C. villosum, C. paniculatum* and *C. chinense* share cordate leaf blade. *C. nutan, C. johorense* and *C. hendersonii* posses linear, lanceolate and deltoid type of leaf blade, respectively. Leaf apex varies from caudate, cuspidate, acuminate and acute. *Clerodendrum* leaf base is commonly acute base except, *C. nutan* with cuneate, *C. deflexum* with truncate whereas rounded based observed in *Clerodendrum* sp1 (Table 1).

Leaf apex characters can be used to segregate *Clerodendrum* into several groups. Most species have caudate leaf apex and the rest four species have cuspidate apices. *C. villosum* and *C. hendersonii* show acuminate leaf blade whereas, *C. chinense* is the only species that shows acute apex. The character of leaf base further distinguishes each individual species studied. Majority of the species have acute type of leaf base. This excludes *C. chinense, C. paniculatum* and *C. villosum* which have cordate leaf base whilst *C. deflexum* and *Clerodendrum* sp1 have truncated and rounded leaf base, respectively. Most of the species share an entire leaf margin. This excludes three species in which they were divided into two groups, lobed and serrate leaf margin. *C. paniculatum* and *C. villosum* have lobed margin while *C. chinense* portrays serrate leaf margin. Among studied *Clerodendrum* species only *C. chinense* and *C. villosum* posses tomentose hairs.

Table 1. General Leaf features of *Clerodendrum* species.

No.	Species	Habit	Type of leaves	Leaves arrangement	Leaf blade shape	Leaf apex	Leaf base	Leaf margin	Leaf lamina	Hair	Abax Hair	Adax Hair
1.	*C. laevifolium*	Shrub	Simple	Opposite	Elliptic	Caudate	Acute	Entire	Symmetry	Absent	Absent	Absent
2.	*C. nutan*	Shrub	Simple	Opposite	Linear	Caudate	Cuneate	Entire	Symmetry	Absent	Absent	Absent
3.	*C. villosum*	Shrub	Simple	Opposite	Cordate	Acuminate	Cordate	Lobe	Symmetry	Present	Hairy	Hairy
4.	*C. deflexum*	Shrub	Simple	Opposite	Aristate	Caudate	Truncate	Entire	Asymmetry	Absent	Absent	Absent
5.	*C. johorense*	SST	Simple	Opposite	Lanceolate	Caudate	Acute	Entire	Symmetry	Absent	Absent	Absent
6.	*C. umbellatum*	Shrub	Simple	Opposite	Elliptic	Caudate	Acute	Entire	Symmetry	Absent	Absent	Absent
7.	*Clerodendrum* sp3	SST	Simple	Opposite	Aristate	Caudate	Acute	Entire	Symmetry	Absent	Absent	Absent
8.	*C. paniculatum*	Shrub	Simple	Opposite	Cordate	Cuspidate	Cordate	Lobed	Symmetry	Absent	Absent	Absent
9.	*C. hendersonii*	SST	Simple	Opposite	Deltoid	Acuminate	Acute	Entire	Symmetry	Absent	Absent	Absent
10.	*C. chinense*	Shrub	Simple	Opposite	Cordate	Acute	Cordate	Serrate	Symmetry	Present	Hairy	Hairy
11.	*C. disparifolium*	Shrub	Simple	Opposite	Aristate	Caudate	Acute	Entire	Symmetry	Absent	Absent	Absent
12.	*C. phyllomega*	SST	Simple	Opposite	Aristate	Cuspidate	Acute	Entire	Symmetry	Absent	Absent	Absent
13.	*Clerodendrum* sp1	Shrub	Simple	Opposite	Elliptic	Cuspidate	Rounded	Entire	Symmetry	Absent	Absent	Absent
14.	*Clerodendrum* sp2	Shrub	Simple	Opposite	Elliptic	Cuspidate	Acute	Entire	Symmetry	Absent	Absent	Absent
15.	*Tectona grandis*	Tree	Simple	Opposite	Elliptic	Apiculate	Acute	Undulated	Symmetry	Absent	Absent	Absent

Legends - SST: Small Slender Tree

Table 2a. Venation characters of *Clerodendrum* species

No	Species	Leaf Venation	2nd Vein distance	Inter 2nd vein	3rd Vein category	3rd Vein Course	3rd Vein angle Variability	No of lateral Vein	Vein spacing	4o vein category	5o Vein category
1.	*C. laevifolium*	Pinnate	1.5 – 2 cm	Strong	RR	Sinuous	Inconsistent	8	Irregular	RPR*	N/A
2.	*C. nutan*	Pinnate	2 – 5.5 cm	Strong	RR	Sinuous	Inconsistent	10	Irregular	RPR	N/A
3.	*C. villosum*	Actinodromous – Basal	4.5 cm	Absent	RR	Sinuous	Inconsistent	6	Irregular	RPR	N/A
4.	*C. deflexum*	Pinnate	3.0 cm	Strong	RR	Sinuous	Inconsistent	7	Uniform	RPR	N/A
5.	*C. johorense*	Pinnate	2 – 2.5 cm	Strong	RR	Sinuous	Inconsistent	14	Uniform	RPR	Regular polygonal
6.	*C. umbellatum*	Pinnate	1.5 – 2 cm	Strong	RR	Sinuous	Inconsistent	10	Irregular	RPR	N/A
7.	*Clerodendrum* sp3	Pinnate	1.5 – 2 cm	Strong	RR	Sinuous	Inconsistent	13 – 14	Uniform	RPR	Regular polygonal
8.	*C. paniculatum*	palinactinodromous	3 – 3.5 cm	Strong	RR	Sinuous	Inconsistent	4-5	Irregular	RPR	N/A
9.	*C. hendersonii*	Pinnate	1.5 – 2.0 cm	Weak	RR	Sinuous	Inconsistent	7	Irregular	RPR	N/A
10	*C. chinense*	Actinodromous-Basal	1.5 – 4 cm	Weak	RR	Sinuous	Inconsistent	4	Irregular	RPR	N/A
11	*C. disparifolium*	Pinnate	1.5 – 2 cm	Absent	RR	Sinuous	Inconsistent	7	Irregular	RPR	Regular polygonal
12	*C. phyllomega*	Pinnate	2.5 – 3.5 cm	Strong	RR	Sinuous	Inconsistent	9	Irregular	RPR	Regular polygonal
13	*Clerodendrun* sp1	Pinnate	1 – 1.5 cm	Strong	RR	Sinuous	Inconsistent	8 – 11	Irregular	RPR	N/A
14	*Clerodendrum* sp2	Pinnate	2 – 2.5 cm	Strong	RR	Sinuous	Inconsistent	8	Irregular	RPR	N/A
15	*Tectona grandis*	Pinnate	2.5 – 4.5 cm	Absent	Opposite percurrent	Straight	Uniform	10	Irregular	Opposite percurrent	Regular polygonal

Note : SST; Small Selender Tree, RPR: Ragular Poligonal Reticulate

Table 2b: Venation of studied species Continue.

No.	Species	Agrophic	Marginal Ultimate	Intercostal area	Areolation			F.E.V.S	Leaf Rank
					Shape	Size	Orientation		
1.	*C. laevifolium*	Simple agrophic	Looped	Irregular	Irregular	Irregular	Irregular	Absent	4^r
2.	*C. nutan*	Simple agrophic	Looped	Irregular	B regular	B regular	Irregular	Absent	4^r
3.	*C. villosum*	Compund agrophic	Looped	Irregular	B regular	B regular	Irregular	Absent	4^r
4.	*C. deflexum*	Simple agrophic	Looped	Irregular	Irregular	Irregular	Irregular	Absent	4^r
5.	*C. johorense*	Simple agrophic	Looped	Irregular	B. regular	B. regular	Irregular	Absent	4^r
6.	*C. umbellatum*	Simple agrophic	Looped	Irregular	B regular	B regular	Irregular	Absent	4^r
7.	*Clerodendrum* sp3	Simple agrophic	Looped	Irregular	Regular	Regular	Irregular	Absent	4^r
8.	*C. paniculatum*	Compund agrophic	Looped	Irregular	B regular	B regular	B regular	Absent	4^r
9.	*C. hendersonii*	Simple agrophic	Looped	Irregular	Irregular	Irregular	Irregular	Absent	4^r
10.	*C. chinense*	Simple agrophic	Looped	Regular	Regular	Regular	Regular	Absent	4^r
11.	*C. disparifolium*	Simple agrophic	Looped	Irregular	B regular	B regular	Irregular	Absent	4^r
12.	*C. phyllomega*	Simple agrophic	Looped	Irregular	Irregular	Irregular	Irregular	Absent	4^r
13.	*Clerodendrum* sp1	Simple agrophic	Looped	Irregular	B regular	B regular	B regular	Absent	4^r
14.	*Clerodendrum* sp2	Simple agrophic	Looped	Irregular	B Irregular	B irregular	Irregular	Absent	4^r
15.	*Tectona grandis*	Na	Looped	Regular	Regular	Regular	Regular	Absent	4^r

Note : F.E.V.S; Free Ending Ultimate Veins, B. regular : Becoming regular

Table 3: Petiole and stem features of *Clerodendrum* species

No.	Species	Blade – Petiole separation	Petiole Feature	P.O.P.A	Petiole Outline	Petiole Hair	Petiole Length	Petiolule	Twig
1.	*C. laevifolium*	Good	Base swollen	Marginal	Rounded	Absent	2.5 – 3.5 cm	N/A	Terete
2.	*C. nutan*	Good	Base swollen	Marginal	Reniform	Absent	6.5 – 8.0 cm	N/A	Terete
3.	*C. villosum*	Good	Base swollen	Marginal	Oval	Present	6.5 – 9.0 cm	N/A	Subterete
4.	*C. deflexum*	Good	Base swollen	Marginal	Reniform	Absent	3.0 cm	N/A	Terete
5.	*C. johorense*	Good	Base swollen	Marginal	Reniform	Absent	3.0 cm	N/A	Subterete
6.	*C. umbellatum*	Good	Base Swollen	Marginal	Round	Absent	3 – 5 cm	N/A	Terete
7.	*Clerodendrum* sp3	Good	Base swollen	Marginal	Reniform	Absent	2 – 3 cm	N/A	Terete
8.	*C. paniculatum*	Good	Base swollen	Marginal	Rounded	Absent	10 – 11.5 cm	N/A	Terete
9.	*C. hendersonii*	Good	Base swollen	Marginal	Rounded	Absent	11 – 12 cm	N/A	Terete
10.	*C. chinense*	Good	Base swollen	Marginal	Oval	Present	3.5 – 7.5 cm	N/A	Terete
11.	*C. disparifolium*	Good	Base swollen	Marginal	Reniform	Absent	4.5 – 6 cm	N/A	Subterete
12.	*C. phyllomega*	Good	Base swollen	Marginal	Reniform	Absent	2 – 4.5 cm	N/A	Terete
13.	*Clerodendrum* sp1	Good	Base swollen	Marginal	Reniform	Absent	1 – 4.5 cm	N/A	Terete
14.	*Clerodendrum* sp2	Good	Base Swollen	Marginal	Rounded	Absent	3 – 4.5 cm	N/A	Terete
15.	*Tectona grandis*	Good	Base swollen	Marginal	Reniform	Present	9.0 – 9.5 cm	N/A	Subterete

P.O.P.A: Position of Petiole Attachment

Table 4: Serration and sinus features of *Clerodendrum* species

No.	Species	Serration Type	Leaf Sinuses	Teeth order	Teeth/cm	Tooth spacing	Tooth shape	Sinus shape
1.	*C. laevifolium*	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2.	*C. nutan*	N/A	N/A	N/A	N/A	N/A	N/A	N/A
3.	*C. villosum*	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4.	*C. deflexum*	N/A	N/A	N/A	N/A	N/A	N/A	N/A
5.	*C. johorense*	N/A	N/A	N/A	N/A	N/A	N/A	N/A
6.	*C. umbellatum*	N/A	N/A	N/A	N/A	N/A	N/A	N/A
7.	*Clerodendrum* sp3	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8.	*C. paniculatum*	N/A	2 sinuses	2nd order	N/A	N/A	N/A	Angular
9.	*C. hendersonii*	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10.	*C. chinense*	Present	Present	1st order	3	Regular	FL/FL	Angular
11.	*C. disparifolium*	N/A	N/A	N/A	N/A	N/A	N/A	N/A
12.	*C. phyllomega*	N/A	N/A	N/A	N/A	N/A	N/A	N/A
13.	*Clerodendrum* sp1	N/A	N/A	N/A	N/A	N/A	N/A	N/A
14.	*Clerodendrum* sp2	N/A	N/A	N/A	N/A	N/A	N/A	N/A
15.	*Tectona grandis*	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Lagend : Apical/basal teeth side. Basal FL = ⟆ Apical FL = ⟅ Adapted from Hickey (1999). Sinus shape = Shape of sinus of the tooth Hickey (1999)

Table 5: Special features of *Clerodendrum* species.

No.	Species	Stipule Shape	Leaf Length (cm)	Leaf width (cm)	Length Between leaf attachment (cm)	Leaf Texture
1.	*C. laevifolium*	Absent	10.5 – 15	4 – 5	2.5 – 3	Rugose
2.	*C. nutan*	Absent	22 – 23	7 – 10	3 – 5	Glabrous
3.	*C. villosum*	Glandular	15 – 18.5	10.5 – 13.5	5.5	Hispid
4.	*C. deflexum*	Absent	12 – 16	5.5 – 7.0	9 – 10.5	Glabrous
5.	*C. johorense*	Absent	23 -27	6.5 – 9.5	8.5	Glabrous
6.	*C. umbellatum*	Absent	12 - 18	5.5 – 7.5	4.5 – 5.5	Rugose
7.	*Clerodendrum* sp3	Cup-like	23.5 – 25.0	8 – 12	3.5 – 4.0	Glabrous
8.	*C. paniculatum*	Scale-like	16.5 – 17	19 – 21	3.5 – 5.0	Glabrous
9.	*C. hendersonii*	Scale-like	12 -17	8.5 – 9	5 – 8.5	Rugose
10.	*C. chinense*	Foliar	12 – 14	7.5 – 8	6.5 – 11.5	Hispid
11.	*C. disparifolium*	Absent	10 -12	5 – 6.5	3 – 4	Rugose
12.	*C. phyllomega*	Absent	21 – 26	7.5 – 10.5	6	Rugose
13.	*Clerodendrum* sp1	Absent	13.5 – 16.5	6 – 7	2	Glabrous
14.	*Clerodendrum* sp2	Absent	13 – 14	4.5 – 6.5	2.5 – 4.5	Glabrous
15.	*Tectona grandis*	Scale-like	18 – 30	17 -19.5	7	Rugose

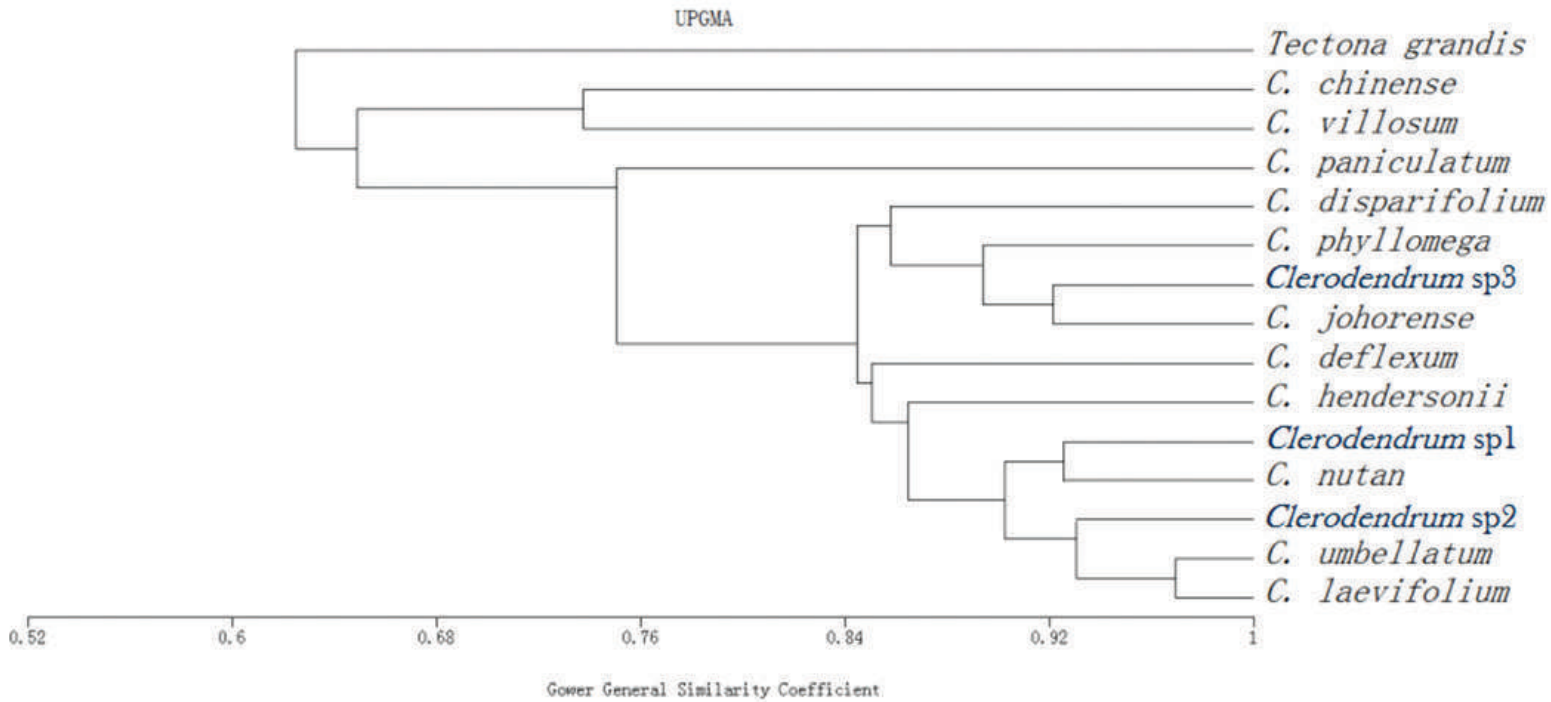

Figure 1: Cluster analysis using MVSP software

Leaf venation
Venation further helps to distinguish the studied species. The majority of the *Clerodendrum* share the same type of venation which is pinnate excluding three species which differentiate themselves by having actinodromous and palinactinodromous types of venation. *C. chinense* and *C. villosum* group themselves into actinodromous type of venation while *C. paniculatum* distinguises itself from the rest of the species by having palinactinodromous type of venation. Strong intersecondaries venation is also a common character in *Clerodendrum* except three species with either weak or absent of intersecondaries vein.

Thorough observation on *Clerodendrum* venation patterns resulted in several findings to be drawn: All *Clerodendrum* species share the same random reticulate tertiary vein category, sinuous vein course and inconsistent vein angle variability. Their 4th vein category, marginal ultimate, free ending veins (F.E.V.S) and leaf rank which are regular reticulate, looped ultimate margin, absence of free ending veins and 4r leaf rank, respectively. These characters add further key characters that can be used as a representative key of the genus. The absence or presence of the 5th vein category further segregate *Clerodendrum* into two groups, of all only *C. umbellatum, C. paniculatum, C. phyllamega* and *Clerodendrum* sp1 possess the character. Regular intercostal area observed only in *C. chinense* and can be a diagnostic charater to identify the species.

Petiole and twig features
Petiole outlines are found to be very helpful in adding useful characters used in delineating taxa at species level. The majority of the species share reniform type of petiole outline. However, *C villosum* and *C. chinense* possess oval type of petiole outline. On the other hand, *C. laevifolium, C. umbellatum, C. paniculatum, C. hendersonii* and *Clerodendrum* sp2 have rounded petiole outline. Furthermore, the presence of trichome on petiole in *C. villosum* and *C. chinense* help to differentiate them from the rest of studied species. Subterete twigs with grooves can be outstanding characters to three species namely, *C. villosum, C. johorense* and *C. disparifolium.* All species have good blade-petiole separation which distinguishes clearly presence of petiole. Swollen petiole base features shows homogeneousness of the members within the genus.

Marginal serration and sinus feature
Another taxonomic significant key features are the marginal serration and sinuses. These features are capable to be utilized in distinguishing species supported with other features. Serration is only seen in *C. chinense* whilst sinuses are found in *C. paniculatum* and *C. chinense* which both are angular shape. Teeth order further divided these two species into their respective groups: *C. chinense* has 1st order teeth while *C. paniculatum* has 2nd order teeth.

Special and diagnostic features
Stipule features are of diagnostic characters. Only several species are stipulate (Table 5). *C. villosum* has a glandular stipule, C. sp3 has cup-like stipule, *C. chinense* has foliar-like stipule and both *C. paniculatum* and *C. hendersonii* have scale-like stipules. Leaf texture further can be used to divide the studied species into several groups which are rugose, glabrous and hispid.

Three uncertain *Clerodendrum* species are collected during the study. It is suggested for further studies to determine and establish the species identity. It is quite possible that these may be new species to science.

An identification key of the studied species based on the investigated characters is presented below:

1. Stipules present ……..... 2
   Stipules absent …….....…..... 3

2. 2nd veins uniform; petiole outline reniform; leaves blade aristate; stipules cup-like ..... *Clerodendrum* sp3
2nd veins irregular; petiole outline rounded or oval; leaves blade cordate or deltoid; stipules not cup-like 4

3. Leaves apex caudate; leaves lamina asymmetry or symmetry; inter 2nd veins absent or strong; veins spacing uniform or irregular; twigs subterete with groove or terete 7
Leaves apex cuspidate; leaves lamina symmetry; inter 2nd veins strong; veins spacing irregular; twigs terete 13

4. Leaves venation pinnate; leaves blade deltoid; leaves base acute; leaves margin entire; petiole outline rounded..... *C. hendersonii*
Leaves venation palinactinodromous or actinodromous-basal; leaves blade cordate; leaves base cordate; leaves margin lobe or serrate; petiole outline rounded or oval 5

5. Leaves venation palinactinodromous; inter 2nd venation strong; leaves apex cuspi date; leaves margin lobed; teeth order 2nd order, leaves texture glabrous, stipules scale like, petiole outline rounded, trichome absent, petiole trichome absent..... ..... *C. paniculatum*
Leaves venation actinodromous-basal, inter 2nd venation weak or absent, leaves apex acute, leaves margin serrate, teeth order none or 1st order, stipules other form, petiole outline oval, trichome present, petiole trichome present..... 6

6. Leaves apex acuminate, inter 2nd venation absent, number of lateral vein 6, agrophic compound, intercostal area irregular, teeth order none, stipules glandular, leaves length 22 – 23 cm, leaves width 7 – 10 cm..... *C. villosum*
Leaves apex acute, inter 2nd venation weak, number of lateral vein 4, agrophic simple, intercostal area regular, teeth order 1st order, stipule foliar like, leaves length 12 – 14 cm, leaves width 7.5 – 8 cm..... *C. chinense*

7. Leaves apex caudate, leaves lamina asymmetry or symmetry, inter 2nd veination absent or strong, veins spacing uniform or irregular, twigs subterete with groove or terete..... 8
Leaves apex cuspidate, leaves lamina symmetry, inter 2nd veins strong, veins spacing irregular, twigs terete 13

8. Leaves base cuneate or truncate, leaves lamina asymmetry or symmetry, inter 2nd veination strong, 5o veins not seen, petiole outline reniform, twigs terete..... 9
Leaves base acute, leaves lamina symmetry, inter 2nd veins absent or strong, 5o veins regular polygonal or not seen, petiole outline rounded or reniform, twigs terete or subterete with groove 10

9. Leaves base cuneate, leaves blade linear, leaves lamina symmetry, 2nd veination distance 2.0 – 5.5 cm, number of lateral veins 10, veins spacing irregular, petiole length 6.5 – 8.0 cm, leaves length 22 – 23 cm, leaves width 7 – 10 cm .... *C. nutan*
Leaves base truncate, leaves blade aristate, leaves lamina asymmetry, 2nd veination distance 3.0 cm, number of lateral vein 7, veins spacing uniform, petiole length 3.0 cm, leaves length 12 – 16 cm, leaves width 5.5 – 7.0 cm ..... *C. deflexum*

10. Leaves blade elliptic, inter 2nd veination strong, vein spacing irregular, 5o veins not seen, petiole outline rounded, twigs terete..... 11
Leaves blade lanceolate or aristate, inter 2nd veination absent or strong, 5o veins regular polygonal, petiole outline reniform, twigs subterete with groove 12

11. Number of lateral veins 8, petiole length 2.5 – 3.5 cm, leaves length 10.5 – 15 cm, leaves width 4 – 5 cm, length between leaves attachment 2.5- 3 cm..... *C. laevifolium*
Number of lateral veins 10, petiole length 3 – 5 cm, leaves length 12 – 18 cm, leaves width 5.5 – 7.5 cm, length between leaves attachment 4.5 – 5.5 cm..... *C. umbellatum*

12. Leaves blade lanceolate, 2nd veins distance 2 – 2.5 cm, inter 2nd veination strong, number of lateral vein 14, veins spacing uniform, petiole length 3.0 cm, leaves length 23 – 27 cm, leaves width 6.5 – 9.5 cm, leaves texture glabrous ……..... *C. johorense*
Leaves blade aristate, 2nd veins distance 1.5 – 2 cm, inter 2nd veination absent, number of lateral veins 7, veins spacing irregular, petiole length 4.5 – 6 cm, leaves length 10 – 12 cm, leaves width 5 – 6.5 cm, leaves texture rugose .....*C. disparifolium*

13. Leaves blade aristate, 5o veins category regular polygonal, leaves texture rugose……..... *C. phyllomega*
Leaves blade elliptic, 5o veins category not seen, leaves texture glabrous.....14

14. Leaves base rounded, 2nd veins distance 1 – 1.5 cm, number of lateral veins 8 – 11, petiole outline reniform, petiole length 1 – 4.5 cm, leaves length 13.5 – 16.5 cm, leaves width 6 – 7 cm…….....*Clerodendrum* sp1
Leaves base acute, 2nd veins distance 2 – 2.5 cm, number of lateral veins 8, petiole outline rounded, petiole length 3 – 4.5 cm, leaves length 13 – 14 cm, leaves width 4.5 – 6.5 cm…….....*Clerodendrum* sp2

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Appendix 1.
Numerical Taxonomic Evaluation of Leaf Architecture
Analysis begun: Friday, February 12, 2016 10:58:49 PM
Analyzing 50 variables x 15 cases

UPGMA
Euclidean

Node	Group 1	Group 2	Dissimil.	Objects in group
1	*C. laevifolium*	*C. umbellatum*	2.646	2
2	*C lerodendrum* sp1	*Clerodendrum* sp2	3.162	2
3	Node 1	*C. disparifolium*	4.062	3
4	*C. johorense*	*Clerodendrum* sp3	5.477	2
5	*C. nutan*	*C. deflexum*	5.657	2
6	*Node 3*	*C. hendersonii*	*6.493*	*4*
7	*C. phyllomega*	*Node 2*	*6.779*	*3*
8	*Node 5*	*Node 4*	*7.280*	*4*
9	*C. villosum*	*C. chinense*	*7.746*	*2*
10	*Node 6*	*Node 8*	*8.232*	*8*
11	*Node 10*	*Node 7*	*8.595*	*11*
12	*Node 9*	*C. paniculatum*	*8.884*	*3*
13	*Node 11*	*Node 12*	*10.150*	*14*
14	Node 13	*Tectona grandis*	10.658	15