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Leaf Architecture of two Species and nine Infraspecific Taxa of the Philippine Mussaenda Linn. (Rubiaceae): Conservation concerns

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Abstract

Two Mussaenda species are included in this study with additional 9 infraspecific taxa making up the total of 11 Philippine Mussaenda species studied. Specimen morphological characters were described and a dichotomous key constructed. Notably, results showed that characters of areolation, secondary vein category, tertiary vein angle variability and quaternary veins proved the most useful. This demonstrates that leaf architecture is an important tool in distinguishing infraspecific taxa just as other parameters used by taxonomists to recognize differences among plants. It is a good tool for plant identification especially in the case where flowers and fruits are not available. There is a need to conserve the genus Mussaenda Linn. due to its ornamental qualities and the over exploitation it is faced with from individuals for home yard beauties.

Keywords: Leaf architecture, ornamental, conservation, taxonomy, ecology.

Introduction

Not much attention on the part of taxonomists is placed on the use of leaf characters in establishing dissimilarities amongst taxa as has been done in other studies[1,2]. The disregard could be due to the principle that leaf characters are quite phenotypically plastic rendering the characters not useful. This idea is gradually becoming an assumption as more and more studies[3-11], [12] continue to show that leaf architecture is an important marker in present-day taxonomic work.

In contrast to the assumption, the use of leaf characters especially venation patterns have shown remarkably as a tool in delineating some species of the angiosperms and attended infraspecific species. For example, Larano and Buot[13] indicated through the use of dichotomous key that leaf architecture characters can be used in distinguishing some species of Malvaceae sensu APG. They also maintained that some basic leaf architecture characters can be used in describing certain clads with in the family. Banaticla and Buot[14] used venation as marker to distinguish ten Philippine Psychotria species of the Rubiaceae family. In another case, Frole and Sack[15] used leaf architecture to find out that leaf structural diversity is related to hydraulic capacity in tropical rain forest trees. Measurement of Laurus nobilis leaves indicate that first and second-order veins have high axial conductance and relatively small radial permeability[16]. Through a genome-wide association study (GWAS) of the maize nested association mapping panel, Edward Buckler[17] and collaborators determined the genetic basis of important leaf architecture traits and identified some of the key genes. The mentioned and other works done by taxonomist using leaf characters to establish similarities and dissimilarities among species is yet to show case the full taxonomic potential of leaf architectural characters which makes it a focus of exploration. In fact, leaf architecture studies in the genus Mussaenda which has become one of conservation concern owing to its massive exploitation had not been done, let alone in its infraspecific taxa.

The genus Mussaenda L. belongs to the family Rubiaceae and includes 200 species with geographic spread from Africa to India, China, Malaysia, Philippines, Polynesia, New Guinea and Australia[18,19]. Its first collection was made by Paul Hermann of the Dutch East India Company in Ceylon beginning 1672-1677 and he gave it the vernacular name "Mussaenda" This name was later adopted by Linnaeus[19].

There are about 20 Mussaenda species in the Philippines with some affinity from mainland China and the Malayan Peninsula, but differ remarkably from the species of India in the hairiness of the corolla tube[19]. The most distinctive feature of Mussaenda is that the flora display is primarily derived from the calyx, with some individual flowers within an inflorescence carrying an enlarged petioloid sepal. Some cultivars have all five sepals enlarged. These are called callycophylls or sometimes semaphylls[19]. In many publications, callophylls are erroneously referred to as bracts.

Mussaenda has been reported as having medicinal properties as well[20] just like other plants having chemical constituents which are either medicinal[21-26] or pesticidal[27].

This paper serves as an inquiry in the use of leaf characters to establish discontinuities among 2 species and 9 infraspecific taxa of Philippine Mussaenda which are very difficult to delineate due to morphological similarities in their floral structures. It is our hope that leaf architecture as a taxonomic too will provide the acute differences between and among the species and infraspecific taxa thus further ensuring its usefulness in the field of taxonomy as an important tool.

Material and Methods

Only 2 Mussaenda species of the Philippines are included in this work with additional 9 infraspecific species making up the total of 11 studied out of Mussaenda species of the Philippines. Ten leaf blades of each species and infraspecific species were collected from the horticulture garden of the University of Philippines Los Banos.

Mussaenda leaves examined are deposited in Los Banos Herbarium of Laguna Province, the Philippines. The leaves were prepared for press and taken to oven-dry at the College of Forestry and Natural Resource Management (CFNR) for proper drying. The required heat read at 60°C throughout the drying period of at most three days.

Suitable matured and fully expended specimens were examined at the Institute of Biological Sciences Systematics laboratory (IBS) using dissecting microscope with 20x magnification. Specimens were placed on papers on a desk for measurement using ruler. The length of a specimen in millimeters was divided by the measurement in width to obtain a precise leaf area. Manual of Leaf Architecture Working Group[28] was used to describe the specimens.

The mentioned differences in leaf architecture were based on the unique characters of each plant leaf. As a result, a dichotomous key is constructed which further justifies the usefulness of leaf characters of dicotyledonous plants as potential marker in delineating infraspecific tax in general.

Results and Discussion

Leaf Architectural Characters of Mussaenda: All the 11 Mussenda taxa studied have in common simple leaf, opposite with petiole base swollen, entire margin and chartaceous. Apart from the general features exhibited, characters of areolation, secondary vein category, tertiary vein angle variability and areolation proved the most useful (tables-1, 2). Blade shapes and sizes were key characters in separating the only 2 species (Mussaenda flava and Mussaenda philippica) studied along the 9 infraspecific taxa. Three different lamina shapes (elliptic, ovate and oblong) were observed and recorded. In total, 6 species (Mussaenda 'Doña Luz', 'Doña Mutya', 'Doña Alicia', 'Queen Sirikit', 'Paraluman' and Mussaenda philippica) exhibited laminar symmetry while 5 (Mussaenda 'Doña Aurora', M. 'Doña Evangelina', M. 'Doña Imelda', M. "Gloria Macapagal Arroyo" and Mussaenda flava) with base asymmetrical were examined. Seven out of 11 had decurrent base shape, 2 with rounded base and 2 concave base shapes.

Information provided thus, demonstrates the use of leaf architecture as a vital tool in establishing discontinuities between and among taxa of Mussaenda species studied. This further adds to all other previous works done by scientists to recognize differences in plants through the use of leaf architecture. Therefore, leaf architecture is useful just as other parameters used by taxonomists to recognize differences among plants. This study is in full agreement with the generalization of Hickey[29], Dilcher[30] and others[31-34] that leaf characters are useful for noticing similarities and dissimilarities, and can therefore serve as unifying and distinguishing elements. This important use of leaf architecture is further illustrated in a dichotomous key to 2 Mussaenda species and 9 infraspecific taxa prepared in this paper (table-3).

Table-1
Leaf Blade Characters of Selected 2 Species and 9 Infraspecific taxa of Mussaenda

Taxa	Blade class	Laminar size	Laminar shape	Blade Symmetry	Base Angle	Base Shape
M. 'Doña Luz'	Mesophyll	7890– 10268mm	Elliptic	Symmetrical	Acute	Decurrent
M. 'Doña Mutya'	Mesophyll	4824 – 9045mm	Ovate	Symmetrical	Obtuse	Rounded
M. 'Doña Alicia'	Mesophyll	7236 – 12221mm	Oblong	Symmetrical	Acute	Decurrent
M. 'Queen Sirikit'	Mesophyll	7236 – 8291mm	Ovate	Symmetrical	Obtuse	Concave
M. 'Doña Aurora'	Mesophyll	3906 – 5357mm	Ovate	Base asymmetrical	Obtuse	Concave
M. philippica	Mesophyll	3183 – 3921mm	Elliptic	Symmetrical	Acute	Decurrent
M. 'Doña Evangelina'	Mesophyll	4238 – 6097mm	Ovate	Base asymmetrical	Acute	Decurrent
M.'Doña Imelda'	Mesophyll	6633 – 9929mm	Ovate	Base asymmetrical	Acute	Decurrent
M. Flava	Microphyll	570 – 1339mm	Elliptic	Base asymmetrical	Acute	Decurrent
M. 'Gloria Macapagal-Arroyo'	Mesophyll	3236 – 4311mm	Elliptic	Base asymmetrical	Acute	Decurrent
M. 'Paraluman'	Mesophyll	6412 – 9388mm	Ovate	Symmetrical	Obtuse	Rounded

Table-2
Leaf Architecture Characters of Selected 2 Species and 9 Infraspecific taxa of Mussaenda

Taxa	Secondary vein category	Secondary vein spacing	Secondary vein angle	Tertiary vein category	Tertiary vein angle	Areolation
M. 'Doña Luz'	Weak brochidodromous	Uniform	Uniform	Random Reticulate	Decreasing exmedially	Well developed
M. 'Doña Mutya'	Intramarginal	Irregular	Evenly enlarging toward base	Mixed opposite alternate	Increasing basally	5 or more
M. 'Doña Alicia'	Intramarginal	Irregular	Evenly enlarging toward base	Alternate Percurrent	Increasing basally	5 or more
M. 'Queen Sirikit'	Intramarginal	Decreasing toward base	Evenly enlarging toward base	Alternate Percurrent	Increasing exmedially	5 or more
M. 'Doña Aurora'	Intramarginal	Decreasing toward base	Evenly enlarging toward base	Mixed opposite alternate	Increasing exmedially	5 or more
M. philippica	Intramarginal	Decreasing toward base	Uniform	Alternate	Increasing exmedially	5 or more
M. 'Doña Evangelina'	Intramarginal	Decreasing toward base	Uniform	Random Reticulate	Increasing exmedially	5 or more
M.'Doña Imelda'	Intramarginal	Decreasing toward base	Evenly enlarging toward base	Alternate Percurrent	Increasing exmedially	5 or more
M. flava	Semicraspedodromous	Decreasing toward base	Uniform	Alternate Percurrent	Inconsistent	5 or more
M. 'Gloria Macapagal-Arroyo'	Intramarginal	Irregular	Uniform	Regular polygon reticulate	Increasing exmedially	5 or more
M. 'Paraluman'	Eucomptodromous	Uniform	Evenly enlarging toward base	Random reticulate	Inconsistent	5 or more

Description of Leaf Architecture for 2 Mussaenda Species and 9 infraspecific taxa Mussaenda 'Doña Luz'

Blade class mesophyll, laminar size 175 – 185mm long , 64 – 79mm broad, elliptic and symmetrical; base angle acute, base shape decurrent. Secondary vein category weak brochidodromous with spacing and angle uniform. Tertiary veins category random reticulate and vein angle decreasing exmedially; areolation well developed (figure-1).
Exsiccata; Kpadehyea 6516 (PBDH)
Mussaenda 'Doña Mutya'

Leaf blade class mesophyll; laminar size 120 – 150mm long and 17 – 21mm broad, ovate and symmetrical; base angle obtuse with rounded shape. Secondary veins intramarginal, spacing irregular with vein angle smoothly increasing toward base. Tertiary vein category mixed opposite alternate with vein angle increasing basally. Areolation 5 or more sided polygons (figure-2).
Exsiccata; Kpadehyea 6517 (PBDH)

Mussaenda 'Doña Alicia': Blade class mesophyll; Laminar size 180 – 228mm long and 60 – 80mm broad, oblong and symmetrical; base angle acute and decurrent. Secondary veins intramarginal, irregular with vein angle smoothly enlarging toward base. Tertiary veins angle category alternate percurrent - cross between secondaries with an offset (an abrupt angular discontinuity), and vein angle increasing basally. Areolation 5 or more sided polygons (figure-3).
Exsiccata; Kpadehyea 6518 (PBDH)

Mussaenda 'Queen Sirikit'
Leaf blade 160 – 184mm long and 63 – 80mm wide, ovate and symmetrical with base angle obtuse and concave shap. Secondary veins intramarginal with spacing decreasing toward base,and angle evenly enlarging toward base. Tertiary veins alternate percurrent and angles becoming more blunt away from the axis of symmetry (figure-4).
Exsiccata; Kpadehyea 6519 (PBDH)

Mussaenda 'Doña Aurora': Leaf size 110 – 132 mm long and 50 – 65 mm width, base ovate and; base angle obtuse and concave. Secondary veins intramarginal, spacing decreasing toward base with angle evenly enlarging toward base. Unbranched ertiary veins with some crossing between adjoining secondary veins in parallel paths and others crossing between secondaries with an offset (an abrupt angular discontinuity), while vein angle variability become more blunt away from the axis. Areolation 5 or more sided polygons (figure-5).
Exsiccata; Kpadehyea 6520 (PBDH)

Table-3
Key to 2 Species and 9 Infraspecific Taxa of Mussaenda

1 Base angle acute...…2
1 Base angle obtuse.…..4
2 Base shape decurrent; 2° vein spacing and angle uniform
with 3° vein random reticulate; areolation well-developed…………*Mussaenda* ‘Doña Luz’
2 Base shape rounded; 2° veins angle smoothly decreasing toward base…….3
3 Leaf size 3236–4311 mm, asymmetrical; 2° vein spacing irregular..*Mussaenda* ‘Gloria Macapagal-Arroyo’
3 Leaf size 7611–9648 mm, ovate and base shape concave…………*Mussaenda* ‘Queen Sirikit’
4 Tertiary vein angle variability increasing basally with category
mixed opposite and alternate; leaf base shape rounded …............*Mussaenda* ‘Doñia Mutya’
4 Tertiary vein branching oriented toward the primary or midline;
areolation well developed…….5
5 Fifth vein category dichotomizing; leaf shape oblong; 2° vein
irregular with angle smoothly moving toward base.....................*Musaenda* ‘Doña Alicia’
5 Fifth vein category irregular polygon……………6
6. Leaf rank 3r; strong intersecondaries; tertiary veins inconsistent ……..*Mussaenda flava*
6 Leaf rank 1r; quaternary veins regular polygon……….7
7 Margin ultimate venation looped (no teeth);
lamina base asymmetrical, concave………….........................…..*Mussaenda* ‘Doña Evangelina’
7 Margin ultimate venation freely ending adjacent to margin…….8
8 Quaternary veins anastomosing with others forming various
geometric figures; secondary vein angle smoothly increasing
toward the base; base shape concave…………........................*Mussaenda* ‘Doña Aurora’
8 Quaternary veins opposite percurrent………..9
9 Lamina shape elliptic, symmetrical with 3° veins alternate ……..*Mussaenda philippica*
9 Lamina shape obovate………..10
10 Leaf base shape rounded, lamina shape ovate; 3° veins inconsistent……*Mussaenda* ‘Paraluman’
10 Leaf base shape decurrent, asymmetrical; 3° veins angle variability
increasing exmedially…………………………………..*Mussaenda* ‘Doña Imelda’

Figure-1
Leaf blade of Mussaenda ‘Doña Luz‘

Figure-2
Leaf blade of Mussaenda ‘Doña Mutya’

Figure-3
Leaf blade of Mussaenda 'Doña Alicia'

Figure-4
Leaf blade of Mussaenda 'Queen Sirikit'

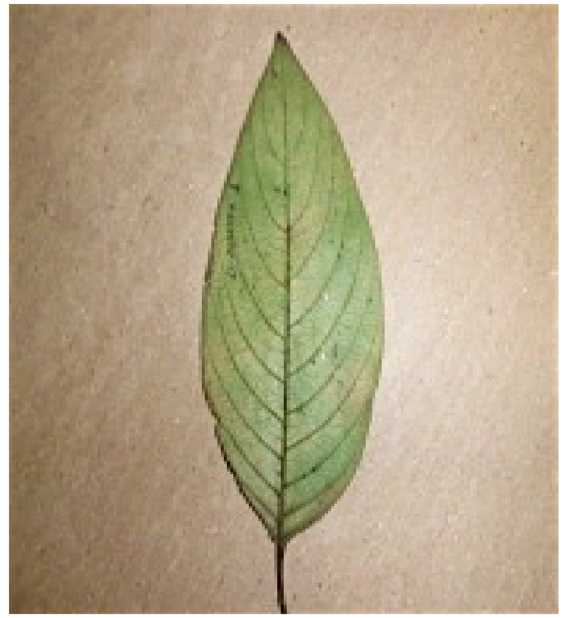

Figure-5
Leaf blade of Mussaenda 'Doña Aurora'

Mussaenda philippica A. Rich
Blade 108 – 133mm in long and 44 – 46mm broad, elliptic with blade approximately the same form on either side of the midvein, base angle < 90° with shape subtype of either concave or concavo-convex in which the laminar tissue extends basally along the petiole in a smoothly decreasing angle. Secondary veins end in a strong vein approximately side by side with the leaf margin and spacing decreasing toward base forming uniform angle with the primary vein. Tertiary veins alternate with vein angle s increasing exmedially. Areolation 5 or more sided polygons (figure-6).

Exsiccata; Kpadehyea 6521 (PBDH)
Mussaenda 'Doña Evagelina'
Leaf blade 115 – 140 mm long, 55 – 62 mm in width, shape ovate, base asymmetrical with acute angle and decurrent. Secondary veins intramarginal, decreasing toward base in uniform angles. Tertiary vein rejoin with other tertiary veins or secondary veins at random angles increasing exmedially, branching oriented toward the primary or midline forming areolation of 5 or more sided polygons (figure-7).
Exsiccata; Kpadehyea 6522 (PBDH)

Mussaenda 'Doña Imelda'
Lamina 150 – 190 mm long and 66 – 79 mm broad, ovate shape with base asymmetrical, margin entire gradually forming acuminate apex. Base angle acute with subtype of either concave or concavo-convex in which the laminar tissue extends basally along the petiole at a gently decreasing angle. Primary vein pinnate. Secondary veins end in a strong vein located side by side with the leaf margin; simple agrophic; spacing decreasing toward base with angle evenly enlarging toward base. Tertiary veins cross between secondaries in an abrupt

angular discontinuity with angles increasing exmedially. Quaternary veins forming regular polygon reticulate with branches dichotomized (figure-8).
Exsiccata; Kpadehyea 6523 (PBDH)

Mussaenda flava (Verde.) Bakh. F.
Blade class microphyll,size 50 – 75 mm long, 17 – 27 mm broad elliptic;; lamina base asymmetrical forming acute angle and decurrent base. Secondary veins semicraspedodromous, spacing decreasing toward base forming uniform angle with primary vein. Tertiary veins alternate percurrent forming inconsistent angles. Areolation 5 or more sided polygons (figure-9).
Exsiccata; Kpadehyea 6524 (PBDH)

Mussaenda 'Gloria Macapacal Arroyo'
Lamina 115 – 143 mm long, 40 – 49 mm width; base asymmetrical with acute angle and blade extends to the base along the petiole at a gently decreasing angle. Secondary veins end in a strong vein side by side with the leaf margin; spacing irregular but forming uniform angles. Tertiary veins anastomosing with other tertiary veins forming more or less similar geometric shapes of same sizes; angles become blunt and less sharper away from the axis of symmetry (figure-10).
Exsiccata; Kpadehyea 6525 (PBDH)

Mussaenda 'Paraluman'
Leaf blade, 145 – 183 mm long, 66 – 81 mm width; ovate symmetrical with obtuse base angle, and base a subtype of convex in which the margin forms a smooth arc across the base. Leaf apex is acuminate forming acute angle. Leaf with a single primary vein. Secondary veins eucomptodromous and vein spacing uniform with angles smoothly increasing toward base. Tertiary veins anatomose with other tertiaries at random angles forming inconsistent angles over the lamina. Areolation 5 or more sided polygons (figure-11).
Exsiccata; Kpadehyea 6526 (PBDH)

Figure-6
Mussaenda philippica

Figure-7
Leaf blade of Mussaenda 'Doña Evangelina'

Figure-8 Leaf blade of Mussaenda 'Doña Imelda"

Figure-9
Leaf blade of Mussaenda flava

Figure-10
Leaf blade of Mussaenda 'Gloria M. Arroyo'

Figure -11
Leaf blade of Mussaenda 'Paraluman'

Conclusion

Concomitantly, leaf architecture was proven useful in establishing differences among infraspecific taxa in this study just as other parameters used by taxonomists to recognize differences among plants. It is therefore a good tool for plant identification especially in the case where flowers and fruits are not available. The growing needs for home yard beautification with Mussaenda species has now become one of major challenge for conservation. It is therefore good to recognize the threat and find a lasting solution to it.

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