

DEVELOPMENT OF AN INTERACTIVE DATABASE TO THE SPECIES OF PHILIPPINE MUSSAENDA (RUBIACEAE)

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ABSTRACT

An illustrated database of the 27 (including three varieties) Philippine species of *Mussaenda* was developed using the DELTA format and translated to an interactive key. The database, based on field observations and herbarium specimens, comprises more than 200 characters from which detailed descriptions of habit and both vegetative and reproductive parts were drawn. Full illustrations of important characters and each taxon (including field and type specimens) as well as key to the species, phenology, distribution maps, vouchers of specimen examined, discussion, and internal transcribed spacer (nrDNA) sequence are also associated with this database. The interactive identification uses 146 characters, the flower morphology and type of external indumentum score with the highest character reliabilities. The database is available at http://www.uni-bayreuth.de/departments/planta2/wgl/delta_ru/index.html.

Key words: DELTA, INTKEY, *Mussaenda*, Philippines, Rubiaceae.

INTRODUCTION

As part of the continuing project of Philippine Rubiaceae for the Flora of the Philippines (Alejandro & Liede, 2003), several genera (e.g., *Ixora* L., *Greeniopsis* Merr., *Hedyotis* L., *Hydnophytum* Jack., *Mussaenda* Burm. ex L., *Oldenlandia* L., *Plectronia* L., *Praravinia* Korth. & Bremek., *Urophyllum* Jack ex Wall., *Villaria* Rolfe) of this large family in the Philippines with numerous indigenous species are still wanting revision. *Mussaenda*, a well-known propagated genus belonging to *Mussaendeae*, *Ixoroideae* (Bremer & Thulin, 1998; Alejandro et al., 2005), has been recently revised for the Philippines comprising a total of 27 species (including three varieties; Alejandro, 2005). These Philippine species of *Mussaenda* are documented in the form of an illustrated DELTA (DEscriptive Language for TAXonomy) database (Dallwitz et al., 1999).

The computer DELTA program proved to be a valuable alternative to the traditional method of taxonomic writing (e.g., Askevold & O'Brien, 1994; Argus, 1997). It provides the means to generate taxonomic descriptions in a uniformly worded and fully comparable manner. More often, it is difficult to identify specimens because the literature is diffuse and makes comparative studies difficult. A DELTA data set, developed collaboratively and used by researchers, renders

taxonomically difficult, diverse groups like *Mussaenda* much more comprehensible. Moreover, the data can be processed for several uses, such as INTKEY for identification (Dallwitz et al., 2000). Such data set developed provides an online access basis for taxonomic treatment of other Asian and African *Mussaenda*.

MATERIALS AND METHODS

The taxonomy of the 27 species of Philippine *Mussaenda* included in this study was based on the recent studies conducted by Alejandro (2005). Data were gathered against a character list which is available and accessible via the web site. The character list provides information on questions of character definition, and includes other comments which do not appear in the printed taxon descriptions. The characters and character states were based on field observations of 20 Philippine *Mussaenda* and herbarium specimens from BM, BR, L, NY, P, PNH, UB, US, USTH, and WAG. The more than 500 specimens were examined with a Wild stereo-microscope. The natural language species descriptions were generated from the CHARS which cover more than 200 characters and ITEMS files using the TONAT directive. Implicit character attributes were excluded in each taxon description.

For every species, characters include habit and morphology of both vegetative and reproductive parts as well as nomenclatural information, phenology, vernacular name(s), details on distribution, voucher of specimen(s) examined, discussion, and the internal transcribe spacer (ITS) sequence. Morphological characters were recorded based on direct observations and measurements, with emphasis on the characters that allow quick and easy identification of the taxa. Distribution maps for each taxon with reference to latitude and longitude were created using <http://www.aquarius.geomar.de> based on collection localities. Images of important characters and each taxon including field and type specimens were also incorporated in the CIMAGES file. The plants were photographed in their natural habitats and full illustrations of both vegetative and reproductive parts were obtained from herbaria and recent collections. The specific character images (e.g., seed structure, type of trichomes inside corolla) were done from SEM (Philips XL-30). All images were scanned and stored digitally as JPEG or GIF files. Furthermore, images were cropped using Adobe Photoshop 6.0 for further manipulations such as reorientation, compilation, and scaling. The program INTIMATE, also part of the DELTA system, was used to associate the images with the taxa and characters for INTKEY and to add labels which can be turned on or off as desired.

In using the INTKEY program for interactive identification and information retrieval generated by the directive CONFOR, a personal computer (PC) with Windows 95/NT or later version must have installed the program Intkey that is available at <http://www.biodiversity.uno.edu/delta>.

RESULTS

A. Dataset specifications (specs)

Of the 209 characters generated from the 27 taxa, unordered multistate was the most numbered comprising 150 characters, followed by 34 real numeric, 10 text characters, 9 unordered multistate, and 6 integer numeric characters. The shape of corolla lobes (character 118) has the maximum number of states (9). A total of 35 characters was dependent. A sample of the DELTA Editor of *Mussaenda* is shown in Fig. 1 and the taxon description, generated from the databank by CONFOR and typeset automatically, is appended to this article.

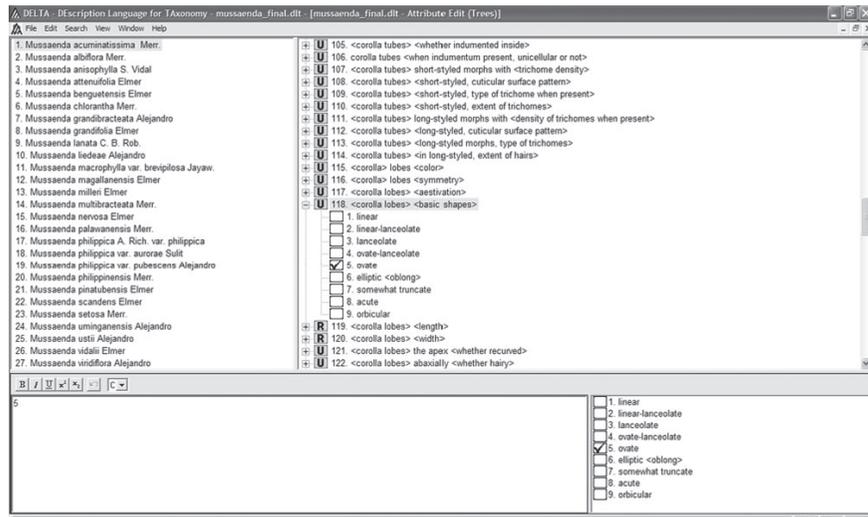


Fig. 1. A sample of the DELTA Editor of the 27 Philippine *Mussaenda* taxa used to generate an INTKEY and natural language descriptions.

B. Implicit characters

The following 54 character attributes were recorded as implicit, therefore, only deviating states were included in the taxon descriptions. Habit and vegetative parts. Trichomes pluricellular, cylindrical type. Leaves decussate, the secondary veins brochidodromous. Stipules interpetiolar. Inflorescence and reproductive parts. Inflorescences terminal, regular, sympodial-dichasial branching, in calycophyllous pseudanthia; bracts and bracteoles lateral lobes shorter when trifid. Flowers hermaphroditic, heterostylous, radially symmetrical. Corolla tubes with unicellular trichomes inside; lobes actinomorphic, reduplicate-valvate, adaxially papillate, the median ridges distinct. Stamens equalling the number of corolla lobes, separate, of equal sizes, included; filaments short, adnate to the tube, free of each other; anthers bilobed at base, dorsifixed near base. Ovary inferior, cylindric-turbinate, papillate, bilocular; annular disk conspicuous, glabrous; placenta peltate, T-shaped with the ends of the cross-bar

incurred; ovules numerous; style glabrous, cylindrical, apical; stigma 2, elongated, not-recurved, included in short-styled morphs. Fruits fleshy, berry-like, annular disk conspicuous, exocarp thin, mesocarp well developed, parenchymatic and laticifers present. Seeds ± angular to variously rounded and laterally compressed, exotesta cells polygonal, outer tangential walls thin and ± smooth, radial and inner tangential walls thickened. Pollen colpi with prominent colpus, colpus ends rounded or truncate, exine thick with distinct columellae, tectum foveolate.

C. The INTKEY program

The INTKEY program is a useful diagnostic tool for rapid interactive identification and information retrieval (Dallwitz et al., 1995, 2000), displaying free-text information and illustrations. More importantly, the program describes, diagnoses, summarizes, and finds similarities or differences between members of a set of taxa (Dallwitz, 1980; Dallwitz et al., 1995, 2000). Moreover, an interactive key has several advantages over a conventional key (e.g., unrestricted character use) (Dallwitz et al., 2000). Complete descriptions of all taxa can be obtained through the INTKEY program, but these descriptions lack the data comments which are provided in the full natural language descriptions produced using CONFOR. The INTKEY program of Philippine *Mussaenda* contains 146 characters (Fig. 2). It advises the user on the most suitable characters for use at any stage of identification so that the user does not have to skip over inconvenient or unreliable characters when choosing a character.

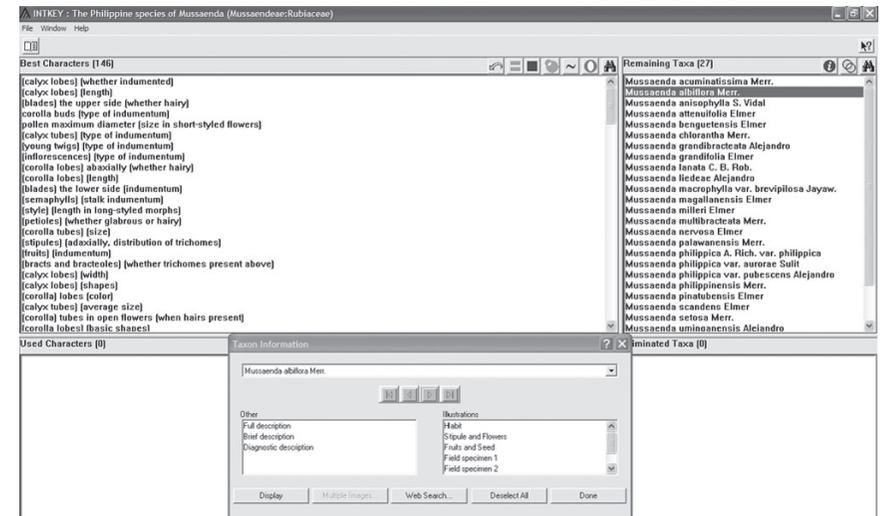


Fig. 2. The generated INTKEY of Philippine *Mussaenda* showing the total number of characters (146) on the left and the taxa number (27) on the right side.

D. Illustrations

The database includes 15 of either illustrated or photographed characters, 27 photographs of type specimens, 23 photographs of field specimens in their natural habitat, nine distribution maps, and 24 full (inked) illustrations of the 27 Philippine *Mussaenda*. A sample of the inked illustration and field specimen of *Mussaenda albiflora* is shown in Fig. 3 which is incorporated in the INTKEY. Efforts were exerted to illustrate each taxon with details on reproductive morphology. More photographs of taxa, particularly in their natural habitat, will be added to the database as they become available.

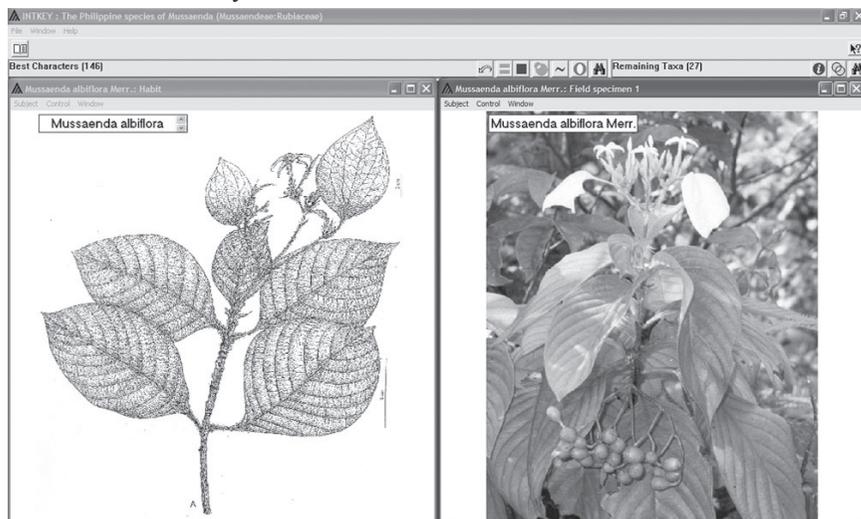


Fig. 3. A sample of inked illustration and field specimen (*Mussaenda albiflora*) incorporated in the INTKEY.

DISCUSSION

The flower morphology, particularly the size and shape of calyx and corolla, followed by the type and distribution of external indumentum in both vegetative and reproductive parts, density of bracts and bracteoles, type of trichomes inside corolla of long-styled morphs, size and shape of fruits as well as persistence of calyces, proved to be generally the most useful characters in recognizing the species of Philippine *Mussaenda*. Therefore, these characters were scored with high reliabilities to give some guidance in choosing characters with a low error probability. The above-mentioned characters occupy the top list of best characters in the INTKEY program.

The Philippine *Mussaenda* database presented here forms a strong foundation on which to build studies of other Asian and African *Mussaenda*. The data set is of long-term utility, developed over a period of time, and shared online

among researchers of the same group. The taxa treated here need not be altered unless one's understanding of a character changes or new characters are to be added. The present data set for taxonomic description of *Mussaenda* will expand, but most Asian and African *Mussaenda* species are probably codeable on the basis of this character list. However, more character states should be added as it is presently restricted only to the Philippine *Mussaenda*. For instance, the corolla lobe color of Philippine *Mussaenda* and mostly other Asian *Mussaenda* are yellow, yellow-orange, or rarely, white. The African *Mussaenda*, however, have more iridescently colored corolla lobes like pink, orange, or bright red.

Furthermore, the character list provides the subsequent basis for generating taxonomic descriptions of soon-to-be included *Mussaenda* species. For their interactive identification, selecting *Mussaenda* species of geographic or special interest for producing other kinds of revisionary work and developing expert systems can be made possible. Anyone interested to work on *Mussaenda* species will find this database a dependable reference. New discoveries and additions can be shared with them for the mutual benefit of all. Hence, there is uniformity of taxonomic treatment and use of characters in the descriptions of all *Mussaenda* species.

ACKNOWLEDGMENTS

The researchers acknowledge the assistance extended by the directors of the herbaria mentioned in this study, for providing loans and/or access to their collections; the Deutscher Akademischer Austauschdienst; the University of Santo Tomas, Manila, Philippines; and University of Bayreuth, Germany.

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APPENDIX: Example of a natural language species description generated by DELTA

Mussaenda albiflora Merr.

In Philipp. J. Sci., C. 5: 241. 1910.—Type: Philippines, Negros Occidental, without exact locality, September 1909, Curran H. M. 17358 (holotype: PNH, destroyed; lectotype, designated by Jayaweera, 1964: NY!).

Habit & vegetative parts. Shrubs, 1.5–5 m; young twigs green, hirsute, dense; trichomes brown, more than 12-cellular; older branches reddish-brown or grayish-brown, glabrous or with few scattered trichomes, the lenticels few to numerous. Leaves anisophyllous; petioles 1–3.5 cm long, hirsute, dense; blades ovate-lanceolate or ovate to elliptic, chartaceous, 11–30 cm long, 5.5–12.3 cm wide, the upper side hirsute, sparse to dense, the lower side hirsute especially on midrib and veins, slenderly acuminate to subcaudate, not conduplicate at apex, the base attenuate or rarely obtuse, entire, ciliate at margins, secondary veins 10–14 pairs, the midrib and veins prominent above. Stipules triangular or broadly ovate, 7–12 mm long, 3.5–7.5 mm broad at base, abaxially with dense indument, adaxially with sparse to dense indument all over, persistent or deciduous, the apex entire or bifid, 1/8 or 1/4 of its length, the lobes slightly diverging at the most; colleters numerous, in groups of two at base.

Inflorescence & reproductive parts. Inflorescences spreading or congested, hirsute, dense, many-flowered; bracts and bracteoles numerous, entire or rarely bilobed, lanceolate, 7–10 mm long, 1.5–3 mm wide, with dense trichomes underneath, glabrous above. Flowers 5-merous, odorless; pedicels 2–3.5 mm long, with trichomes, sparse, appressed or ascending. Calyx tubes cup shaped to shortly tubular, 2.5–4 mm long, hirsute, sparse to dense; lobes not recurved, linear to lanceolate, 6–8 mm long, 1 mm wide, hirsute outside, glabrous inside, the median ridge indistinct, occasionally with a single semaphyll; colleters present, 1 pair per lobe, in sinuses between calyx lobes. Semaphylls white, ovate or elliptic-ovate, 5–9.4 cm long, 3–6 cm broad, acute or acuminate, the base cuneate or obtuse, 5-nerved, sparsely pubescent especially on the nerves of both sides, margins ciliate; stalks 1.5–3.3 cm long, hirsute, dense. Corolla buds hirsute, sparse or dense; tubes in open flowers with trichomes only on the upper half, 2.2–3.5 cm long, white or greenish white, cylindrical, forming a distinctly swollen part around anthers, tuft of hairs surrounding the opening absent, with trichomes inside; short-styled morphs with densely long, unstriated, ribbon-like trichomes, up to the base of anthers from the top; long-styled morphs with sparsely, striated, short ribbon-like trichomes, up to the short filaments from the top; lobes white, linear-lanceolate, 9–12(–22) mm long, 1–1.5(–4) mm wide, the apex recurved, abaxially hirsute, adaxially papillate, filiform apical appendages absent. Stamens of equal sizes, in short-styled morphs inserted to distal 1/4, in long-styled morphs inserted around the middle; filaments glabrous; anthers linear, obtuse, glabrous, 3–4 mm long in short-styled, 3 mm long in long-styled morphs. Ovary 3–3.5 mm long, 1.5–2 mm wide; style glabrous, 4–6 mm long in short-styled, 18–20(–23) mm long in long-styled morphs; stigma smooth, 1.5–2 mm long in short-styled, 7 mm long, recurved, included in long-styled morphs. Fruits ellipsoid or obovoid, green, 1–2 cm long, 1–1.2 cm wide, hirsute, sparse, calyces persistent or deciduous, with warts, the vertical ridges slightly prominent; mesocarp 0.5–0.7 mm thick, pedicels 5–8 mm long, hirsute, sparse. Seeds 0.67–0.83 mm long, 0.43–0.53 mm broad, inner wall perforations 2–8, radial and inner tangential walls without or with slightly prominent tuberculate thickenings. Pollen maximum diameter 15.3 µm, the apertures 4 or rarely 3.

Phenology. Flowering April–November; fruiting August–December.

Distribution. Negros Occidental & Panay Islands; 50–400 m.

Vernacular name/s. Agboy (BisPn); Boyon (BisSL); Buyon (Bis).

Additional specimens examined. Negros Occidental: Iglamgam, 09°50'N, 122°31'E, Dias F. 29885 (NY). Panay: Aklan, between Naojon and Idio, 11°38'N, 122°06'E, Alejandro G. D. 043 (UBT), 046 (UBT), 050 (BR, USTH), 051 (L), Nabas, Mt. Laserna, 11°49'N, 122°05'E, Alejandro G. D. 020 (BR, UBT, USTH), 029 (NY, UBT, US, USTH), 030 (PNH, USTH), 031 (USTH), 036 (L, WAG), 037 (BM); Capiz Prov., Jamindan, 11°25'N, 122°30'E, Ramos M. & Edano G. 31382 (US), Libacao, 11°28'N, 122°18'E, Martelino A. & Edano G. 35391 (L, NY), SW range of Mt. Baloy, Musay, 3–7 km N of Lublub, 11°05', 122°05', Varadarajan G. S. 1531 (L, NY).

Discussion. *Mussaenda albiflora* can be easily recognized among Philippine *Mussaenda* by its distinctive purely white, long, linear-lanceolate corolla lobes. In addition, it is characterized by long, slender corolla tubes; large, sometimes ovate-lanceolate leaves; small anthers in both short- and long-styled morphs; and long fruit pedicels. Furthermore, it is one of the few species with long trichomes on both sides of the leaf blades, numerous bracts and bracteoles, a recurved stigma in long-styled morphs, and slightly prominent vertical ridges on fruits. This species is very abundant even in the roadsides of Panay, Aklan.

ITS sequence.

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tcgaatcCTGCAAAGCAGACGACCGCGAACTTGTGTAATTGCCG-  
GGCGTCGGGGAACAGGGGAGACTAAAGCCTCCCCTAACTC-  
CCCGACGCTCCCCGCGCACCGCGCGGACAACAACCTCAACCCCG-  
GCGCGGAAAGCGCCAAGGAAAACCTCAAAGGATTGCCCGCCTC-  
CCCGTGC GCGGGGTGTGTTGTGGCGTCTGTTCGTAACCAAAAC-  
GACTCTCGGCAACGGATATCTCGGCTCTCGCATCGATGAAGAACG-  
TAGCGAAATGCGATACTTGGTGTGAATTGCAGAATCCCGTGAACCA-  
TCGAGTCTTTGAACGCAAGTTGCGCCCGAAGCCATTAGGCGGAG-  
GGCACGCCTGCCTGGGCGTCACGCATCGCGTCGCCACCCCTTTT-  
GCGGGGCGGCGGATACTGGCCTCCCGTCCCAAGAAGGCGCG-  
GCTGGCCTAAATTCGAGTCCTCGACGGGGGACGTCACGACAAGT-  
GGTGGTTGAATGCCTCAACTCGATTCTGTTCGTTCACTGGC-  
CTCGTCGTTTCTCGGGCTCCTTGACCCTTCTTGCTTGCATCTCGATGC-  
GAGCCTCGACCGCGACCCcaggt [592]
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