# CYTOGENETICS OF CULTIVATED BOUGAINVILLEAS

## I. MORPHOLOGICAL VARIATION

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*B. glabra, B. spectabilis* and *B. peruviana* are the only species of the genus *Bougainvillea*, possessing, showy colourful bracts. *B. glabra* and *B. spectabilis* show natural variation in shape of leaves and bracts, colour of bracts and degree of hairiness. *B. peruviana*, however, does not show any variability and is represented by only one cultivar. *B. glabra* and *B. spectabilis* are similar in essential morphological features, the only major difference being the villous character of the latter. However, *B. peruviana* differs from above two species in leaf shape, division of floral cyme, shape of floral tube and unbranched main shoot. The cultivars which do not fall within the taxonomic limits of above species, can be by and large, divided on morphological grounds into three hybrid groups viz. *B.* × *buttiana* (*B.* × *glabraperuviana*), *B.* × *specto-peruviana* and *B.* × *specto-glabra*.

The cultivars show a great range of shape, size and colour of bracts, most of which have arisen by spontaneous hybridization and/or bud sports. 'Mary Palmer' and 'Thimma' are conspicuous in being chimeral for bract colour, possessing white and magenta bracts on the same plant but differing in leaves which are with yellow centre in the latter.

The varieties of *B. spectabilis* bloom in response to dry hot weather, while *B. glabra* and *B. peruviana* bloom recurrently. Only *B. spectabilis* has season-bound flowering habit.

## INTRODUCTION

The genus *Bougainvillea* is native of South American tropics and sub-tropics. Out of about 15 species reported, only three species, *B. glabra, B. spectabilis* and *B. peruviana* are involved in the origin of modern-day cultivars of *Bougainvillea*. Since their first introduction into cultivation outside their native place, an immense range of variation has appeared in bougainvilleas. The present account aims to examine the range of variability in various phenotypic characters, within the basal species and cultivars of subsequent origin.

## MATERIALS AND METHODS

Three species and about 50 cultivars of *Bougainvillea* available at National Botanic Gardens, Lucknow, were taken up for the present study. Herbarium specimens of the three species, i.e. *B. glabra* Choisy, *B. spectabilis* Willd., *B. peruviana*

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Humb. and Bonp. and the hybrid group *B.* × *buttiana* were acquired for taxonomic comparisons, from the Royal Botanic Gardens, Kew, Gray Herbarium and Herbarium of Arnold Arboretum, Harvard University, U.S.A.

## Systematic Position

The generic name, *Bougainvillea* Commers. (Nyctaginaceae), was first published for Commerson, by A. L. De Jussieu (1789) in his work 'Genera Plantarum', The earlier spelling being *Beuginvillea*, but as the name was given in honour of the famous French navigator, L. A. De Bougainville, during whose round-the-world voyage, the plants were collected by Commerson, the subsequent authors, following International Code of Botanical Nomenclature, for latinization of personal names, spelt it as *Bougainvillea.*

Heimerl (1900) recognized 10 species, three of which (*B. spectabilis* Willd., *B. glabra* Choisy and *B. peruviana* Humb. and Bonp.) were of horticultural importance with very showy and colourful bracts. Heimerl noted a great deal of variation with regard to colour and shape of bracts in *B. glabra* and *B. spectabilis.* In *B. glabra* he described two principal varieties in addition to typical form, but did not distinguish by name all the horticultural varieties because of smaller differences.

Standley (1931) described eight species under the genus *Bougainvillea* and there was no essential difference from that of Heimerl (1900) as far as cultivated species were concerned. Being concerned with wild plants, Standley did not recognize the cultivated varieties.

Following Standley (1931), the distinguishing features of the three species in cultivation are as follows :

Bracts brightly coloured, purplish red or bright red, retaining the colour when dried, mostly 2.5 to 4 cm long :

Perianth tube glabrous..... *B. peruviana*
Perianth tube variously pubescent.
Perianth tube hirsute or villous, leaves usually copiously villious..... *B. spectabilis*
Perianth tube puberulent or glabrate; leaves glabrate..... *B. glabra*

## Morphological Variation in Basal Species

*B. spectabilis* Willd., *B. glabra* Choisy and *B. peruviana* Humb. and Bonp. are the only species possessing large, colourful and showy bracts. It was due to this horticultural attribute that the said species were cultivated in gardens throughout the world. During a short history of their cultivation, an immense range of different forms, with respect to shape, size and colour of bracts has arisen. This could be due to spontaneous hybridization and/or bud sports, among the basal species which in themselves showed a great deal of variation in these characteristics. The range of variability in the basal species has been brought out below :

*B. glabra* Choisy (Fig. 1)

The species was first described by Choisy in De Candolle's Prodromus (1849). The original descriptions were made from a series of dried specimens collected from various localities in Southern Brazil, probably mostly from cultivated plants (Holttum 1955*c*). Subsequent to the published description, several plants ranking in the same category were brought into cultivation in various parts of Europe. Heimerl (1900) recognized the species *B. glabra* including considerable variation in characters like, shape, size and colour of bracts, shape of flower tube etc. He described three varieties var. *typica*, var. *graciflora*, and var. *brachycarpa*. Variety *typica* was further divided into three forms (*acutibracteata, obtusibracteata* and *laeviuscula*), and it is not clear whether this included the whole range of variation recognized by Heimerl.

It is not possible to say as to what was the original form of *B. glabra* like, the form to which the name *B. glabra* should specially apply (Holttum 1955*c*). Even if one selects a single specimen from those described by Choisy, it will not be possible to find out to which form now in cultivation it resembles most. The dried specimens cannot give an idea about the habit of growth and colour of bracts. As such the reasonable course, as suggested by Holttum (1955*c*), would be to give a general description indicating the principal characters of the variable species *B. glabra.*

The three cultivars of the species taken up in the present study show gross similarities in outline of leaves and bracts, and glabrous nature of shoots, leaves and bracts. However, a detailed examination reveals the variation in leaf and bract apices. More pronounced difference is in colour of the bracts which is white in 'Jennifer', phlox purple in 'Formosa,' and mauve in 'Dream.' The variation in shape and size of leaves and bracts is also evident from herbarium specimens acquired from Harvard.

*B. spectabilis* Willd. (Fig. 2)

The species was described by Willdnow for the first time in fourth edition of Linnaeus's 'Species Plantarum' (1798). As with *B. glabra*, here again the descriptions were prepared on the basis of dried specimens obtained from Brazil. The description by Willdnow was not enough to differentiate it from *B. glabra.* It was left to Heimerl and Choisy to make a more detailed study so as to differentiate it from *B. glabra.*

*B. spectabilis* differs from *B. glabra* in having villous shoots and leaves. Another major difference between the two is in their flowering seasons (Holttum 1956, present studies) which is not clear from herbarium specimens. As with *B. glabra,* Heimerl (1900) found a good deal of variation in *B. spectabilis* particularly with reference to the shape, size and colour of bracts. As with *B. glabra* it is not possible to be certain which of the variants should be regarded as typical form of the species.

The cultivars studied in the present work differ chiefly in the colour of their bracts which is phlox purple in 'Splendens,' jasper red in 'Lateritia' and brick red in 'Mrs. Chico.' Variability in the leaf shape and size and shape of the bracts is evident from herbarium specimens of species obtained from Kew and Harvard.

*B. peruviana* Humb. and Bonp. (Fig. 3)

This species was described first by Humboldt and Bonpland (1808). Only two cultivars of this species e.g. 'Princess Margaret Rose' and 'Lady Hudson' are cultivated in gardens. In our collection at National Botanic Gardens, Lucknow, a detailed morphological, cytological and horticultural study of the two cultivars revealed that these are not different as has also been concluded by Holttum (1955*c*).

*B.* × *buttiana* 'Mrs. Butt'

The descriptions of this plant was based on specimens brought by Mrs. Butt from Cartagena (Columbia) to Trinidad in 1910. The name *B.* 'Mrs. Butt.' was first published in the Report of Department of Agriculture, St. Vincent, in 1916-17, by R. O. Williams (vide Holttum 1955*b*). As the specimen differed from all other bougainvilleas in cultivation in some morphological features including the colour of bracts, Holttum and Standley (1947) described it as a separate species *B. buttiana*. But owing to the subsequent establihment of the hybrid nature of these plants a change in name became necessary and Holttum (1955*b*) referred it as *B.* × *buttiana*. The plant resembles *B. peruviana* in essential features of habit and morphology. Incidently *B. peruviana* is one of the putative parents of this group (S. C. Harlands vide Holttum 1955*b*). During subsequent years a number of sports arose from 'Mrs. Butt', thus making it one of the important groups of cultivated bougainvilleas on account of the considerable colour diversity in its bracts. As far as general habit and morphology is concerned there is no essential difference within the varieties of this group. The only difference being in flower tube, which may be perfect or imperfect, and colour of bracts. A summary of morphological analysis of this group is given in Tables I and II.

## Morphological Features of Cultivars vis-a-vis Basal Species

*Bougainvillea* cultivars show considerable variation with respect to some important phenotypic characters. These are discussed below :

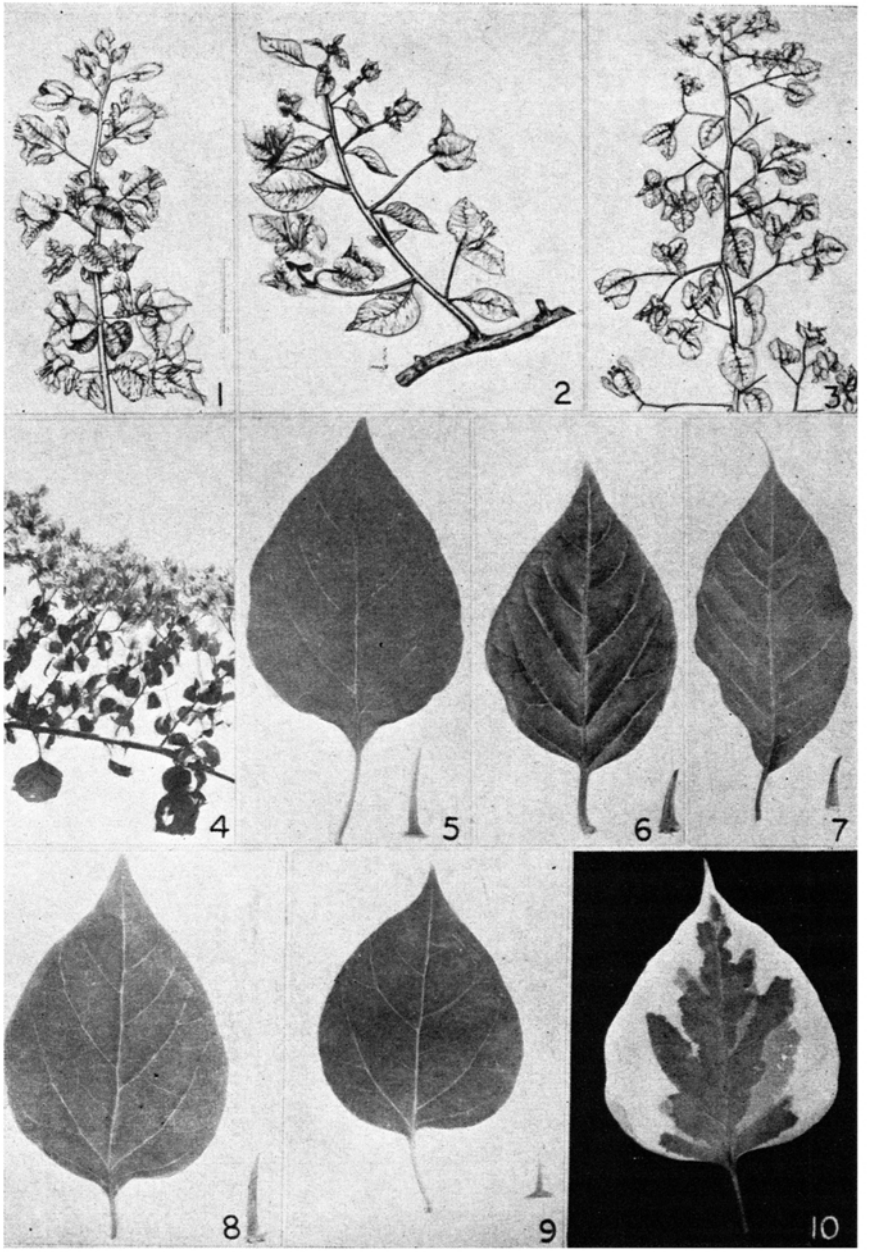
## Observations

### *Stem*

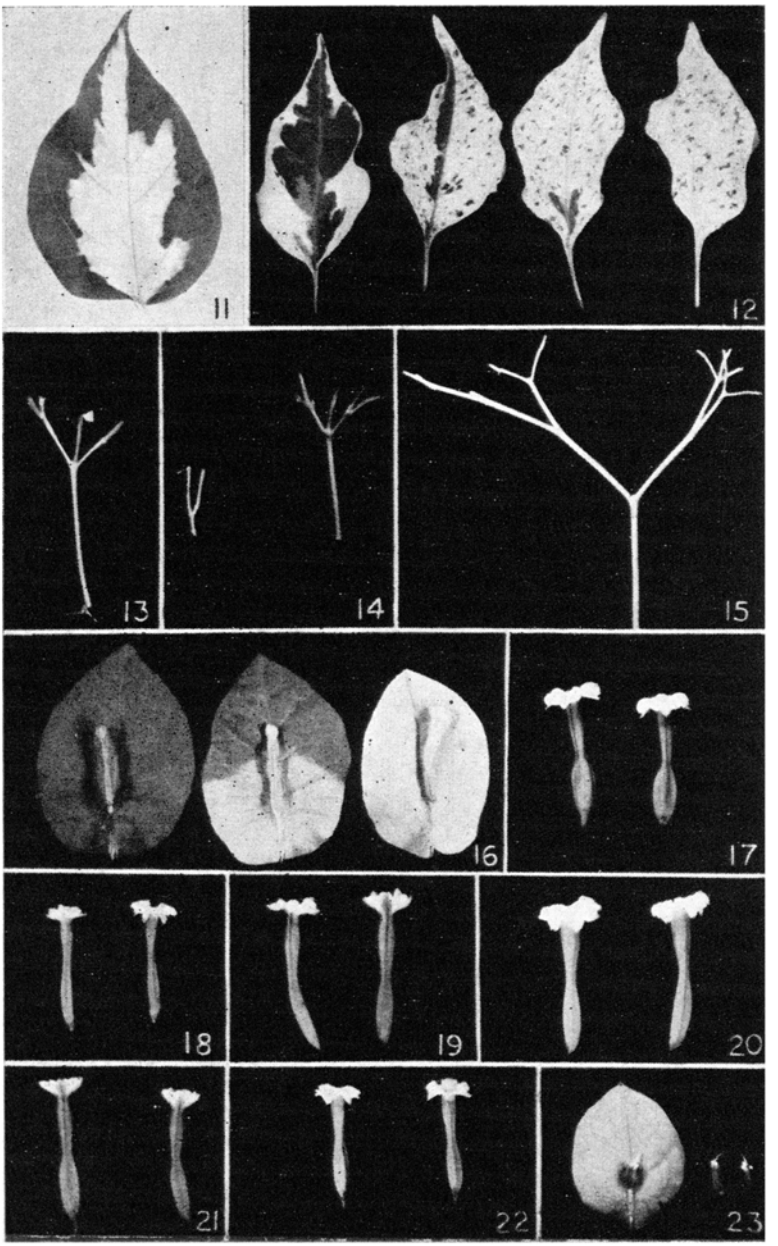
Young shoots may be glabrous (*B. peruviana* and *spectoperuviana* group), tomentose (*B. glabra* and *B.* × *buttiana* group) or densly villous (*B. spectabilis*). Sucker shoots are green, but in some cultivars like 'President Roosevelt' and 'Scarlet Glory' the young shoots are red. Shoots may be unbranched (*B. peruviana* and *B.* × *buttiana* group) or with small lateral branches (Fig. 4; *B. spectabilis*, *B. glabra*, *specto-peruviana* and *specto-glabra* group).

### *Spines*

Spines are long and slender (*B. peruviana*; Fig. 5), or short slender, laterally flattened in varieties of *B. spectabilis* and *B. glabra* (Figs. 6-7). In cultivars spines are intermediate in length and thickness and laterally flattened (*specto-peruviana*; Fig. 8) and short and slender (*B.* × *buttiana*; Fig. 9).




FIGS. 1–10. 1–9. 1, Flowering shoot of *B. glabra* 'Dream'; 2, Flowering lateral of *B. spectabilis* 'Mrs. Chico'; 3, Flowering shoot of *B. peruviana* 'Princess Margaret Rose'; 4, Flowering branch of 'Mrs. H. C. Buck' showing lateral branching. 5–9. Variation in leaves and spines. 5, *B. peruviana* 'Princess Margaret Rose'; 6, *B. spectabilis* 'Mrs. Chico'; 7, *B. glabra* 'Dream'; 8, *B.* 'Mrs. H. C. Buck' (× *specto-peruviana*); 9, *B.* × *buttiana* 'Mrs. McClean'; 10, Leaf variegation. Albino-marginate 'Scarlet Queen Variegata'.




FIGS. 11–23. 11–12. 11, Medio-albinate 'Thimma'; 12, Mosaic pattern 'Partha Variegata'. 13–15. Inflorescence cymes. 13, *B. spectabilis* 'Mrs. Chico', 14, *B. glabra* 'Dream'; 15, *B. peruviana* 'Princess Margaret Rose. 16. Bract colour variation in 'Mary Palmer'; 17–23. Floral tubes. 17, *B. glabra* 'Formosa'; 18, *B. peruviana* 'Princess Margaret Rose'; 19, *B. spectabilis* 'Mrs. Chico'; 20, 'Mrs. H. C. Buck' (× *specto-peruviana*); 21, 'Sanderiana' (× *spectra-glabra*); 22, 'Mrs. McClean' (× *buttiana*); 23, Imperfect flower tubes of *B.* × *buttiana* 'Scarlet Queen'.

TABLE I

*Morphological comparisons of three species and one hybrid group of Bougainvilleas*

| Character | *B. peruviana* | *B. glabra* | *B. spectabilis* | *B. × buttiana* |
|---|---|---|---|---|
| *Leaf* | | | | |
| Outline | Broadly ovate to suborbicular | Ovate-lanceolate | Broadly ovate to sub-orbicular or rounded oval | Broadly ovate |
| Base | Sub-truncate | Rounded to acute | Rounded to acutish or short decurrent | Truncate |
| Apex | Sub-obtuse or abruptly acute | Abruptly or gradually acute to acuminate | Abruptly acute or acuminate | Abruptly acuminate |
| Pubescence | Glabrous | Glabrous except when very young | Copiously villous | Puberulent |
| Length (cm) | 5–7 | 4–10 | 5–10 | 6–10 |
| Breadth (cm) | 3.7–4.6 | 2.7–5.2 | 3.3–6.8 | 5–8 |
| *Spines* | | | | |
| Shape | Slender | Stout, laterally flattened | Stout | Slender, laterally flattened, recurved |
| Length (cm) | 1–2.5 | 1.0–3.0 | 1.0–4.0 | 1.0–1.5 |
| *Bracts* | | | | |
| Colour | Roseine purple | Various shades or purple | Purple, pink or brick red | Crimson, burnt orange, majolics yellow, magenta |
| Outline | Ovate | Broadly ovate or oval | Ovate, oval or broadly ovate | Broadly ovate |
| Base | Sub-cordate | Sub-cordate | Sub-cordate | Cordate |
| Apex | Obtuse | Acute or acuminate | Acute or acuminate | Shortly tipped |
| Length (cm) | 2.9–3.2 | 2.9–3.3 | 2.0–4.5 | 3.0–3.5 |
| Breadth (cm) | 2.1–2.3 | 1.7–2.1 | 2.0–2.5 | 2.0–2.5 |
| Pubescence | Glabrous | Glabraje | Pubescent | Puberulent |
| *Flower tube* | | | | |
| Shape | Cylindrical | Lower half distinctly angled | Lower half less distinctly angled | Cylindrical slightly angled (sometimes imperfect) |
| Pubescence | Glabrous | Puberulent | Villous | Puberulent |
| Colour | Greenish white | Green | Variously coloured | Varies with colour of subtending bract |
| Length (cm) | 1.6–2.0 | 1.5–2.5 | 1.5–3.0 | 1.80 |
| *Flowering shoots* | | | | |
| Branching | Unbranched | May be branched or unbranched | Branched | Unbranched, rarely branched |
| Pubescence | Glabrous | Glabrous except when young | Villous | Puberulent |
| Inflorescence cyme division | More than twice | Once, rarely twice | Once, rarely twice | More than twice |
| *Style* | | | | |
| Length (cm) | 0.5 | 0.3 | 0.4 | 0.5 |

TABLE II

*Bract colour and nature of flower tube in cultivars of* B. × buttiana *group*

| Cultivar | Colour of bract | Flower tube |
|---|---|---|
| 'Mrs. Butt' | Crimson | Perfect |
| 'Scarlet Queen' | Crimson | Imperfect |
| 'Mrs. McClean' | Burnt orange | Perfect |
| 'Louis Wathen' | Burnt orange | Imperfect |
| 'Mary Baring' | Majolica yellow | Perfect |
| 'Enid Lancaster' | Majolica yellow | Imperfect |
| 'Alick Lancaster' | Magenta | Imperfect |
| 'Versicolor' | Magenta with crimson flecks | Imperfect |

TABLE III

*Variegation pattern of the three variegated cultivars*

| Cultivars | Pattern |
|---|---|
| 'Scarlet Queen Variegata' | Green centre and creamy white margin. |
| 'Thimma' | Yellowish white centre and green margin. |
| 'Partha Variegata' | Green centre and white or mosaic margin or indifferent pattern. |

*Leaf*

Leaves are broadly ovate or ovate with truncate and subtruncate bases and acute apex (*B. peruviana*; Fig. 5, *B. spectabilis,* Fig. 6) or elliptic with obtuse base and abruptly acute or acuminate apex (*B. glabra*, Fig. 7). Hairiness is directly correlated with that of shoots. The cultivars of *B.* × *buttiana* group have broadly ovate leaves (Fig. 9) with subtruncate bases (*peruviana* type) and acute or acuminate apices (*glabra* type). Similarly the leaves of cultivars belonging to *specto-peruviana* group (Fig. 8) have somewhat intermediate leaves as compared to the species. Some cultivars have variegated leaves. The gross pattern of three cultivars is given in Table III (Figs. 10-12).

*Inflorescence cyme*

Cymes may be borne on main shoot (*B. peruviana* and *B.* × *buttiana* group) or on lateral branches (*B. glabra, B. spectabilis, specto-peruviana* and *specto-glabra* group). The cyme may divide once or twice (Figs. 13-14) in *B. spectabilis* and *B. glabra* (species showing branching of shoots), while in *B. peruviana,* which has unbranched shoot it divides more than twice (Fig. 15). 'Mary Palmer', 'Sonnet',

'Spring Time'; combine both the features i.e. branched stem and division of cymes more than twice.

*Bract*

*B. spectabilis* has largest bracts among the species followed by *B. glabra* and *B. peruviana* (Table I). In cultivars size of the bracts is more often larger than the basal types (Table IV). Colour in basal species is roseine purple, various shades of purple or brick red (Table I), while the cultivars especially of *B.* × *buttiana* group show a wide range of colours (Table II). 'Mary Palmer' and 'Thimma' are conspicuous in having bracts of two different colours (Fig. 16). The bracts of most of the cultivars of *B.* × *buttiana* group change in colour with maturity. Pubescence is directly correlated with that of shoots.

TABLE IV

*Size of floral bracts in some representative cultivars*

| Taxon | Length (cm) | Breadth (cm) |
|---|---|---|
| *B. peruviana* | | |
| cv. 'Margaret Rose' | 2.5 | 1.8 |
| *B. glabra* | | |
| cv. 'Dream' | 2.8 | 1.7 |
| cv. 'Formosa' | 2.5 | 1.8 |
| *B. spectabilis* | | |
| cv. 'Mrs. Chico' | 3.0 | 2.1 |
| *Cultivars* | | |
| 'R. R. Pal' | 3.3 | 2.5 |
| 'Scarlet Glory' | 3.3 | 2.3 |
| 'Spring Festival' | 2.8 | 2.3 |
| 'Killie Campbell' | 3.0 | 2.8 |
| 'Partha' | 3.6 | 2.3 |
| 'Lady Mary Baring' | 3.3 | 2.5 |
| 'Mary Palmer' | 4.3 | 2.8 |
| 'Perfection' | 4.1 | 3.0 |
| 'Poultonii Special' | 4.8 | 4.4 |

*Flower tube*

Flower tube varies in shape and colour in basal species (Figs. 17, 18, 19; Table I). Different cultivars show various types of tube shape and grade of pubescence which in most cases are intermediate between basal types (Figs. 20-22). Flower tube in some cultivars of *B.* × *buttiana* is imperfectly developed (Fig. 23, Table II). Tube lacks the conspicuous star, filament length is reduced while style remains unchanged. With the result anthers are arranged in a bunch at the base of protruding style.

TABLE V

*Classification of* Bougainvillea *cultivars*

| Species/hybrid group | Cultivars |
|---|---|
| *B. glabra* Choisy | 'Formosa', 'Dream', 'Jennifer'. |
| *B. spectabilis* Willd. | 'Mrs. Chico', 'Splendens', 'Lateritia', 'Pradhan's Profusion'. |
| *B. peruviana* Humb. and Bonp. | 'Princess Margaret Rose'. |
| *B.* × *buttiana* (*B.* × *glabra-peruviana*) | Mrs. Butt', 'Scarlet Queen', 'Scarlet Queen Variegata', 'Mrs. McClean', 'Louis Wathen', 'Lady Mary Baring', 'Enid Lancaster', 'Alick Lancaster', 'Versicolor', 'Scarlet Glory', 'Mahara', 'President Roosevelt'. |
| *B.* × *specto-peruviana* | 'Mrs. H. C. Buck', 'Mary Palmer', 'Thimma', 'Shubhra', 'Elizabeth', 'Gopal', 'Padmini', 'Sonnet', 'Spring Festival', 'Summer Time', 'Sensation', 'Mahatma Gandhi', 'R. R. Pal.' |
| *B.* × *specto-glabra* | 'Jubilee', 'Sanderiana', 'Lilicina', 'Cypheri', 'Joe'. |
| Undetermined group | 'Lord Willingdon', 'Refulgens', 'Magnifica', 'Perfection', 'Poultonii', 'Poultonii Special', 'Killie Campbell', 'Partha', 'Superba', 'Isobel Green Smith', 'Glady's Hepburn', 'Tomato Seedling', 'Partha Variegata'. |

*Blooming period*

Bougainvilleas are ever bloomers with the exception of rainy months. *B. spectabilis* flowers often only once in response to dry weather conditions, while as *B. glabra*, *B. peruviana* and all other cultivars are recurrent bloomers.

## RESULTS

From the foregoing account, a few general conclusions emerge. The basal species differ chiefly in outline, base and apex of leaf, degree of pubescence, division of main shoot and flowering cymes and shape of flower tube. While *B. glabra* and *B. spectabilis* are close to each other in various morphological characteristics, *B. peruviana* is distinct from both of the species.

The cultivars which do not fall within the limits of the three basal species, more often overlap between the variation patterns of two species. The cultivars of *B.* × *buttiana* group, whose hybrid nature has been confirmed by unpublished studies of Dr. S. C. Harlands and the seedling progeny raised at USDA (Holttum 1955*b*). show characters both of *B. peruviana* and *B. glabra*. The leaf outline, unbranched flowering shoot, and division of flowering cyme in the cultivars of this group is akin to *B. peruviana*, while as shape of leaf tip, pubescence of young leaves and shoots and shape of flower tube are typical of *B. glabra*. All the cultivars of *B.* × *buttiana* group are rather similar morphologically except a few which have imperfect flower tube, which may be a subsequent event in their origin probably through bud sports.

Similarly the cultivars like 'Mary Palmer' and 'Spring Time' show characteristic features of both *B. peruviana* and *B. spectabilis*, and may therefore be designated as

*B.* × *specto-peruviana* group. These cultivars combine in themselves the branched main shoot (*spectabilis* type) and division of flowering cyme more than twice and recurrent blooming habit (*peruviana* type). A third group of cultivars represented by 'Sanderiana' and 'Lilicina' possess the morphological features of *B. spectabilis* and *B. glabra* and may be given the name *B.* × *specto-glabra* group. The degree of hairiness and shape of flower tube in these cultivars is intermediate between *B. spectabilis* and *B. glabra.* These cultivars are recurrent bloomers which character is akin to *B. glabra.* Table V gives the classification of the bougainvillea cultivars investigated here taking into account the basal species and the three hybrid groups together with a fourth one of such cultivars which do not fall either under the basal species or the hybrid groups. While evolving this classification for cultivated bougainvilleas due consideration has been paid to the principles and procedures involved in horticultural taxonomy as outlined by Khoshoo (1971*a*, *b*).

The red colour of young shoots and leaves in some cultivars like, 'President Roosevelt' and 'Scarlet Glory' is a peculiar feature not met within any of the basal species. The origin of these varieties is not recorded. This feature may be a direct result of hybridization and/or mutation. This is supported by our experimental studies which will be discussed elsewhere.

As regards the size of bracts, it may be pointed out that in most of the cultivars the size of the bracts is larger than those of the basal species. The largest being in triploid 'Poultonii Special' which may be due to its polyploid nature *per se.* The colour of the bracts in basal species is roseine purple/phlox purple. In cultivation, colours like crimson, burnt orange, jasper red, and majolica yellow and white have come up. Most of these are of bud sport origin, and a few may be due to the result of recombination. Variegated types have arisen as a result of somatic mutations and have been propagated and maintained for their ornamental foliage. 'Partha Variegata', which is an unstable variegated form, has arisen just a few years back at National Botanic Gardens by spontaneous bud sport mutation. Lastly, in basal species we have got floriferous types (*B. spectabilis*), which bloom only once in a year in response to dry weather. The species *B. glabra* and *B. peruviana* are recurrent bloomers and flower irrespective of cold and hot weather. However, none of the cultivars shows the season-bound flowering of *B. spectabilis.*

To sum up the foregoing observations on morphological and horticultural aspects, there is a strong evidence that morphological and horticultural diversity may be primarily due to variability within species *B. spectabilis* and *B. glabra* which were involved in indiscriminate hybridization among themselves and with *B. peruviana.* Somatic mutations seem to account for variability in colour of bracts, flower tube shape (imperfect/perfect) and leaf variegation. The new colour combinations may have also arisen as a consequence of hybridization and interaction of alleles responsible for bract colour in the basal types.

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