



Morphological diversity within *Dendrobium* (Orchidaceae) of Nepal

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Abstract: The morphological diversity within *Dendrobium* Sw., comprising 29 species of Nepal Himalaya, is presented. The paper provides detailed information about the range of diversity in vegetative and reproductive characteristics. An artificial key to the species is provided for their identification. According to the updated classification of Orchidaceae, genera like *Epigeneium* and *Flickingeria* of subtribe Dendrobiinae are merged into genus *Dendrobium* sensu lato. In the present investigation, the morphological diversity within 29 species of *Dendrobium* viz. *D. amoenum*, *D. amplum*, *D. anceps*, *D. aphyllum*, *D. bicameratum*, *D. chrysanthum*, *D. crepidatum*, *D. darjeelingense*, *D. denneanum*, *D. densiflorum*, *D. denudans*, *D. eriiflorum*, *D. fimbriatum* var. *oculatum*, *D. formosum*, *D. fugax*, *D. fuscescens*, *D. gibsonii*, *D. heterocarpum*, *D. longicornu*, *D. moniliforme*, *D. monticola*, *D. moschatum*, *D. nobile*, *D. plicatile*, *D. polyanthum*, *D. porphyrochilum*, *D. rotundatum* and *D. transparens* of Nepal Himalaya were studied.

Keywords: *Dendrobium*; Orchidaceae; Morphological diversity

Introduction

Dendrobium Sw. is the second largest genus of the family Orchidaceae and was established by Olof Swartz in 1799. *Dendrobium moniliforme* (L.) Sw. is the type for the genus *Dendrobium* (Holttum, Brieger & Cribb 1979). *Dendrobium* Sw. comes under subtribe Dendrobiinae, and it consists of about 1500 species worldwide (Schuitman 2017). According to Dressler (1993) subtribe Dendrobiinae comprises 6 genera (*Cadetia*, *Dendrobium*, *Diplocaulibium*, *Epigeneium*, *Flickingeria* and *Pseuderia*) and 1147 species. The subtribe Dendrobiinae consists of 900 species of *Dendrobium*, 12 species of *Epigeneium* and 70 species of *Flickingeria* (Dressler, 1993). Among them, 26 species of *Dendrobium* and 2 species of *Epigeneium* have been reported from Nepal (Rajbhandari & Rai, 2017). But according to update classification, genera *Epigeneium* and *Flickingeria* were merged into genus *Dendrobium* s.l. (Schuiteman & Adams, 2014). The species of *Dendrobium* show great variation in vegetative and floral characters. Based on variations, *Dendrobium* species are divided into 30 sections (Schuitman & Adams 2014). *Dendrobium*

species of Nepal Himalaya come under 6 sections out of 30 sections. The morphological variations within 29 species of *Dendrobium* of Nepal Himalaya belonging to 6 sections are presented here.

The genus *Dendrobium* ranges from Sri Lanka throughout tropical Asia and Pacific region, north to Japan, east to Tahiti and south to New Zealand and absent in Africa and America (Schuiteman and Adams 2014). The genus *Dendrobium* is characterized by epiphytic, litho-phytic or rarely terrestrial habits, presence of cane-like stem with pseudo-bulb covered with or without sheathing leaf bases, distichous or duplicate leaves, spiral flowers with basally jointed lips with prominent spurs formed by the column foot and naked pollinia.

The genus *Dendrobium* belongs to the subtribe Dendrobiinae, tribe Malaxideae, subfamily Epidendroideae, family Orchidaceae (Chase *et al.* 2015). Various generic delimitations and infrageneric systems have been proposed by Kranzlin (1910), Schlechter (1912), Brieger

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(1981), Seidenfaden (1985), Clements (2006), Wood (2006), Schuitman and Adams (2014) based on the morphological and molecular characters after the establishment of *Dendrobium* by Swartz in 1799.

The exploration of the orchid flora of Nepal Himalaya begins in 1802 with the collections by Buchanan-Hamilton. D. Don published "Prodromus Florae Nepalensis" in 1825 based on the plant collections of Buchanan-Hamilton and Wallich. Wallich published "Tentamen Florae Nepalensis" in 1824-1826. Buchanan-Hamilton (1802-1803) described *Epidendron moschatum* (*Dendrobium moschatum*) in his unpublished manuscript from Nepal Himalaya. Hara, Stearn, and Williams (1978) enumerated 26 species of *Dendrobium* and 3 species of *Epigeneium* from Nepal. Banerji and Pradhan (1984) enlisted 21 species of *Dendrobium* and 2 species of *Epigeneium* from Nepal. Press, Shrestha, and Sutton (2000) enumerated 26 species of *Dendrobium* and 3 species of *Epigeneium* from Nepal. White and Sharma (2000) described 22 species of *Dendrobium*, 1 species of *Epigeneium* and 1 species of *Flickingeria* from Nepal.

Raskoti (2009) enlisted 26 species of *Dendrobium*, 2 species of *Epigeneium* and 1 species of *Flickingeria* from Nepal Himalaya. Rokaya, Raskoti, Timsina and Munzbergova (2013) enlisted 31 species of *Dendrobium*, 3 species of *Epigeneium* and 2 species of *Flickingeria* from Nepal Himalaya.

Rajbhandari and Rai (2017) enlisted 26 species of *Dendrobium* and 2 species of *Epigeneium* from Nepal Himalaya. Shrestha, Bhattarai and Bhandari (2018) enumerated 30 species of *Dendrobium*, 3 species of *Epigeneium* and 2 species of *Flickingeria* from Nepal Himalaya.

Materials and Methods

Study sites and sample collection

In this study, the plant materials were collected from West, Central, and East Nepal based on those regions mentioned in the herbaria and the available literature. Altogether 29 species of *Dendrobium* viz. *D. amoenum* Wall. ex Lindl., *D. amplum* Lindl., *D. anceps* Sw., *D. aphyllum* (Roxb.) C.E.C. Fisch., *D. bicameratum* Lindl., *D. chrysanthum* Wall. ex Lindl., *D. chryseum* Rolfe, *D. crepidatum* Lindl. & Paxton, *D. darjeelingense* Pradhan, *D. denneanum* Kerr, *D. densiflorum* Wall., *D. denudans* D. Don, *D. eriiflorum* Griff., *D. fimbriatum* Hook., *D. formosum* Roxb. ex Lindl., *D. fugax* Rchb. f., *D. fuscescens* Griff., *D. gibsonii* Paxton, *D. heterocarpum* Wall. ex Lindl., *D. longicornu* Lindl., *D. moniliforme* (L.) Sw., *D. monticola* P.F. Hunt & Summerh., *D. moschatum* (Buch.-Ham.) Sw., *D. nobile* Lindl., *D. plicatile* Lindl., *D. polyanthum* Wall. ex Lindl., *D. porphyrochilum* Lindl., *D. rotundatum* (Lindl.) Hook. f. and *D. transparens* Wall. ex Lindl. were studied in the present study.

Methodology

The study was based on the collected live specimens and voucher specimens deposited at different herbaria like KATH, TUCH, BM, TI, E, and K. The specimens were collected from different localities of Nepal Himalaya. The collected live specimens as well as voucher specimens, were studied for morphological variations existing within them. The collected live specimens were identified by tallying with protologues, valid taxonomic literature, and type specimens deposited at different herbaria of the world. The type specimens (Holotype, Isotype, Lectotype, and Paratype) were determined based on protologue texts. The type specimens were acquired from different online websites and personal contact.

Results and Discussion

Morphology

In-plant taxonomy, morphological characters are essential for identifying different species. The wide range of morphological variations helps delimitate and identify plants up to the lowest taxonomic hierarchy level.

Range of vegetative structures

a. Habit and Habitat

The habit of different species of *Dendrobium* is sympodial with elongated cane-like stems or pseudobulbs. All species are perennial, epiphytic, erect or pendulous herbs and some are lithophytic also. Epiphytic with lithophytic species are *D. amoenum*, *D. denneanum*, *D. eriiflorum*, *D. fimbriatum*, *D. fuscescens*, *D. monticola*, and *D. plicatile*. The height of plants varies from 2 cm to 70 cm, the smallest plant being *D. porphyrochilum* (2 cm) and the largest being *D. amplum* (70 cm). All species are adapted to a wide variety of habitats from high altitudes to humid lowland forests. Most species are distributed from tropical, subtropical to temperate regions ranging from 200-2500 m, and 2 species like *D. fimbriatum* and *D. formosum* are distributed in tropical regions only (Fig. 1) (Table 1).

b. Root and Rhizome

Roots of *Dendrobium* are developed from base of stem or pseudobulb and from rhizome. In most species roots are developed from nodes allowing the development of adventitious growth. The roots are fasciculate, thick and covered by shiny, silver-grey velamen. Rhizome is found in some *Dendrobium* species such as *D. amplum*, *D. fugax*, *D. fuscescens*, *D. plicatile*, *D. rotundatum*. Rhizomes are creeping, branched and covered with sheaths. Roots are developed from nodes of rhizome.

c. Stem/Pseudobulb

Most *Dendrobium* species has elongated cane-like stems, and few species had distinct pseudobulbs like *D. amplum*, *D. fugax*, *D. fuscescens*, *D. plicatile*, *D. rotundatum*, *D. monticola* and *D. porphyrochilum*. The size of stems or pseudobulbs varies from few centimeters to nearly about a meter. Stems are erect or pendant with few to many nodes. Species like *D. amoenum*, *D. amplum*, *D. aphyllum*, *D. chrysanthum*, *D. chryseum*, *D. crepidatum*, *D. fugax*, *D. fuscescens*, *D. gibsonii*, *D. plicatile*, *D. polyanthum*, *D. rotundatum* has pendant stems and remaining species with erect stems. Stems are branched or unbranched and covered with leaf sheaths. Unbranched stems are found in species like *D. aphyllum*, *D. bicameratum*, *D. chrysanthum*, *D. chryseum*, *D. crepidatum*, *D. darjeelingense*, *D. fimbriatum*, *D. gibsonii*, *D. longicornu*, *D. moniliforme*, *D. moschatum*, *D. nobile*, *D. polyanthum* and branched stems in remaining species. In *D. anceps* the stems are compressed, flattened without any fleshy internodes and leaves are present all along the stem. In *D. densiflorum* the stems are stout, clavate, compressed and quadrangular with leaves at apex. In *D. bicameratum* the stems are slender and swollen towards the apex. In *D. longicornu* and *D. formosum* the stems are short to long, slender or robust, sheaths are hirsute. In *D. darjeelingense*, *D. denudans*, *D. eriiflorum* the stems are long, slender and fusiform tapering towards the apex. Pseudobulb varies in shape in different species. In *D. monticola* and *D. porphyrochilum* the pseudobulbs are small, elongate and cylindrical. Pseudobulbs are large, ellipsoid in *D. amplum*, fusiform in *D. fugax* and *D. plicatile*, cylindrical-ovoid in *D. fuscescens*, ovoid in *D. rotundatum*. In the remaining *Dendrobium* species, the stems are short, long, erect, or pendulous with few to many nodes.

d. Leaves and Leaf sheaths

Leaves of *Dendrobium* show variation in orientation, shape and size. Leaves are arranged distichously along the stem or one to many leaves at apex of pseudobulb. *D. fugax* and *D. plicatile* have single leaves at apex of pseudobulb. *D. amplum*, *D. fuscescens* and *D. rotundatum* have two leaves at apex of pseudobulb. *D. monticola* and *D. porphyrochilum* have three to four leaves developed apically at pseudobulb. The remaining *Dendrobium* species have more than four leaves. Leaves are lanceolate, linear-lanceolate, elliptic-lanceolate, oblong-lanceolate, ovate-lanceolate, oblong, oblong-lanceolate, or oblong-elliptic. Leaves are membranous, coriaceous, fleshy or subleathery. The apex of leaf is acute, obtuse or acuminate, bilobed or emarginated. The leaf surface is glabrous in most species and puberulous in *D. longicornu*. The size of leaves varies from 2.5 to 20.0 cm in length and 0.5 to 5.0 cm in width. Leaf margins are entire in all species of *Dendrobium*. Leaf-sheaths are present in all species of *Dendrobium*. Leaf-sheaths are covered with blackish hairs in *D. longicornu* and *D. formosum* and the remaining species of *Dendrobium* have glabrous leaf sheaths.

Range of reproductive structures

e. Inflorescence

The inflorescence of *Dendrobium* is axillary, terminal, lateral or subterminal raceme. It arises from short or long peduncles borne on nodes of leafy or leafless stems. The peduncles are slender and sheathed. The rachis is slender, short or long. Inflorescence is erect or pendulous. In *D. anceps* the inflorescence is axillary raceme with one flower. Inflorescence is short, capitate raceme, lateral or subterminal on leafless stem, subdensely 4-6 flowered, rachis weakly zigzag in *D. bicameratum*. Inflorescence is axillary raceme, pendant, borne

on apex of stem, densely many-flowered, rachis long in *D. densiflorum*. Inflorescence in *D. formosum* is terminal or lateral raceme with 1-5 flowers on leafy stem, borne at nodes near the stem's apex. In *D. longicornu* the inflorescence is terminal or axillary raceme with 1-3 flowers on leafy stem. The inflorescence is lateral or subterminal raceme with many flowers on long rachis in *D. darjeelingense*, *D. denudans*, *D. monticola*, *D. porphyrochilum*. In remaining *Dendrobium* species, the inflorescence is raceme with few to many flowers borne on nodes of leafy or leafless stems. Length of peduncle and rachis varies in all species of *Dendrobium* (Table 1).

f. Floral Bracts

Floral bracts vary in shape, size and texture in all species of *Dendrobium*. The shapes of floral bracts are ovate, oblong, lanceolate and triangular in all species of *Dendrobium*. The apex of floral bract is acute, obtuse, acuminate and subacute. Margin is entire and surface is glabrous or hirsute. Floral bracts are membranous or scarious. The size of floral bract ranges from 0.2-2.0 cm in length and 0.1-1.2 cm in width. The number of veins in floral bract varies from one to seven in different species (Table 2).

g. Flowers

The flowers of *Dendrobium* are very showy, resupinate, ephemeral or long-lived. Flowers vary in shape, size and colour. The size of flowers varies from 0.8-10.0 cm across. *D. anceps*, *D. bicameratum*, *D. darjeelingense*, *D. denudans*, *D. eriiflorum*, *D. monticola*, *D. porphyrochilum* have smaller flowers as compared to flowers in remaining species of *Dendrobium*. Largest flower is present in *D. formosum* and smallest in *D. porphyrochilum*. The flowers are yellow or white in most species and in remaining species the flowers are creamy, yellowish green or light greenish white. Pedicel

with ovary varies in length in different species of *Dendrobium*. The longer pedicel with ovary is found in most of species and shorter in few species of *Dendrobium* (Table 1) (Plate 1).

h. Sepals

Dorsal sepals are lanceolate, oblong, elliptic, oblong-lanceolate, ovate-lanceolate, elliptic-oblong or ovate-oblong in all species of *Dendrobium*. The apex of dorsal sepal is acute, obtuse, acuminate and subacute. Margin of dorsal sepal is entire and surface is glabrous. The size of dorsal sepal ranges from 0.5-4.7 cm in length and 0.15-1.6 cm in width in all species of *Dendrobium*. Dorsal sepals vary in number of veins from 3-10 in different species of *Dendrobium* (Table 3). Lateral sepals are lanceolate, elliptic, ovate, triangular, oblong, oblong-lanceolate, falcate-lanceolate, ovate-lanceolate in all species of *Dendrobium*. The apex of lateral sepal is acute, obtuse, acuminate and subacute. Margin of lateral sepal is entire and surface is glabrous. The size of lateral sepal ranges from 0.7-5.5 cm in length and 0.2-1.6 cm in width in all species of *Dendrobium*. Lateral sepals vary in number of veins from 3-10 in different species of *Dendrobium* (Table 4).

i. Mentum

Lateral sepals adnate to the foot of column to form mentum. The shape of mentum varies in all species of *Dendrobium*. In species like *D. amoenum*, *D. aphyllum*, *D. chryseum*, *D. nudans*, *D. eriiflorum*, *D. formosum*, *D. fugax*, *D. heterocarpum*, *D. monticola*, *D. moschatum*, *D. nobile*, *D. plicatile*, *D. transparens* the mentum is conical shaped. Mentum is rounded in *D. amplum*, *D. chrysanthum*, *D. denneanum*, *D. densiflorum*, *D. fimbriatum*, *D. moniliforme*, *D. polyanthum*, *D. porphyrochilum*, *D. rotundatum*. Mentum is saccate in *D. anceps* and *D. fuscescens*, subglobose in *D. crepidatum* and *D. gibsonii*, urceolate in *D. bicameratum*, spur-like in *D.*

darjeelingense and long, funnel shaped in *D. longicornu* (Fig. 2).

j. Petals

Shape and size of petals vary in all species of *Dendrobium*. Shape of petals varies from ovate, elliptic, obovate, oblong, lanceolate, linear-lanceolate, oblong-lanceolate, ovate-lanceolate, oblong-elliptic, elliptic-obovate, oblong-ovate to ovate-orbicular. The apex of petals varies in all species of *Dendrobium*. The apex of petal is acute, subacute, obtuse, acuminate, emarginate, rounded and cuspidate. The margin of petal is entire and surface is glabrous in all species of *Dendrobium*. The size of petals ranges from 0.4-5.0 cm in length and 0.1-3.3 cm in width. No. of veins ranges from 3-7 in different species of *Dendrobium* (Table 5).

k. Lip

The lip is attached to the column foot. The lip varies greatly in shape, size, and margins in all species of *Dendrobium*. The morphological characters of lip are of utmost importance in taxonomy to distinguish the genus at the infraspecific level. The lip characters are considered as most distinguishing characters for the delimitation of species of *Dendrobium*. The lip is simple or tri-lobed. There is variation in shape of simple lip, midlobe and side lobes in trilobed lip and presence or absence of ornamentation in lip. The lip size varies from 0.4-6.00 cm in length and 0.25-3.5 in width in different species of *Dendrobium*. There is variation in the ornamentation on the lip surface of *Dendrobium* (Table 6). The lip can be distinguished into following types on the basis of structure of simple and trilobed lip of *Dendrobium* (Fig. 3).

Type A. Lip simple without side lobes. There is variation in shape, margin and apex of lip in different species of *Dendrobium*. The following

types are differentiated based on shape, margin and apex of lip.

a. Lip orbicular-oblong, obovate and subglobular, margin denticulate and fimbriate with apex rounded in *D. chrysanthum*, *D. polyanthum*, *D. fimbriatum* and *D. moschatum*.

b. Lip orbicular, suborbicular and subreniform, margin ciliolate, fimbriate and lacerate with apex emarginated and retuse in *D. crepidatum*, *D. aphyllum*, *D. chryseum*, *D. denneanum*, *D. densiflorum* and *D. gibsonii*.

c. Lip trowel-shaped and elliptic, margin undulate and entire with apex acute and subacute in *D. heterocarpum* and *D. porphyrochilum*.

d. Lip ovate-oblong, margin entire with apex obtuse in *D. nobile*.

Type B. Lip trilobed with side lobes and midlobe. There is variation in shape, margin and apex of midlobe of lip in different species of *Dendrobium*. Following types are differentiated on the basis of shape, margin and apex of midlobe of lip.

a. Lip oblong-ovate, obovate, oblong-lanceolate, subelliptic and elliptic-obovate, margin crenulate, lacerate, undulate and entire with apex acute in *D. darjeelingense*, *D. denudans*, *D. eriiflorum*, *D. moniliforme*, *D. monticola* and *D. transparens*.

b. Lip oblong-ovate and broadly triangular, margin undulate and fimbriate-lacerate with apex obtuse in *D. amoenum* and *D. longicornu*.

c. Lip pandurate, margin crenulate with apex mucronate in *D. amplum*.

d. Lip ovate-oblong, obovate-oblong and ovate, margin undulate with apex emarginated and retuse in *D. fuscescens*, *D. rotundatum* and *D. formosum*.

e. Lip oblong-obovate, subovate and broadly triangular, margin undulate and entire with apex truncate and subtruncate in *D. fugax*, *D. plicatile* and *D. bicameratum*.

f. Lip wedge-shaped, margin crenulate with apex bilobed in *D. anceps*.

Ornamentation on lip

Ornamentation on lip varies in different species of *Dendrobium*. Following types of ornamentation are found in lip of *Dendrobium*.

Type i. Without ornamentation on disc of lip: *D. moschatum*.

Type ii. Ridges on disc of lip: *D. chrysanthum*, *D. crepidatum*, *D. denudans*, *D. eriiflorum*, *D. formosum*, *D. longicornu* and *D. porphyrochilum*.

Type iii. Lamellae on disc of lip: *D. amplum*, *D. fugax*, *D. fuscescens*, *D. monticola* and *D. plicatile*.

Type iv. Callus on disc of lip: *D. bicameratum*, *D. moniliforme* and *D. polyanthum*.

Type v. Clawed at base of lip: *D. chryseum*, *D. denneanum*, *D. densiflorum*, *D. fimbriatum* and *D. nobile*.

Type vi. Sub-villous disc of lip: *D. amoenum*.

Type vii. Papillary hairs on disc of lip: *D. aphyllum*, *D. gibsonii* and *D. heterocarpum*.

Type viii. Central distinct veins from base to apex of lip: *D. transparens*.

Type ix. Shallow depression ending near apex of lip: *D. anceps*.

Type x. Keels from base to apex of lip: *D. darjeelingense* and *D. rotundatum*.



Fig. 1. Habit of *Dendrobium* species.

1. *D. anceps* 2. *D. fugax* 3. *D. plicatile* 4. *D. amoenum* 5. *D. aphyllum* 6. *D. bicameratum* 7. *D. chrysanthum* 8. *D. chryseum* 9. *D. crepidatum* 10. *D. denneanum* 11. *D. densiflorum* 12. *D. fimbriatum* 13. *D. gibsonii* 14. *D. heterocarpum* 15. *D. moniliforme*.

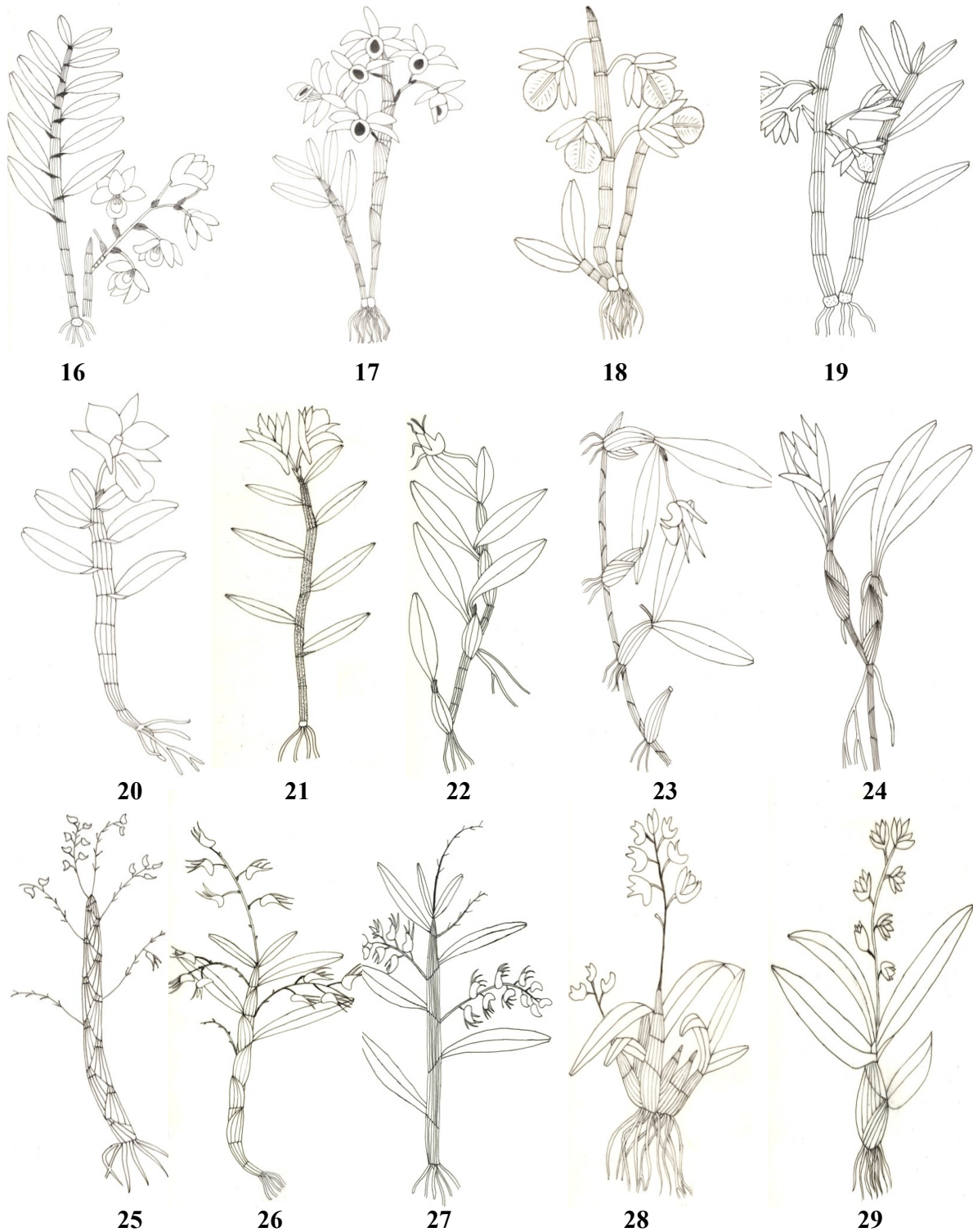


Fig. 1 contd.

16. *D. moschatum* 17. *D. nobile* 18. *D. polyanthum* 19. *D. transparens* 20. *D. formosae* 21. *D. longicornu* 22. *D. amplum* 23. *D. fuscescens* 24. *D. rotundatum* 25. *D. darjeelingense* 26. *D. denudans* 27. *D. eriiflorum* 28. *D. monticola* 29. *D. porphyrochilum*.

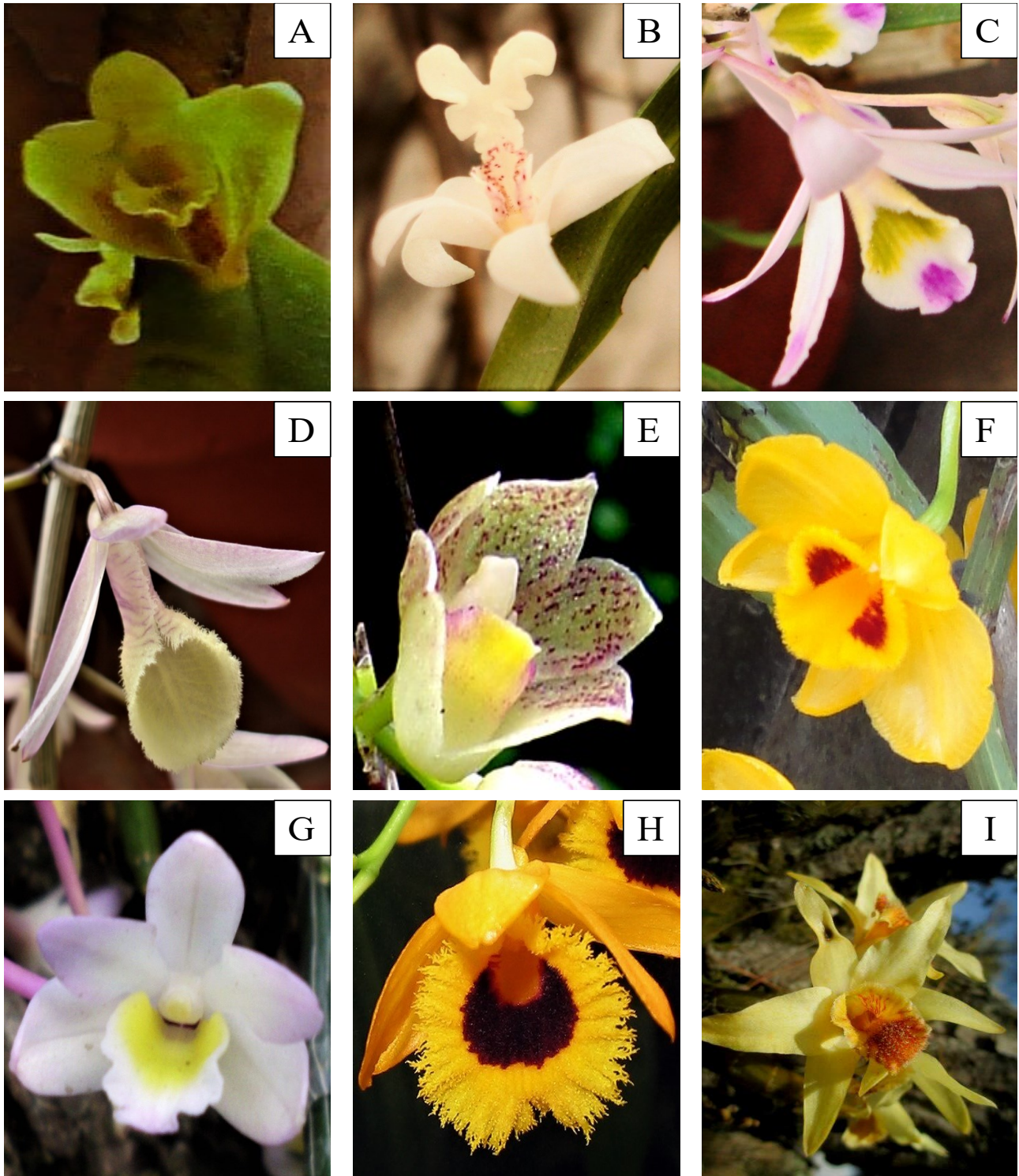
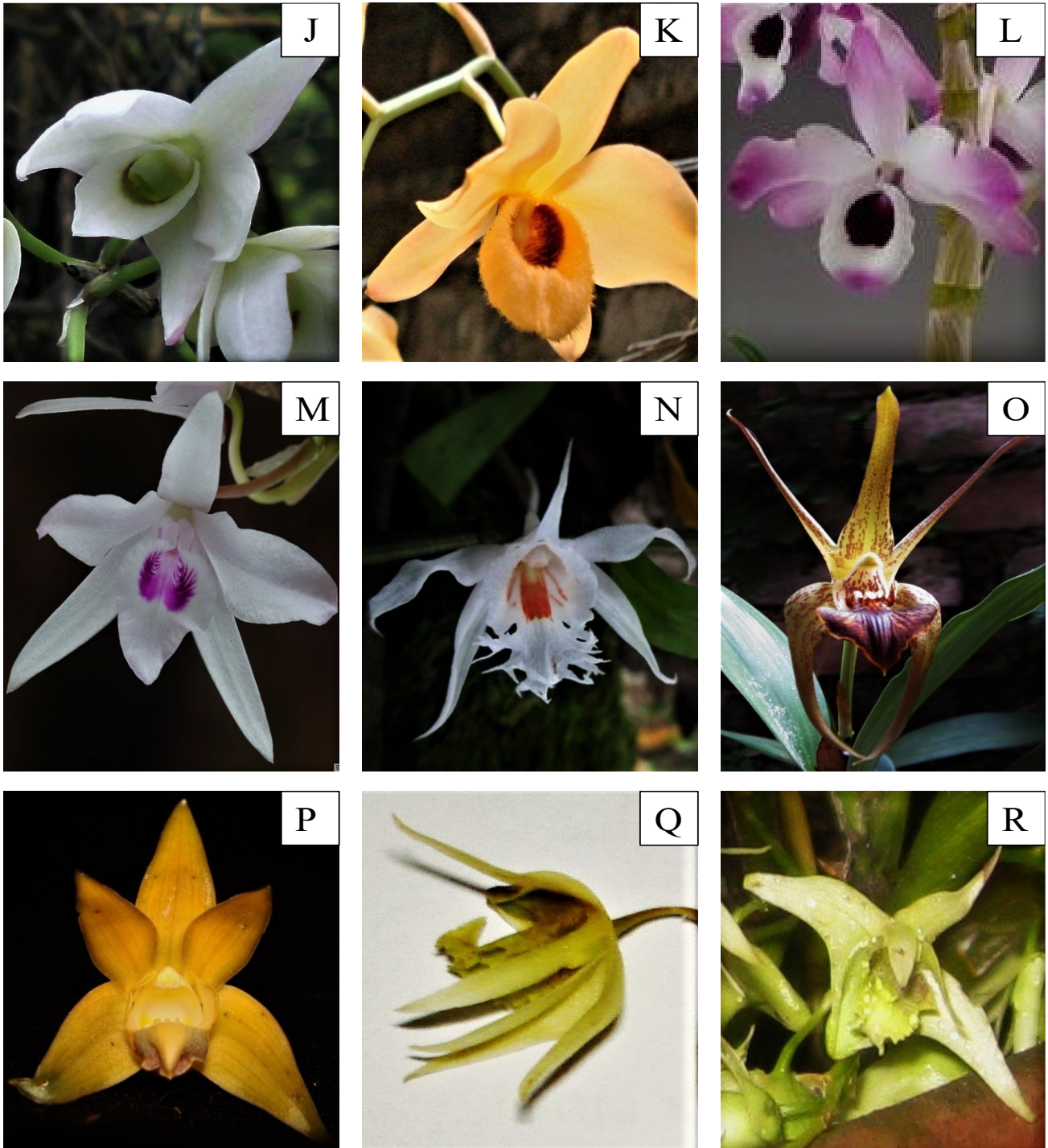


Plate 1. Flowers of *Dendrobium* species

A. *D. anceps*; B. *D. fugax*; C. *D. amoenum*; D. *D. aphyllum*; E. *D. bicameratum*; F. *D. chrysanthum*; G. *D. crepidatum*; H. *D. fimbriatum* var. *oculatum*; I. *D. heterocarpum*.

**Plate 1. contd.**

J. *D. moniliforme*; K. *D. moschatum*; L. *D. nobile*; M. *D. transparens*; N. *D. longicornu*; O. *D. amplum*; P. *D. rotundatum*; Q. *D. denudans*; R. *D. eriiflorum*.

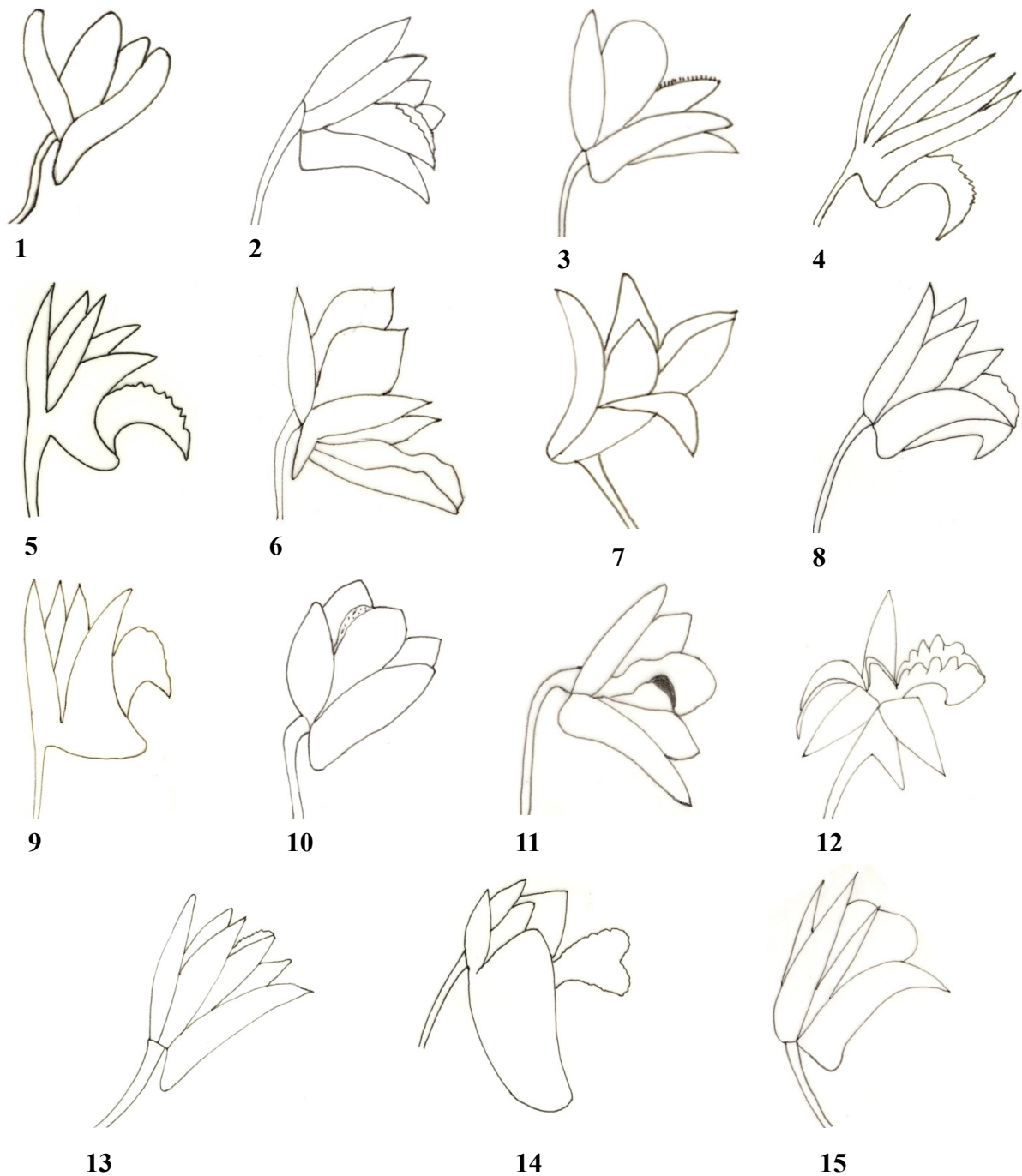
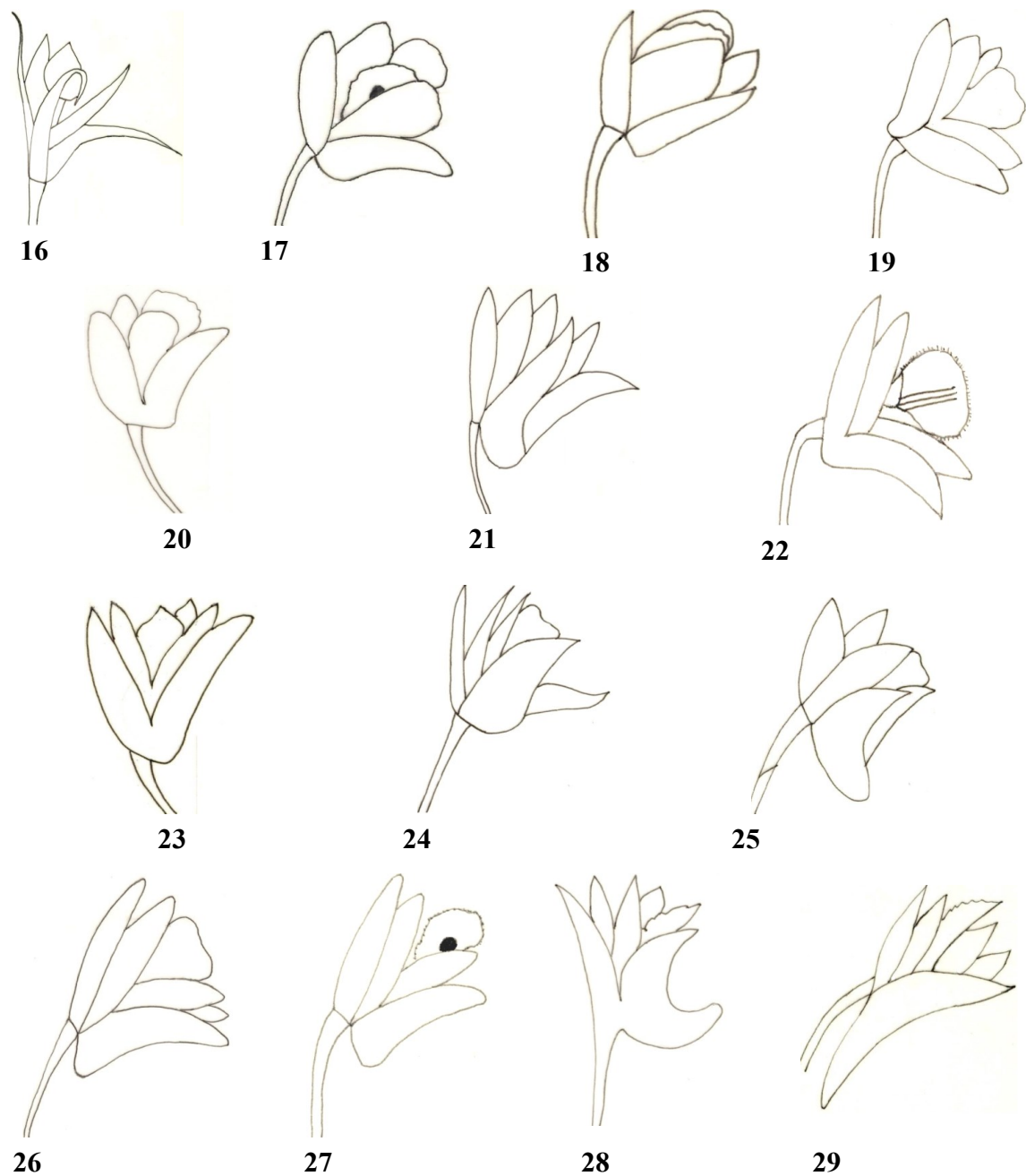


Fig. 2. Mentum of *Dendrobium* species.

1. *D. amoenum* ; 2. *D. aphyllum*; 3. *D. chryseum*; 4. *D. denudans*; 5. *D. eriiflorum*; 6. *D. formosum*; 7. *D. fugax*; 8. *D. heterocarpum*; 9. *D. monticola*; 10. *D. moschatum*; 11. *D. nobile* ;12. *D. plicatile*; 13. *D. transparens*; 14. *D. anceps*; 15. *D. fuscescens*.

**Fig. 2. contd.**

16. *D. amplum*; 17. *D. chrysanthum*; 18. *D. denneanum*; 19. *D. densiflorum*; 20. *D. fimbriatum*; 21. *D. moniliforme*; 22. *D. polyanthum*; 23. *D. porphyrochilum*; 24. *D. rotundatum*; 25. *D. bicameratum*; 26. *D. crepidatum*; 27. *D. gibsonii*; 28. *D. darjeelingense*; 29. *D. longicornu*.

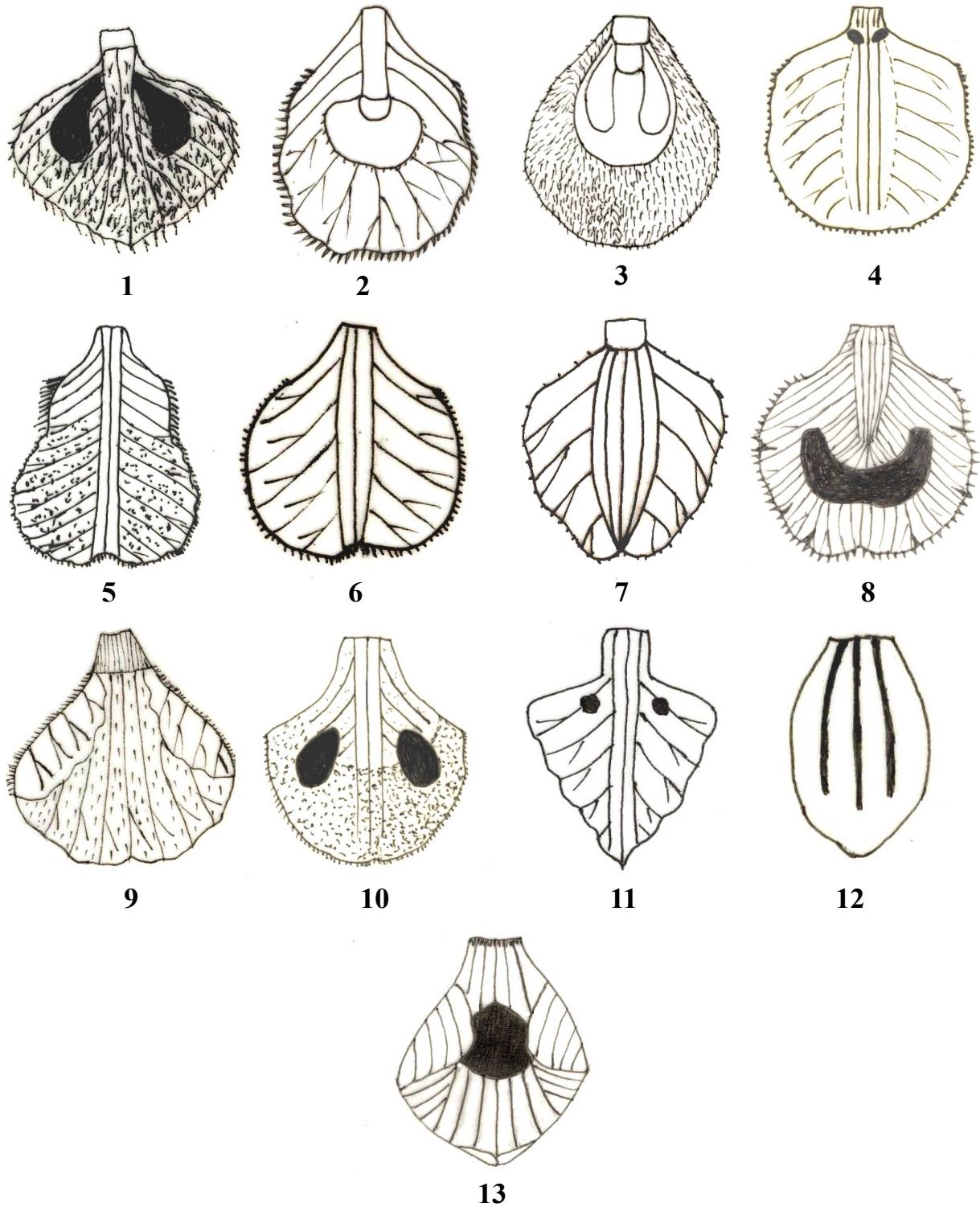
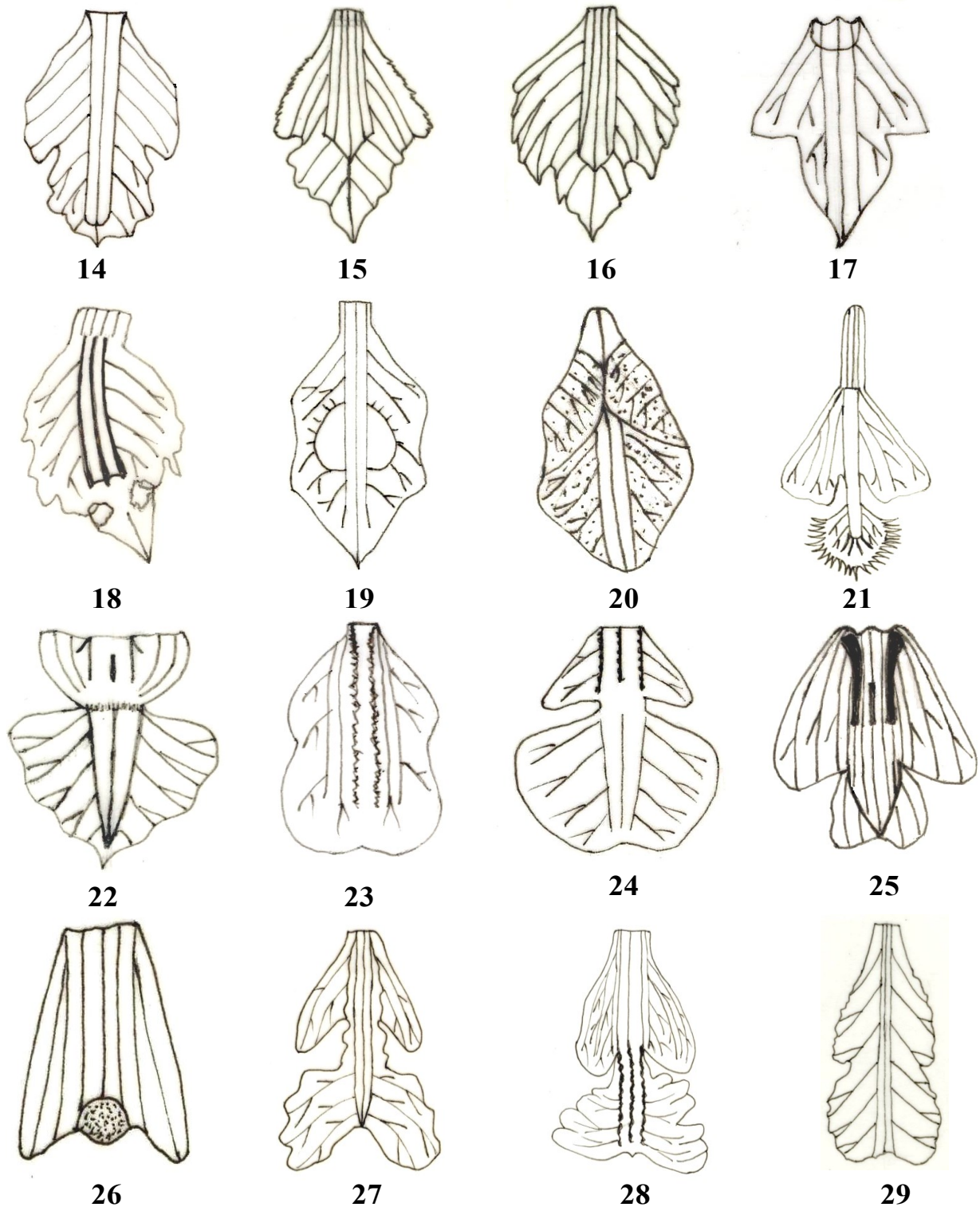


Fig. 3. Lip of *Dendrobium* species.

1. *D. chrysanthum*; 2. *D. fimbriatum*; 3. *D. moschatum*; 4. *D. polyanthum*; 5. *D. aphyllum*; 6. *D. chryseum*; 7. *D. crepidatum*; 8. *D. denneanum*; 9. *D. densiflorum*; 10. *D. gibsonii*; 11. *D. heterocarpum*; 12. *D. porphyrochilum*; 13. *D. nobile*.

**Fig. 3. contd.**

14. *D. darjeelingense*; 15. *D. denudans*; 16. *D. eriiflorum*; 17. *D. moniliforme*; 18. *D. monticola*; 19. *D. transparens*; 20. *D. amoenum*; 21. *D. longicornu*; 22. *D. amplum*; 23. *D. formosum*; 24. *D. fuscescens*; 25. *D. rotundatum*; 26. *D. bicameratum*; 27. *D. fugax*; 28. *D. plicatile*; 29. *D. anceps*.

1. Column, Anther and Pollinia

Column is sub-terete to clavate, straight or curved in all species of *Dendrobium*. Column varies from 0.1 - 2.9 cm in length in different species of *Dendrobium*. Longer column is found in *D. longicornu*, *D. amplum*, *D. formosum*, *D. rotundatum*, *D. aphyllum* and *D. fuscescens*, shorter in remaining species of *Dendrobium*. Filaments are fused along the style length to form column. The base of column extends ventrally to form column foot. Lateral sepals are attached to column foot to form mentum. Column foot varies from 0.14 -2.8 cm in length in different species of *Dendrobium*. Column foot is longer in *D. longicornu*, *D. formosum*, *D. amplum*, *D. anceps* and *D. transparens* and shorter in remaining species of *Dendrobium*. Column foot with 2 calli at lower end with thickened line is present in *D. amoenum*, at right angle to column in *D. amplum* and *D. eriiflorum*, bilocular in *D. bicameratum*, margin with fine papillose in *D. monticola*, transverse ridge at lower end in *D. chrysanthum*, slightly winged in *D. rotundatum* and simple in remaining species. The anther is inserted on filament near stigma base with base of operculum. A single fertile anther is present at apex of column and attached by short connective on clinandrium. The anther is two chambered, oblong or bilobed, rounded, emarginated or retuse at the apex, surface glabrous or papillous, yellow or white, anther cap entire, dentate, erose, hairy. The anther contains four pollinia in two pairs. Pollinia are oblong or ellipsoid, usually subequal. They are mostly yellow and pale-yellow in few species. The caudicle or viscidia is absent in pollinia.

The stigma is three-lobed, two lateral lobes are fertile while the posterior lobe is modified into rostellum. The rostellum is small, lamellate, narrow or wide. The stigmatic cavity is entire in

most *Dendrobium* species but bilobed in *D. amplum*, *D. formosum* and *D. porphyrochilum* and four-lobed in *D. densiflorum*.

Keys to species of *Dendrobium* Sw. of Nepal Himalaya

- 1a. Plants with pseudobulbs ----- 2
 1b. Plants with cane-like stems ----- 11
 2a. Plants small, stems or pseudobulbs with few internodes, leaves 2 or 3 to many, leaf deciduous or persistent, leafy throughout or at apical part, flowers small, few to many arising apically or laterally, lip simple or trilobed ----- 3
 2b. Pseudobulbs with one or few internodes, leaves one or two, flower solitary or two in between leaves or at apex of pseudobulb, flower long-lived or ephemeral ----- 7
 3a. Plants with elongate stems ----- 4
 3b. Plants with cylindrical or elongate pseudobulbs ----- 6
 4a. Stems 4-15 cm long, deciduous leaves, 8-many flowered, lip trilobed, obovate, disc with 3 ridges with triangular apex, margin of sidelobes lacerate -----
 -----26. *D. denudans*
 4b. Stems 7-21 cm long, leaves deciduous or persistent, flowers more than ten, lip trilobed, oblong-ovate, margin of sidelobes entire or pectinate-serrate ----- 5
 5a. Stems 20-21 cm long, leaves deciduous, flowers 16-20, lip with 3 keels from base to apex, side lobes margin entire -----25. *D. darjeelingense*
 5b. Stems 7-12 cm high, leaves persistent, flowers many, lip with a mesial ridge from base to apex, side lobes margin pectinate-serrate -----27. *D. eriiflorum*
 6a. Plants 1-2 cm high, pseudobulb cylindrical, flowers 7-12, lip simple with 3 obscure ridges of variable lengths from base to apex, margin entire -----
 ----- 29. *D. porphyrochilum*
 6b. Plants 4-6 cm high, pseudobulb elongate, flowers 3-8, lip 3-lobed with irregular, orbicular and triangular apex, margin inciso-serrate -----
 ----- 28. *D. monticola*
 7a. Pseudobulbs with one internode, leaves two, flower solitary in between leaves, flower long-lived -----8

- 7b. Pseudobulbs with few internodes, leaves one, one to three flowers at apex of pseudobulb, flower ephemeral or long-lived- 10
- 8a. Flowers 2.0-3.4 cm across, midlobe of lip suborbicular to subreniform ----- 9
- 8b. Flowers 7.5 cm across, midlobe of lip subrhomboid, disc with 3 parallel mesial ridges -----
-----**22. *D. amplum***
- 9a. Flowers 5.0 cm across, midlobe of lip suborbicular, disc with 3 crenulate lamellae between side lobes ----- **23. *D. fuscescens***
- 9b. Flowers 3.4 cm across, midlobe of lip subreniform, disc with a triangular thickened keel ---
-----**24. *D. rotundatum***
- 10a. Leaf 14.0-16.0 x 2.0-2.5 cm, flower white with pink purple spots, lip oblong ovate, 1.3 x 0.6 cm -----
-----**2. *D. fugax***
- 10b. Leaf 10.0-20.0 x 3.0-5.0 cm, flower milky yellow tinged with purplish red spots, lip subovate, 1.5 x 0.8 cm -----**3. *D. plicatile***
- 11a. Stems compressed, flattened with fleshy and equitant leaves throughout, flowers small, 1.2 cm across, solitary on the leafy stems, lip simple, densely pubescent except at basal part -----
----- **1. *D. anceps***
- 11b. Stems tufted, erect, cylindrical, clavate, subclavate, pendulous, leaves membranous, subleathery or leathery, persistent or deciduous, flower small to large, lip simple or tri-lobed -----12
- 12a. Stems erect, suberect, stout, cylindrical, clavate, subclavate, leaves membranous, leathery, persistent or deciduous, inflorescence axillary or lateral, lip tri-lobed or simple----- 13
- 12b. Stems pendulous, cylindrical, leaves membranous, fleshy, leathery, subleathery, deciduous, persistent, inflorescence lateral or axillary, lip simple or trilobed ----- 24
- 13a. Stems clavate, subclavate, leaves membranous, leathery, deciduous, persistent, inflorescence lateral, axillary, one-many flowered, flower 1.0-4.5 cm across, lip simple, trilobed ----- 14
- 13b. Stems erect, suberect, cylindrical, stout, fractiflex, leaves membranous, leathery, deciduous, persistent, inflorescence lateral or axillary, 1-12 flowered, flower 2.5-10.0 cm across, lip simple or trilobed ----- 17
- 14a. Stems subclavate, leaves leathery, deciduous, inflorescence axillary, 1-3 flowered, flower 4.5 cm across, pale yellow, lip simple -- **14. *D. heterocarpum***
- 14b. Stems clavate, leaves membranous, leathery, deciduous, persistent, inflorescence lateral, axillary, 4-many flowered, flower 1.0-4.0 cm across, lip simple, trilobed ----- 15
- 15a. Stems clavate, leaves membranous, leathery, persistent, deciduous, inflorescence lateral, subterminal, 4-6 flowered, flower 1.0-5.5 cm across, lip simple, trilobed ----- 16
- 15b. Stems clavate, 4-angled with 3-5 leaves at apex, leaves leathery, persistent, inflorescence axillary, many flowered, flower 2.5 - 4.0 cm across, flower light yellow, lip simple -----**11. *D. densiflorum***
- 16a. Stems clavate, leaves membranous, deciduous, inflorescence lateral, 4-6 flowered, flower 1.0 cm across, flower yellow with dull red in circular heads, lip trilobed -----**6. *D. bicameratum***
- 16b. Stems clavate, leaves leathery, persistent, inflorescence subterminal, 5 flowered, flower 4.0-5.5 cm across, flower dark yellow, lip simple, tomentose with dark, purple reniform patch -**10. *D. denneanum***
- 17a. Stems erect, stout, fractiflex, leaves leathery, persistent, inflorescence lateral, axillary, terminal, subterminal, 1-12 flowered, flowers 3.5-19.0 cm across, lip simple, trilobed----- 18
- 17b. Stems erect, suberect, cylindrical, leaves membranous, leathery, deciduous, persistent, inflorescence lateral, axillary, 1-8 flowered, flowers 1-6 cm across, lip simple, trilobed ----- 21
- 18a. Stems erect, stout, fractiflex, leaves leathery, persistent, inflorescence axillary, lateral or terminal, 1-5 flowered, flower 3.5-10.0 cm across, lip trilobed -
----- 19
- 18b. Stems erect, stout, leaves leathery, persistent, inflorescence lateral, subterminal, 1-12 flowered, flowers 4.0-7.0 cm across, lip simple, trilobed ----- 20
- 19a. Stems fractiflex covered by short coarse deciduous black hairs, leaves leathery, persistent, inflorescence axillary, 1-3 flowered, flower 3.5 cm across, white with orange yellow lip, lip trilobed, margin fimbriate----- **21. *D. longicornu***
- 19b. Stems stout, young stem clothed in fine black hairs, inflorescence lateral or terminal, 1-5 flowered, flower 8.0-10.0 cm across, lip trilobed, margin

- undulate disc with two yellow tuberculate ridges, margin undulate ----- **20.D. formosum**
- 20a. Inflorescence 8-12 flowered, flower 6.5-7.0 cm across, lip with purplish-brown blotches on either sides, margin cucullate and fimbriate -----
- **16. D. moschatum**
- 20b. Inflorescence 1-4 flowered, flower 6.0-7.0 cm across, lip with large purple blotch in the center, margin cucullate and entire----- **17. D. nobile**
- 21a. Stems erect, cylindrical, leaves membranous, leathery, deciduous, inflorescence lateral, axillary, 1-3 flowered, flowers 2.5-3.4cm across, lip simple, trilobed ----- 22
- 21b. Stems erect, suberect, leaves leathery, deciduous, persistent, inflorescence, lateral, axillary, 2-8 flowered, flowers 4.0-6.0 cm across, lip simple ---
- 23
- 22a. Inflorescence lateral, 1-3 flowered, flower 2.5 cm across, lip trilobed, white with yellowish green central spot near the base of mid-lobe, margin entire -----
- **15. D. moniliforme**
- 22b. Inflorescence axillary, 2-3 flowered, flower 3.4 cm across, lip trilobed, white with purple patch at middle, margin fimbriate ----- **19. D. transparens**
- 23a. Stems erect, leaves leathery, deciduous, inflorescence lateral, 2-4 flowered, flowers 4.0-6.0 cm across, lip with 2-lobed purple blotch, margin denticulate ----- **8. D. chryseum**
- 23b. Stems suberect, leaves leathery, persistent, inflorescence axillary, 6-8 flowered, flowers 4.5-5.5 cm across, lip deep orange-yellow with dark purple blotch on the disc, margin deeply fimbriate -----
- **12.D. fimbriatum**
- 24a. Leaves membranous, fleshy, deciduous, persistent, inflorescence lateral, axillary, 1-4 flowered, flowers 2.0-5.0 cm across, lip simple, trilobed ----- 25
- 24b. Leaves leathery, subleathery, deciduous, persistent, inflorescence lateral, 2-12 flowered, flowers 2.0 -5.0 cm across, lip simple ----- 28
- 25a. Leaves membranous, deciduous, persistent, inflorescence lateral, axillary, 1-4 flowered, flowers 2.0-5.0 cm across, lip simple, trilobed ----- 26
- 25b. Leaves fleshy, deciduous, inflorescence lateral, 1-3 flowered, flowers 4.0 cm across, lip simple, pale yellow or cream with purple veins at base -----
- **5.D. aphyllum**
- 26a. Leaves membranous, deciduous, persistent, inflorescence lateral, 2-4 flowered, flowers 2.0-5.0 cm across, lip simple -----27
- 26b. Leaves membranous, deciduous, inflorescence axillary, 1-3 flowered, flowers 2.0-3.0 cm across, lip trilobed, white with purplish blotch at apex and green yellow at centre, margin undulate -----
- **4.D. amoenum**
- 27a. Leaves membranous, persistent, inflorescence lateral, 2-4 flowered, flowers 5.0 cm across, lip simple, golden yellow with purplish red blotch on each side, margin denticulate -----
- **7. D. chrysanthum**
- 27b. Leaves membranous, deciduous, inflorescence lateral, 2-3 flowered, flowers 2.0-5.0 cm across, lip simple, pinkish yellow at apex and white at base with purple veins, margin denticulate -----
- **18. D. polyanthum**
- 28a. Leaves leathery, persistent, inflorescence lateral, 6-12 flowered, flowers 3.0 cm across, lip simple, orange yellow with a rounded deep purple blotch on each side, margin fimbriate -----
- **13.D. gibsonii**
- 28b. Leaves subleathery, deciduous, inflorescence lateral, 2-3 flowered, flowers 2.0-5.0 cm across, lip simple, pale purplish pink above middle, yellow below middle, margin undulate -----
- **9. D. crepidatum.**

Table 1: Distribution range and comparative morphological characters in *Dendrobium*

S.N.	Taxa	Altitude (m)	Length of Stem/Pseudobulb (cm)	Length of Internode (cm)	Leaf texture	Leaf size l x w (cm)	Inflorescence position	Length of peduncle (cm)	Length of rachis (cm)	No. of flowers/ inflorescence	Length of Pedicel with ovary (cm)	Flower size (cm)	Colour of Flower	Pollinia	
														Shape	Size (mm)
1	<i>D. amoenum</i>	200 - 2000	24.0-75.0	2.5-3.0	Membranous	4.4-10.9 x 0.6-1.8	Axillary	0.6	Absent	Two-three	2.8-3.0	2.0-3.0	White with tinged of purple	Elliptic	1.45 x 1.25
2	<i>D. amplum</i>	1300-2100	60.0-64.0	3.0-5.5	Coriaceous	9.0-18.0 x 2.2-5.0	Terminal	2	Absent	one	5	7.5	Yellowish brown, lip deep purple with bronze edges	Oblong	2.4 x 2.0
3	<i>D. anceps</i>	200-1400	15.0-56.0	2.0-2.5	Fleshy	2.5-3.5 x 0.8-1.2	Axillary	0.2	Absent	one	0.6	1.2	Yellowish green with pink lines	Oblong lanceolate	1.0 x 0.8
4	<i>D. aphyllum</i>	200-1500	20.0-50.0	2.5-3.0	Fleshy	4.0-6.0 x 1.5-3.0	Axillary	0.2	Absent	one-three	3.0	4	White with pale purplish red	Elliptic	2.3 x 2.3
5	<i>D. bicameratum</i>	1400-2400	10.0-26.0	1.7-3.0	Membranous	5.0-8.0 x 1.2-2.5	Lateral or subterminal	0.5	0.3-0.8	four-six	0.8	1	Yellow with dull red in circular heads	Oblong	1.2 x 0.7
6	<i>D. chrysanthum</i>	1300-2000	25.0-70.0	3.0-3.2	Membranous	8.5-20.0 x 2.5-4.5	Lateral	0.1	Absent	two-four	7	5	Golden yellow with purplish red blotch	Oblong	1.6 x 1.2
7	<i>D. chryseum</i>	1200-2100	25.0-50.0	2.0-5.0	Coriaceous	10.0-14.0 x 2.0-4.0	Lateral	4.0-6.0	3.0-10.0	two-four	3.5-5.0	4.0-6.0	Yellow orange with purple blotch	N.O.	N.O.
8	<i>D. crepidatum</i>	600-1400	14.0-20.0	2.0-2.5	Subleathery	5.5-9.5 x 1.0-1.6	Lateral	0.3	Absent	two-three	3.5	2.5	White with pale purplish pink	Oblong	2.0 x 1.6
9	<i>D. darjeelingense</i>	1500-2000	20.0-21.0	1.5-2.0	Membranous	6.0 x 1.2	Terminal or axillary	1-1.5	4	sixteen-twenty	0.4	1	Creamy with light greenish tinge	Oblong	0.5 x 0.2
10	<i>D. denneanum</i>	600-2500	40.0-65.0	2.0-3.0	Coriaceous	8.5- 12.0 x 1.5-2.5	Subterminal	1.5-2.0	7.0-12.0	five	2.0-4.0	4.0-5.5	Dark yellow	Ovate oblong	2.0 x 1.8
11	<i>D. densiflorum</i>	900-1500	20.0-40.0	2.5-3.8	Coriaceous	10.0-16.0 x 2.0-3.5	Axillary	4	10 to 12	more than ten	2.5-3.0	2.5-4.0	Light Yellow	Ovate oblong	1.6 x 1.1
12	<i>D. denudans</i>	1000-2200	4.0-15.0	1.0-2.0	Membranous	6.0-10.0 x 1.0-1.5	Axillary	2.5-3.0	5.0-7.0	eight-many	0.6-0.9	1.0-2.0	Creamy to pale green with red-purple lines	Oblong	1.1 x 1.0
13	<i>D. eriiflorum</i>	1500-2100	7.0-12.0	1.6-2.0	Membranous	4.0-6.8 x 0.3-0.6	Terminal or axillary	2.5-3.0	3.0-10.0	more than ten	0.7	1.5	Light greenish white	Oblong lanceolate	1.1 x 1.0

14	<i>D. fimbriatum</i>	500-1000	55.0-70.0	2.5-5.0	Coriaceous	12.5-14.0 x 1.4-3.5	Axillary	2	5.0-8.0	six-eight	2.5-3.0	4.5-5.5	Orange-yellow	Oblong	2.0 x 1.5
15	<i>D. formosum</i>	500-1000	18.0-21.0	1.8-2.0	Coriaceous	5.5-8.0 x 2.0-2.8	Terminal or lateral	4.0-4.5	Absent	one-five	5.5	8.0-10.0	White with attractive yellow inner lip	Oblong	2.5 x 1.0
16	<i>D. fugax</i>	500-1600	21.0-29.0	2.0-3.0	Coriaceous	14.0-16.0 x 2.0-2.5	Terminal	1	Absent	one-two	0.6	2	White sprinkled with pink-purple spots	Oblong	1.1 x 1.0
17	<i>D. fuscescens</i>	600-1800	42.0-46.0	3.0-4.0	Coriaceous	7.5-9.0 x 1.7-2.0	Terminal	0.3-0.4	Absent	one	2.5-3.0	4.5-5.0	Purplish-brown	N.O.	N.O.
18	<i>D. gibsonii</i>	900-2000	25.0-48.0	2.0-3.0	Coriaceous	9.0-18.5 x 2.0-4.0	Lateral	1.0-2.0	9.0-13.0	six-twelve	4.7	3	Orange yellow with a rounded deep purple blotch on each side	Oblong	2.0 x 1.5
19	<i>D. heterocarpum</i>	900-2130	15.0-25.0	2.0-3.0	Coriaceous	7.0-12.0 x 1.0-2.0	Axillary	0.4	Absent	one-three	2.5	4.5	Pale yellow	Oblong	2.0 x 1.6
20	<i>D. longicornu</i>	1300-2900	13.0-36.0	2.5-3.0	Coriaceous	4.0-6.0 x 0.7-1.6	Axillary	0.5	Absent	one-three	2.5	3.5	White with orange yellow lip	Oblong elliptic	2.0 x 1.4
21	<i>D. moniliforme</i>	1700-2500	15.0-25.0	1.5-3.0	Membranous	3.5-8.0 x 0.5-1.3	Axillary	0.3	0.9	one-three	1.2	2.0-2.5	White with yellowish green spot	Oblong	1.1 x 1.2
22	<i>D. monticola</i>	1700-2200	4.0-6.0	1.0-1.5	Membranous	2.5-3.0 x 0.4-0.6	Terminal	1.5	2.5	three-eight	0.6	1.5	White with purplish red stripes	N.O.	N.O.
23	<i>D. moschatum</i>	200-1200	78.0-150.0	3.0-4.5	Coriaceous	7.5-14.5 x 1.5-5.5	Lateral	3.5-5.0	16.0-26.0	eight-twelve	5	6.5-7.0	Pale yellow with purplish brown blotches on lip	Oblong	2.0 x 1.6
24	<i>D. nobile</i>	400-1500	25.0-40.0	2.0-2.5	Coriaceous	8.0-13 x 1.5-2.5	Lateral	0.5-1.5	Absent	one-four	3.5-4.0	6.0-7.0	White at base, mauve above	Oblong	2.0 x 1.5
25	<i>D. plicatile</i>	500-2400	20.0-28.0	0.7-0.8	Coriaceous	10.0 -20.0 x 3.0-5.0	Terminal	0.7	Absent	one-three	0.6	2	Milky yellow tinged with purplish red spots	N.O.	N.O.
26	<i>D. polyanthum</i>	400-1400	10.0-25.0	1.5-2.0	Membranous	7.0-10.0 x 2.0-3.0	Lateral	0.2	Absent	two-three	2.0-2.5	6	Pink-purple	Ellipsoid	2.2 x 2.5
27	<i>D. porphyrochilum</i>	1800-2500	1.0-2.0	0.5	Membranous	2.5-5.0 x 0.5-0.8	Terminal	3	4.0-5.0	seven-twelve	0.7	0.8-1.0	Creamy or yellowish green	N.O.	N.O.
28	<i>D. rotundatum</i>	1300-2500	40.0-48.0	2.5-5.0	Coriaceous	4.0-13.5 x 1.2-2.8	Terminal	0.5	Absent	one	2.5	3.4	Pale yellowish brown	Oblong	1.8 x 1.7
29	<i>D. transparens</i>	700-2100	24.0-40.0	2.0-2.5	Membranous	5.0-10.5 x 1.5-2.0	Axillary	0.1	Absent	eight-twelve	3.5	3.4	White with pink flooded	Oblong	1.0 x 0.8

Note: N.O. = Not observed.

Table 2: Comparative Bract Structures in *Dendrobium*

S.N.	Taxa	Length (cm)	Width (cm)	Shape	Veins	Apex	Distinguished Characters
1	<i>D. amoenum</i>	0.7	0.2	Ovate-lanceolate	3	Acute	Membranous, much shorter than ovary
2	<i>D. amplum</i>	1.7	0.5	Ovate-oblong	5	Acute	Large, scarious
3	<i>D. anceps</i>	0.35	0.2	Oblong	5	Obtuse	Much shorter than ovary
4	<i>D. aphyllum</i>	0.3	0.25	Ovate	1	Acute	Pale-white and membranous
5	<i>D. bicameratum</i>	0.6	0.4	Oblong-ovate	3	Acute	Sheathing the shortly stalked ovary
6	<i>D. chrysanthum</i>	0.4	0.25	Ovate-triangular	1	Acute	Small and scarious
7	<i>D. chryseum</i>	1.5-2.0	0.4-0.5	Ovate-lanceolate	5	Obtuse	Membranous
8	<i>D. crepidatum</i>	0.4	0.2	Ovate	1	Acute	Small, thin and membranous
9	<i>D. darjeelingense</i>	0.4	0.1	Triangular	3	Acute	Small and membranous
10	<i>D. denneanum</i>	2	0.6	Oblong	7	Acute	Large and membranous
11	<i>D. densiflorum</i>	1.9	1	Oblong	7	Obtuse	Large, membranous, twisted, margin revolute
12	<i>D. denudans</i>	0.3	0.15	Lanceolate	1	Acute	Minute and membranous
13	<i>D. eriiflorum</i>	0.4	0.15	Ovate-lanceolate	1	Acuminate	Minute and membranous
14	<i>D. fimbriatum</i>	0.4	0.3	Ovate-triangular	5	Acute	Small and membranous
15	<i>D. formosum</i>	0.5	0.2	Ovate	5	Subacute	Much shorter than ovary and sheathing
16	<i>D. fugax</i>	1	1.2	Triangular	1	Acute	Small, membranous
17	<i>D. fuscescens</i>	1	0.5	Ovate-lanceolate	5	Acute	Small, scarious, shorter than pedicel with ovary
18	<i>D. gibsonii</i>	0.5-0.7	0.2-0.3	Lanceolate	5	Acute	Minute, membranous and cymbiform
19	<i>D. heterocarpum</i>	0.6	0.4	Ovate	3	Obtuse	Broad and convolute
20	<i>D. longicornu</i>	1.5	0.5	Ovate-lanceolate	5	Acute	Concave and hairy abaxially
21	<i>D. moniliforme</i>	0.6	0.3	Ovate	3	Acute	Pale white with brown spots
22	<i>D. monticola</i>	0.35	0.2	Ovate	1	Acute	Small and membranous
23	<i>D. moschatum</i>	1.5	0.7	Lanceolate	5	Obtuse	Leathery
24	<i>D. nobile</i>	0.5-0.9	0.4-0.6	Oblong-ovate	5	Obtuse	Scarious
25	<i>D. plicatile</i>	0.1	0.12	Triangular	1	Acute	Small and membranous
26	<i>D. polyanthum</i>	0.8	0.5	Ovate	1	Obtuse	Minute and membranous
27	<i>D. porphyrochilum</i>	0.2-0.4	0.1-0.12	Lanceolate	1	Acuminate	Minute, longer than pedicel with ovary
28	<i>D. rotundatum</i>	1	0.6	Ovate	5	Acute	Small, scarious
29	<i>D. transparens</i>	1.1	0.7	Lanceolate	5	Acute	Scarious, much shorter than stalked ovary

Table 3: Comparative Structure of Dorsal Sepals in *Dendrobium*

S.N.	Taxa	Length (cm)	Width (cm)	Veins	Shape	Apex	Distinguished characters
1	<i>D. amoenum</i>	2.4	0.7	5	Oblong-lanceolate	Obtuse	White with tinged of purple
2	<i>D. amplum</i>	4.7	0.7	10	Lanceolate	Acuminate	Yellowish brown with dark brown spots
3	<i>D. anceps</i>	0.5	0.4	5	Elliptic	Sub-acute	Erect, tip folded inward
4	<i>D. aphyllum</i>	2.8	0.8	5	Oblong-lanceolate	Sub-acute	White with pale purplish red lines
5	<i>D. bicameratum</i>	0.9	0.6	5	Ovate-oblong	Sub-acute	Concave, broad
6	<i>D. chrysanthum</i>	2.2	1.2	7	Elliptic	Obtuse	Concave, entire, incurve apical half
7	<i>D. chryseum</i>	2.5	0.9	5	Oblong-lanceolate	Subacute	Concolor yellow
8	<i>D. crepidatum</i>	1.4	0.7	5	Oblong-lanceolate	Obtuse	Entire, spotted (tinged with light purple)
9	<i>D. darjeelingense</i>	0.8	0.2	3	Lanceolate	Acuminate	Entire, creamy tinged with light green
10	<i>D. denneanum</i>	1.8	1	7	Oblong	Acuminate	Entire, dark yellow
11	<i>D. densiflorum</i>	2	1.1	7	Ovate-oblong	Obtuse	Light yellow
12	<i>D. denudans</i>	1.2	0.25	3	Linear-lanceolate	Acuminate	Creamy to pale green
13	<i>D. eriiflorum</i>	1.2	0.25	5	Lanceolate	Acuminate	Light greenish white
14	<i>D. fimbriatum</i>	2.4	1	5	Elliptic-oblong	Obtuse	Entire, light orange-yellow
15	<i>D. formosum</i>	4.2	1.2	7	Elliptic-oblong	Acuminate	Erect, slightly concave
16	<i>D. fugax</i>	1.3	0.4	5	Elliptic-oblong	Sub-acute	White sprinkled with pink-purple spots
17	<i>D. fuscescens</i>	2.8	0.8	10	Ovate-lanceolate	Acuminate	Purplish-brown
18	<i>D. gibsonii</i>	1.6	1	6	Elliptic	Obtuse	Entire, slightly incurved, base slightly zigzag
19	<i>D. heterocarpum</i>	2.8	0.7	5	Oblong-lanceolate	Sub-acute	Pale yellow
20	<i>D. longicornu</i>	2.5	0.7	7	Ovate-lanceolate	Acuminate	Keeled
21	<i>D. moniliforme</i>	1.5	0.5	5	Broadly lanceolate	Acute	Subfalcate
22	<i>D. monticola</i>	1	0.2	3	Lanceolate	Acuminate	White
23	<i>D. moschatum</i>	3.2	1.6	7	Oblong	Obtuse	Pale yellow
24	<i>D. nobile</i>	3.1	0.9	7	Oblong-lanceolate	Obtuse	White at base mauve above
25	<i>D. plicatile</i>	0.9	0.25	5	Ovate-lanceolate	Acuminate	Rolled inside, milky yellow tinged with purple red spots
26	<i>D. polyanthum</i>	2.2	0.6	5	Lanceolate	Sub-acute	Pink-purple
27	<i>D. porphyrochilum</i>	0.6	0.15	3	Lanceolate	Obtuse	Creamish-green
28	<i>D. rotundatum</i>	3	1	7	Ovate-lanceolate	Acute	Pale yellowish brown
29	<i>D. transparens</i>	3.2	0.5	5	Lanceolate	Obtuse	White with pink flooded

Table 4: Comparative Structure of Lateral Sepals in *Dendrobium*

S.N.	Taxa	Length (cm)	Width (cm)	Veins	Shape	Apex	Distinguished Characters
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1	<i>D. amoenum</i>	2.9	0.8	5	Lanceolate	Acute	Broader than dorsal sepal
2	<i>D. amplum</i>	4.6	0.7	10	Lanceolate	Acuminate	Falcate, broadly based
3	<i>D. anceps</i>	0.8	0.5	5	Elliptic	Obtuse	Tip folded inward, falcate, pink-spotted
4	<i>D. aphyllum</i>	2.9	0.7	5	Oblong-lanceolate	Subacute	White with pale purplish red lines
5	<i>D. bicameratum</i>	0.7	0.75	5	Triangular	Subacute	Concave
6	<i>D. chrysanthum</i>	2.2	1.1	7	Ovate-triangular	Obtuse	Concave, base broad and oblique, incurve apical half
7	<i>D. chryseum</i>	2.7	0.9	5	Oblong-lanceolate	Subacute	Concolor yellow
8	<i>D. crepidatum</i>	1.5	0.6	5	Ovate-oblong	Obtuse	Midrib thick, spotted (tinged with light purple)
9	<i>D. darjeelingense</i>	0.8	0.25	5	Ovate-lanceolate	Acute	Obliquely curved
10	<i>D. denneanum</i>	2.2	0.8	5	Oblong	Acuminate	Subfalcate
11	<i>D. densiflorum</i>	2.1-2.4	1.0-1.2	7	Oblong-elliptic	Obtusely acute	Light yellow
12	<i>D. denudans</i>	1.2	0.4	5	Lanceolate-triangular	Acuminate	Falcate
13	<i>D. eriiflorum</i>	1.2	0.3	5	Lanceolate	Acuminate	Falcate, broadly based
14	<i>D. fimbriatum</i>	2.4	1	5	Ovate-lanceolate	Obtuse	Small outgrowth at lower side of apex
15	<i>D. formosum</i>	4	1.6	7	Oblong-lanceolate	Acuminate	Subfalcate, keeled, spreading
16	<i>D. fugax</i>	1.4	0.5	5	Oblong-elliptic	Subacute	Adnate at base to form mentum
17	<i>D. fuscescens</i>	2.8	1.0	10	Ovate-lanceolate	Acuminate	Base broad, slightly falcate
18	<i>D. gibsonii</i>	1.6	0.9	5	Oblong	Obtuse	Slightly incurved, entire
19	<i>D. heterocarpum</i>	2.8	0.7	7	Lanceolate	Acute	Pale yellow
20	<i>D. longicornu</i>	5.5	1	7	Lanceolate	Acuminate	Adnate to form a long spur-like mentum, keeled, recurved
21	<i>D. moniliforme</i>	1.6	0.6	5	Lanceolate	Acute	Subfalcate
22	<i>D. monticola</i>	0.9	0.35	5	Falcate-lanceolate	Acute	Base broad, contracted above middle part
23	<i>D. moschatum</i>	3.2	1.6	7	Oblong	Acute	Pale yellow
24	<i>D. nobile</i>	3.2	0.8	7	Oblong-lanceolate	Acute	Base oblique, margin incurved slightly
25	<i>D. plicatile</i>	0.9	0.25	5	Ovate lanceolate	Acuminate	Obliquely ovate-lanceolate
26	<i>D. polyanthum</i>	2.3	0.5	5	Lanceolate	Subacute	Base oblique
27	<i>D. porphyrochilum</i>	0.8	0.2	3	Lanceolate	Obtuse	Slightly broader than dorsal sepal
28	<i>D. rotundatum</i>	3.0	1.3	7	Ovate	Acute	Subfalcate, adnate to column foot
29	<i>D. transparens</i>	3.3	0.5	5	Lanceolate	Acuminate	White with pink flooded

Table 5: Comparative Structure of Petals in *Dendrobium*

S.N.	Taxa	Length (cm)	Width (cm)	Veins	Shape	Apex	Distinguished Characters
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1	<i>D. amoenum</i>	2.6	1.2	5	Ovate	Obtuse	Broader than dorsal sepal, entire
2	<i>D. amplum</i>	4.8	0.3	5	Linear-lanceolate	Acute	Wide spreading
3	<i>D. anceps</i>	0.4	0.2	5	Elliptic	Obtuse	Much shorter than sepals, entire
4	<i>D. aphyllum</i>	3.1	1.2	5	Oblong-elliptic	Obtuse	Broader than sepals, entire
5	<i>D. bicameratum</i>	0.9	0.5	5	Elliptic	Obtuse	As long as sepal, yellowish with dull red spots and stripes
6	<i>D. chrysanthum</i>	2.4	1.7	7	Obovate	Rounded	Concave slightly, margin erose minutely
7	<i>D. chryseum</i>	2.5	1.4	3	Elliptic-obovate	Obtuse	Broader than sepal, major lateral veins branched
8	<i>D. crepidatum</i>	1.5	0.9	5	Obovate	Obtuse	Broader than sepal, entire, spotted (tinged with light purple)
9	<i>D. darjeelingense</i>	0.7	0.15	3	Oblong-lanceolate	Acute	Smaller than sepal
10	<i>D. denneanum</i>	2.5	1.2	3	Ovate	Obtuse	Broader than sepal, lateral veins branched
11	<i>D. densiflorum</i>	1.5-2.0	1.3-1.6	7	Ovate-orbicular	Obtuse	Shortly clawed, margin erose
12	<i>D. denudans</i>	1.3	0.12	3	Linear-lanceolate	Acuminate	Smaller than sepal in breadth
13	<i>D. eriiflorum</i>	1.1	0.18	3	Linear-lanceolate	Acute	Lying parallel above column
14	<i>D. fimbriatum</i>	2.4	1.5	5	Oblong-elliptic	Obtuse	Broader than sepal, margin slightly erose
15	<i>D. formosum</i>	5	3.3	7	Obovate	Cuspidate	Larger than sepal, truncate, margin undulate
16	<i>D. fugax</i>	1.1	0.2	3	Oblong-ovate	Subacute	Narrower than sepals
17	<i>D. fuscescens</i>	2.7	0.3	5	Linear-lanceolate	Acute	Petal spreading
18	<i>D. gibsonii</i>	1.7	1.3	5	Elliptic	Emarginate	Margin slightly undulate
19	<i>D. heterocarpum</i>	2.8	1	5	Ovate-lanceolate	Acute	Equal to dorsal sepal, entire, many secondary veins
20	<i>D. longicornu</i>	2.5	0.5	3	Linear-lanceolate	Acute	As long as dorsal sepal
21	<i>D. moniliforme</i>	1.6	0.7	5	Ovate-lanceolate	Acute	As long as sepal, entire
22	<i>D. monticola</i>	0.8	0.15	3	Linear-lanceolate	Acuminate	Smaller than sepal
23	<i>D. moschatum</i>	3.5	1.8	7	Ovate	Obtuse	Larger than sepal
24	<i>D. nobile</i>	3.5	2	7	Oblong-ovate	Obtuse	Margin slightly incurved
25	<i>D. plicatile</i>	0.9	0.2	3	Lanceolate	Subacute	Narrower than sepals, rolled inside
26	<i>D. polyanthum</i>	2.2	0.4	5	Oblong	Obtuse	Pink purple petals
27	<i>D. porphyrochilum</i>	0.5	0.1	3	Oblong-lanceolate	Acute	Pale yellow green with red veins
28	<i>D. rotundatum</i>	2.8	0.8	7	Oblong-lanceolate	Acuminate	As long as dorsal sepal
29	<i>D. transparens</i>	3.3	1.3	5	Oblong	Obtuse	White flushed with pink

Table 6: Comparative Structure of Lips in *Dendrobium*

S.	Taxa	Lip	Distinguished
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No.		Structure					Side Lobe			Mid Lobe			Characters on disc
		Outline	Length (cm)	Width (cm)	Shape	Colour	Shape	Apex	Margin	Shape	Apex	Margin	
1	<i>D. amoenum</i>	Tri-lobed	2.8	1.4	Oblong-ovate	White with purplish blotch at apex, greenish yellow at middle	Rounded	Obtuse	Convolute	Oblong-ovate	Obtuse	Undulate	Sub-villous on disc
2	<i>D. amplum</i>	Tri-lobed	2.7	1.7	Pandurate	Dark purple with bronze edges	Short, Rounded	Obtuse	Entire	Sub-rhomboid	Mucronate	Crenulate	Disc with 3 lamellae, outer 2 having an erect tooth at bases, middle one shorter and toothless
3	<i>D. anceps</i>	Tri-lobed	1.2	0.4	Cuneately oblong	Yellowish green with pink spotted	Oblong	Obtuse	Entire at lower part, crenulate at apex	Obovate	Bilobed	Crenulate	Shallow thickened depression ending near apex
4	<i>D. aphyllum</i>	Simple	3.4	2.6	Suborbicular	Pale yellow or cream at apex, purple veined at base	–	–	–	Convolute forming a tube at base	Rounded, emarginate	Fimbriate	Disc hairy
5	<i>D. bicameratum</i>	Tri-lobed	0.5	0.45	Triangular	Yellow marked with dull red	Triangular	Acute	Entire	Rectangular	Truncate	Entire	Disc with cushion-shaped callus
6	<i>D. chrysanthum</i>	Simple	2.2	2.4	Orbicular-oblong	Golden yellow with purplish red blotch	–	–	–	Reniform	Rounded	Denticulate	Thick and broad ridge extending from base to middle
7	<i>D. chryseum</i>	Simple	2.8	2.4	Suborbicular	Yellow orange with 2-lobed purple blotch	–	–	–	Suborbicular	Rounded	Fimbriate	Minutely pubescent to tomentose on adaxial side, clawed at base
8	<i>D. crepidatum</i>	Simple	1.4	1.1	Orbicular	Pale purplish-pink above middle, yellow below middle	–	–	–	Obovate, incurved sides at base	Retuse	Undulate, ciliate	A transverse ridge at the claw

9	<i>D. darjeelingense</i>	Tri-lobed	0.6	0.3	Oblong-ovate	Red lined in cream tinged with light green	Triangular	Acute	Entire	Obovate	Acute	Undulate, crenulate	3 keels from base to apex
10	<i>D. denneanum</i>	Simple	2.2	2	Orbicular	Dark yellow with dark purple reniform patch	–	–	–	Reniform, convolute in basal part	Retuse	Undulate, fimbriate	Clawed at base, tomentose
11	<i>D. densiflorum</i>	Simple	2.2	2.1	Orbicular-rhomboid	Orange yellow	–	–	–	Orbicular-rhomboid, convolute in basal half	Retuse	Revolute, lacerate	Clawed at base
12	<i>D. denudans</i>	Tri-lobed	1.1	0.5	Obovate	Pale green with radiating red-purple lines	Oblong	Acute	Lacerate	Obovate	Acute	Serrate-crisped	Disc with 3 ridges having a triangular apex ending at mid-lobe
13	<i>D. eriiflorum</i>	Tri-lobed	0.8	0.7	Oblong-ovate	Light greenish-white spotted with dull purple	Elongate, narrow	Acute	Pectinate-serrate	Orbicular	Acute	Undulate	Disc with a mesial ridge running from base to apex of mid-lobe
14	<i>D. fimbriatum</i>	Simple	3	2.2	Suborbicular	Deep orange yellow with dark purple blotch	–	–	–	Suborbicular	Rounded	Deeply fimbriate	Shortly clawed, base with purple red stripes, densely pubescent adaxially
15	<i>D. formosum</i>	Tri-lobed	6	3.5	Obcuneate	White with yellow marks	Rounded	Obtuse	Entire	Orbicular	Retuse, apiculate	Undulate	Disc with two yellow tuberculate central ridges
16	<i>D. fugax</i>	Tri-lobed	1.3	0.6	Oblong-obovate	White sprinkled with pink-purple spots	Oblong	Truncate	Erose-crisped	Oblong-elliptic	Truncate	Undulate	Disc with two plicate lamellae extending from base to apex
17	<i>D. fuscescens</i>	Tri-lobed	1.8	1.6	Ovate-oblong	Purplish-brown	Oblong	Obtuse	Undulate	Sub-orbicular	Emarginate to Mucronate	Undulate	Disc with 3 crenulate lamellae between side lobes, middle lamella shorter

18	<i>D. gibsonii</i>	Simple	1.5	1.7	Sub-reniform	Orange yellow with deep purple blotch on each side	–	–	–	Orbicular	Emarginate	Fimbriate	Deep purple blotch, papillary hairs with short fringed edges on both sides of disc
19	<i>D. heterocarpum</i>	Simple	2.8	1.6	Trowel-shaped	Pale yellow with reddish purple radiating lines	–	–	–	Ovate-oblong	Acute	Undulate	Disc papillose-pubescent
20	<i>D. longicornu</i>	Tri-lobed	5.1	2.3	Broadly triangular (spreading)	White streaked orange yellow	Rounded	Truncate	Slightly wavy	Sub-orbicular	Obtuse	Fimbriate	A broad central ridge from base to mid-lobe ending into 4 branches
21	<i>D. moniliforme</i>	Tri-lobed	1.5	0.9	Oblong-lanceolate	White with yellowish green central spots	Rounded, incurved near middle	Rounded	Entire, slightly wavy	Ovate-elliptic	Acute	Entire	Disc with an elongated callus
22	<i>D. monticola</i>	Tri-lobed	0.8	0.45	Subelliptic	White with purplish red stripes in side lobes	Rounded	Acuminate	Incisolate	Ovate triangular	Acute	Undulate, recurved	disc with irregular, orbicular, triangular apex, 3 lamellate ridged projections in centre
23	<i>D. moschatum</i>	Simple	3	1.7	Calceolate	Pale yellow with purplish brown blotches on either sides	–	–	–	Sub-globular	Rounded	Cucullate, fimbriate	No callus
24	<i>D. nobile</i>	Simple	3.5	2.2	Ovate-oblong	White at base becoming mauve at apex with large purple blotch	–	–	–	Ovate-oblong	Obtuse	Cucullate, entire	Shortly clawed, upper half cucullate, lower half incurved, densely pubescent
25	<i>D. plicatile</i>	Tri-lobed	1.5	0.8	Subovate	White with yellowish white lamellae	Subovate	Rounded	Entire	Flabellate	Sub truncate	Undulate	Disc with two or three lamellae extending from base to apex of mesochile.

26	<i>D. polyanthum</i>	Simple	2.5	2	Obovate, convolute at base	Pinkish yellow at apex white at base with purple veins	–	–	–	Obovate	Rounded	Denticulate	Short claw, callus at base,
27	<i>D. porphyrochilum</i>	Simple	0.4	0.25	Elliptic	Purplish brown with yellowish green margin	–	–	–	Elliptic	Subacute	Entire	3 obscure ridges of variable lengths from base to apex
28	<i>D. rotundatum</i>	Tri-lobed	1.9	1.2	Obovate-oblong	Brownish yellow	Sub-ovate	Obtuse	Slightly undulate	Sub-reniform	Emarginate	Undulate	Midlobe with a triangular thickened keel adaxially, disc with 3 crenulate lamellae between side lobes, middle one shorter
29	<i>D. transparens</i>	Tri-lobed	3.6	1.8	Elliptic-obovate	White with purple patch at middle	Broad, convolute	Rounded	Erose	Sub-orbicular	Acute	Undulate	Disc hairy with 3 distinct veins running from base to apex

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References

- Banarjee, M. L. and P. Pradhan. "The Orchids of Nepal Himalaya". Vaduz; J Cramer, Germany. (1984). Print.
- Brieger, F.G. "Subtribus Dendrobiinae". In: Brieger, F.G., R. Maatsch and K. Sanghas (eds.) *Die Orchideen by Schlechter, R.*, 3rd edition (11-12) Parey, Berlin. (1981): 636-752. Online.
- Chase, M. W., K. M. Cameron, J. V. Freudenstein, A. M. Pridgeon, G. Salazar, C. Van den Berg, and A. Schuiteman. "An updated classification of Orchidaceae". *Bot. Jour. Linn. Soc.* (2015) 177: 151-174. Online.
- Clements, M.A. "Molecular phylogenetic systematics in Dendrobieae (Orchidaceae)". *Aliso* (2006) 22: 465-480. Online.
- Don, D. "Prodromus Florae Nepalensis". J. Gale, London. (1825). Print.
- Dressler, R. L. "Phylogeny and Classification of the Orchid Family". Cambridge University Press. Cambridge MA. (1993). Print.
- Hara, H., W. T. Stearn and L. H. J. Williams. "An Enumeration of the Flowering plants of Nepal" 1:42. British museum (Natural History) London. (1978). Print.
- Holttum, R. E., F. G. Brieger and P. J. Cribb. "A proposal for the re-typification of *Dendrobium* Sw. nom. cons". *Taxon* 28 (4) (1979): 409. Online.
- Kranzlin, F. "Orchidaceae-Monandrae-Dendrobiinae". In: A. Engler (Ed.), *Das Pflanzenreich* 45. Leipzig. (1910). Online.
- Press, J. R., K. K. Shrestha and D. A. Sutton. "Annotated checklist of the Flowering plants of Nepal". The Natural History Museum, London. (2000). Print.
- Rajbhandari, K. R. and S. K. Rai. "A Handbook of the Flowering Plants of Nepal". (2017) 1: 92 - 99. Dept of Plant Resources, Govt. of Nepal. Print.
- Raskoti, B.B. "The Orchid of Nepal". Author, Kathmandu, 252 pp. (2009). Print.
- Rokaya, M. B., B. B. Raskoti, B. Timsina and Z. Munzbergova. "An annotated Checklist of the Orchids of Nepal". In: *Nordic Journal of Botany* (2013) 31: 511-550. Online.
- Schlechter, R. "Die Orchidaceen von Deutsch-Neu-Guinea". In: Fedde, F. (Ed.) *Repertorium Specierum Novarum Regni Vegetabilis*. Beihefte Band 1. Koeltz, Berlin. (1912) 440-643. Online.
- Schuiteman, A. and P. B. Adams. "Tribe Dendrobieae". In: Pridgeon, A.M., P. J. Cribb, M. W. Chase and F. N. Rasmussen (Eds.). *Genera Orchidacearum*. (2014) Vol: 6. Epidendroideae (Part three): 3-4, 51-73, 89-100. Oxford University Press, Oxford. Online.
- Schuiteman, A. "Evolution and Systematics of the Orchid Genus *Dendrobium* Sw.". Ph.D. Thesis, Oxford Brookers University. (2017). Online.
- Seidenfaden, G. "Orchid genera in Thailand XII. *Dendrobium* Sw.". *Opera Botanica* 83 (1985): 1-296. Print.
- Shrestha, K. K., S. Bhattarai and P. Bhandari. "Handbook of Flowering Plants of Nepal 1". (2018): 110-114. Print.
- Swartz, O. "Dianome epidendri generis Linn.". *Nova Acta Regiae Societatis Scientiarum Upsalensis ser. 2*, 6 (1799): 82-85. Online.
- The Plant List. (2014). Available at: www.theplantlist.org. [accessed on 18 October 2019]. Online.

21. White, K. and B. Sharma. "Wild Orchids in Nepal". White Lotus Co. Ltd. (2000). Print.
22. Wood, H. P. "The dendrobiums". Gantner, Ruggell. (2006). 3-84. Print.

Websites

www.theplantlist.com

www.ipni.org

www.jstor.org>subject>botany

www.kew.org

www.eflora.org


plants.jstor.org

<http://www.leca.univ-savoie.fr/db/florhy/infos.html>

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