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GENTIANA MACNEILLIANA (GENTIANACEAE), A NEW SPECIES FROM SIKKIM HIMALAYA (INDIA) BASED ON MORPHOLOGICAL AND MOLECULAR DATA

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Gentiana macneilliana (Gentianaceae), a new species from North Sikkim, in the Eastern Himalayan region of India, is described, illustrated and discussed. It is morphologically similar to *Gentiana lacinulata* T.N.Ho of *Gentiana* sect. *Chondrophyllae* Bunge but differs markedly in having acute and usually mucronate leaf apex, ovate corolla lobes with acuminate apex, much longer plicae (1.5–2.6 mm), which are more than half as long as corolla lobes, and longer pedicel (up to 8 mm). This new species also resembles *Gentiana muscicola* C.Marquand (*Gentiana* sect. *Chondrophyllae*) but can easily be differentiated by its unique corolla lobe, shorter petiole, narrowly based leaf lamina, longer pedicel and shorter style. The affinity of the new species with *Gentiana grata* Harry Sm., a member of the same section, is also highlighted. A taxonomic description, images and illustrations of the new taxon are provided, along with a discussion of closely related taxa.

Keywords. Eastern Himalaya, *Gentiana* sect. *Chondrophyllae*, ITS, IUCN, new species, *trn*L–F
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Introduction

The genus *Gentiana* L. (Gentianaceae), which includes approximately 344 species, is chiefly distributed in temperate and alpine regions of the world (POWO, 2025). In India, the genus is represented by c.73 species, mostly distributed in the Himalaya except for four taxa, namely *Gentiana kurumbae* Anilkumar & Udayan, *G. pedicellata* (Wall. ex D.Don) Griseb. subsp. *pedicellata*, *G. pedicellata* subsp. *zeylanica* (Griseb.) Halda and *G. sasidharanii* K.M.P.Kumar & Sunil, which occur in the Western Ghats (Jayanthi, 2022). The majority of the Indian *Gentiana* (c.56 species) occur in the Sikkim Himalayan region, and this appears to be the centre of diversity of the genus in India.

A field trip was conducted in North Sikkim (Mangan district) in July 2024 to collect *Gentiana* species. During this trip, several populations of a *Gentiana* were observed along the

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hillslopes, with some populations growing on moss beds between 3900 and 4000 m a.m.s.l. Taxonomic study of the specimens collected revealed notable morphological variation from existing species, and they were identified as representatives of a previously undescribed species of *Gentiana*. The novelty of the specimens was confirmed through a comprehensive literature search (Clarke, 1883; Garg, 1987; Ho & Pringle, 1995; Aitken, 1999; Ho & Liu, 2001; Maity & Saha, 2024) and study of herbarium specimens. To help ascertain the identity and systematic position of this new species, the internal transcribed spacer region (ITS1 + 5.8s + ITS2) and cpDNA (*trn*L–F) were sequenced and analysed.

In this article, we provide a comprehensive morphological description of the new species, accompanied by an illustration and photographs. Additionally, information on its habitat ecology, distribution and conservation are presented.

Materials and methods

Field trips and morphological study

Specimens of the putative new species were collected from five populations in North Sikkim. Standard herbarium practices were followed for the preparation of voucher specimens (Davis & Heywood, 1963). Morphological observations were made using a Leica EZ4 stereo microscope (Leica, Wetzlar, Germany), and measurements were taken of all floral and vegetative parts. Detailed illustrations were made and photographs taken. The type specimens, deposited at CAL, CUH, GNBUH and SSFH, were physically examined, as were specimens from BM and K (herbarium codes follow Thiers, continuously updated). The conservation status of the putative new species was assessed using IUCN Red List Categories and Criteria, version 3.1 (IUCN, 2012) and IUCN guidelines (2024).

Taxon sampling

To determine the phylogenetic relationships of the putative new species, sequences of 178 *Gentiana* samples were included in the analysis; they represented 177 of the c.344 species in the genus and one variety used in a previous study (Favre *et al.*, 2016) available via GenBank. We also included samples of 24 of the 163 species currently considered to be members of *Gentiana* sect. *Chondrophyllae* (Ho & Liu, 2001). Additionally, two samples of our putative new species were included. Outgroup sampling and rooting were based on the phylogenetic studies of Favre *et al.* (2016). Four species from each of the two genera *Crawfurdia* and *Kuepferia* were chosen as outgroups, and the tree was rooted on the *Crawfurdia* samples (Yuan *et al.*, 1996; Favre *et al.*, 2010, 2016, 2020). Details of all samples used in the present study are presented in **Appendix table 1**.

DNA extraction, PCR amplification and sequence alignment

Total genomic DNA was extracted from silica gel–dried leaf material, using a DNeasy Plant Mini Kit (Qiagen, Amsterdam, Netherlands). The extracted DNA was evaluated for its quality and quantity using an EPOCH Microplate Spectrophotometer (BioTEK, Winooski, Vermont, USA). DNA amplification and sequencing of the ITS region (ITS1, 5.8S and ITS2) were carried out using the primers ITS1 and ITS4 (White *et al.*, 1990). For the chloroplast plastid *trn*L intron and adjacent *trn*L–*trn*F spacer (*trn*L–F region), we used primers c and f (Taberlet *et al.*, 1991).

PCR was carried out using 25 µL reaction mixtures consisting of 12.5 µL RedDye Master mix (Genei, Bangalore, India) to which we had added 1.5 µL of a 0.3 µM solution of each forward and reverse primer, 2 µL of genomic DNA, and 7.5 µL of double-distilled water. PCR amplification was carried out with an initial denaturation of 1 min at 95°C, 35 cycles of denaturation for 10 s at 95°C, primer annealing for 60 s at 60°C, and 1 min of extension at 72°C, followed by the last cycle of final extension for 90 s at 72°C.

PCR products were checked for the presence of a single band of appropriate size on a 0.8% agarose gel stained with ethidium bromide. Amplicons were purified using ExoSAP-IT (Fermantas, Burlington, California, USA), and sequenced at 1st Base Labs (Seri Kembangan, Selangor, Malaysia) using Sanger ABI technology (Noida, New Delhi, India). Chromatograms for the forward and reverse sequences were assembled and edited using the computer program DNA Baser v.4 (2013, Heracle BioSoft, Lilienthal, Germany), and aligned using Geneious v.6.1.8 (Drummond *et al.*, 2010). All newly generated sequences have been deposited in GenBank (see **Appendix table 1**).

Phylogenetic analyses

A total of four sequences (2 ITS and 2 *trn*L–F) were generated from two different populations of the putative new species. The boundaries for the newly generated sequences of nuclear internal transcribed spacers (ITS1 + ITS2), chloroplast *trn*L gene (including intron), and the *trn*L–F intergenic spacers, were determined using the FEATURES option of Geneious v.6.1.8 as part of another study and will be described separately in an article currently being prepared by the authors for publication.

The best-fitting partitioning scheme and models for evolution for individual as well as concatenated (ITS + *trn*L–F) regions, respectively, were selected using Partition Finder 2 (Lanfear *et al.*, 2016). For the ITS region, the data were partitioned into three parts: ITS1, 5.8S and ITS2. For the *trn*L–F region, they were partititioned into the intron and spacer regions.

The phylogenetic analyses were carried out at the CIPRES Science gateway (Miller *et al.*, 2010). Maximum-likelihood (ML) analyses were conducted for the individual nrDNA ITS and cpDNA *trn*L–F regions, separately and combined, using RAxML-HPC2 on XSEDE v.8.2.12

(Stamatakis, 2014), run under the models determined by Partition Finder 2 with 20 heuristic searches from distinct random stepwise-addition sequence-parsimony starting trees, followed by a selection of best-scoring tree. RAxML bootstrap values were calculated using 1000 replicates.

Results

The best-scoring ML tree generated through analysis of the combined ITS and *trn*L–F sequences placed the two accessions of the putative new species (*Dmaity* 27326 and 27329) in a strongly supported single clade (BP: 100) within *Gentiana* sect. *Chondrophyllae* (BP: 100) (**Figure 1**). The ML tree based on analysis of individual ITS and *trn*L–F data has the same topology (data not shown).

Gentiana grata Harry Sm. resolved as sister to the putative new species (BP: 85). They share key morphological characters such as short stolon, basal leaves withered at anthesis, tubular calyx and funnelform corolla, but *Gentiana grata* differs from the putative new species in key morphological characters such as dichotomously branched stems, rounded to cordate leaf laminar base, ciliolate leaf laminar margin, entire corolla lobe margin, corolla lobe base not contracted, stamens inserted at middle of corolla tube, and longer filaments.

The putative new species is morphologically most similar to *Gentiana lacinulata* T.N.Ho and *G. muscicola* C.Marquand, but unfortunately no sequence data were available for these species. *Gentiana lacinulata* is endemic to the Xizang (Tibet) region of China, and *G. muscicola* is found in Southeast Xizang, Northwest Yunnan and Northeast Myanmar (Ho & Liu, 2001). In the absence of molecular data for both these species, their phylogenetic relationship to the putative new species could not be confirmed. However, in-depth morphological comparison of our putative new species with herbarium material examined while visiting BM, CAL, CUH, GNBUH, K and SSFH, and a comprehensive literature search (Smith, 1936; Marquand, 1937; Ho, 1984; Ho & Pringle, 1995; Ho & Liu, 2001) provide sufficient evidence to support the recognition of a new species and a close relationship to *Gentiana grata*, *G. lacinulata* and *G. muscicola*. A comparison of major morphological features between the new species and its most closely related species is presented in **Appendix table 2**.

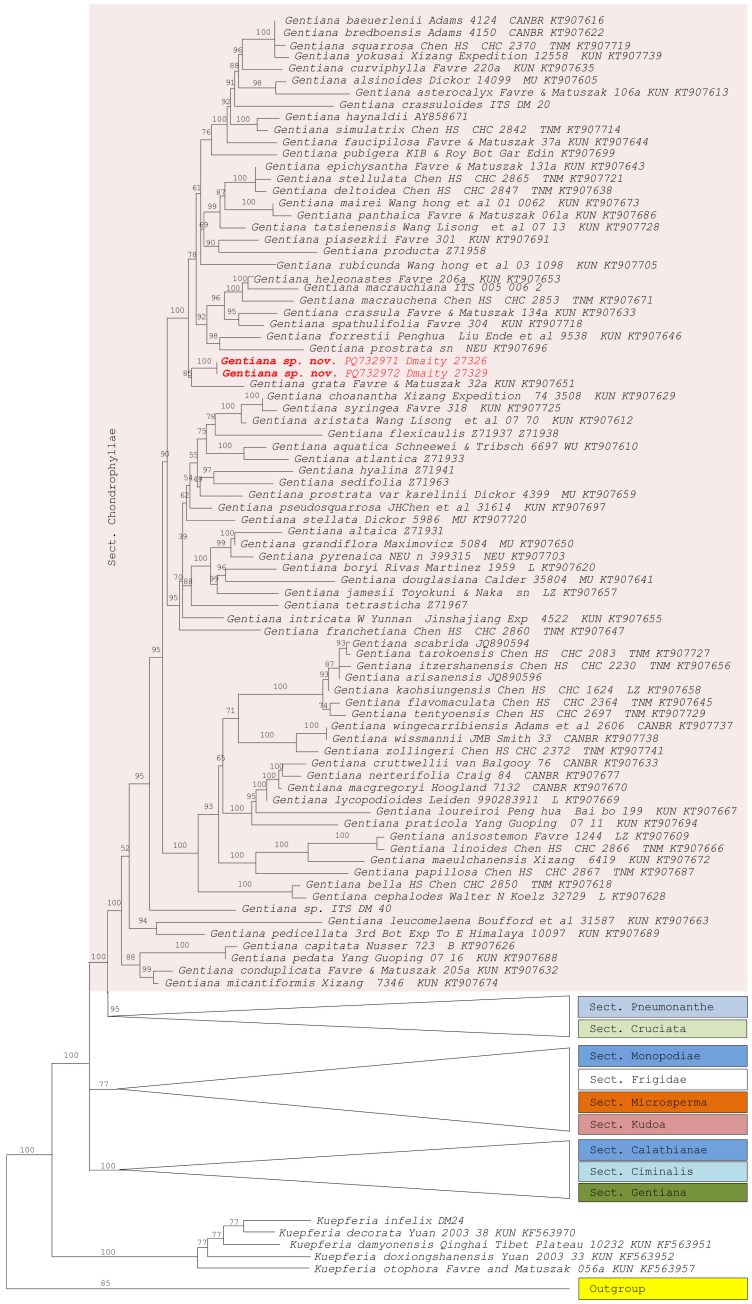

Figure 1. The best-scoring maximum-likelihood tree generated through analysis of the combined nrDNA (ITS) and cpDNA (*trn*L–F) sequence data of 188 samples, showing the *Gentiana* sect. *Chondrophyllae* clade containing the two samples of the putative new species. Bootstrap values ≥ 75 are indicated along the branches.

Species description

Gentiana macneilliana A.K.Halder & D.Maity, **sp. nov.**

Gentiana macneilliana is morphologically most similar to *Gentiana lacinulata* but differs from that species by its short petiole, 0.5–1.5 mm long (vs up to 3 mm); acute and usually mucronate leaf apex (vs obtuse leaf apex); narrowly revolute leaf margin (vs flat leaf margin); longer pedicel, up to 8 mm long (vs up to 3 mm long); ovate corolla lobes with acuminate apex (vs suborbicular with obtuse-rounded or rounded apex); much longer plicae, 1.5–2.6 mm long (vs 0.7–1 mm); and plicae more than 1/2 as long as corolla lobes (vs less than 1/3 as long as corolla lobes). It also resembles *Gentiana muscicola* but can be differentiated from that species by its unique ovate, acuminate corolla lobes with erose margin and distinctly contracted base (vs ovate–lanceolate or ovate–triangular, obtuse or subacute lobes with entire margin and widened base); short petiole, 0.5–1.5 mm long (vs up to 2.5 mm); narrowed leaf bases (vs rounded to cordate leaf bases); long pedicel, up to 8 mm (vs up to 3.1 mm); and short style, 1.5–1.9 mm (vs 3–4 mm). – Type: North Sikkim, Panchpokhri, 3950 m, 25 vii 2024, *A. K. Halder, B. K. Jha & S. Chakrobortty* 27326 (holotype CUH; isotype CAL, CUH). **Figures 2**, **3**.

Stoloniferous, perennial herb, 2–6 cm tall; stolon medium, 1–2 cm long, slender; roots weak, branched, up to 4.5 cm long. *Stem* ascending, rooting at basal nodes, glabrous, simple or with 1 or 2 weak branches towards base, glabrous. *Basal leaves* distantly spaced (not in rosette), withered at anthesis, elliptic–obovate, 1.5–3 × 0.5–1.6 mm, apex acute, mucronate, margin entire, narrowly cartilaginous and narrowly revolute, densely and minutely papillate above, glabrous below, 3-veined from base, prominent adaxially on drying. *Stem leaves* elliptic to ovate–elliptic), 2–5 × 1.5–2 mm, apex acute, usually mucronate (mucro 0.05–0.2 mm long), margin smooth, narrowly cartilaginous and narrowly revolute, green, densely and minutely papillate above (adaxially), pale green and glabrous below (abaxially), base narrowed to petiole; free petioles 0.5–1 mm long, bases fused to petiolar sheath to c.0.5 mm long, margin papillate. *Flower* solitary, terminal, erect. *Pedicels* 0.5–8 mm long, glabrous, yellow-green. *Calyx* narrowly funnel-shaped, 5–6.5 mm long, purplish green or green throughout except purplish lobe margins; tube 4–4.5 mm long, glabrous; lobes 5, erect, triangular, 1–2 × 0.65–1 mm, apex acuminate, margin narrowly membranous, midvein prominent, sinus narrowly obtuse. *Corolla* funnelform, 0.8–1.5 cm long, dark blue outside, lavender inside, lower half yellowish green outside; tube 0.6–1.2 cm long; lobes ovate, spread almost at right angle, 2.3–3.3 × 1.9–2.7 mm, apex acuminate, margin erose, base distinctly contracted (thus lobes appear rhombic); plicae broadly oblong, 1.5–2.6 × 0.85–1.07 mm, more than 1/2 as long as corolla lobes, primarily 2-lobed, lavender; lobes divide into 9–12 fringed hairs; hair tip narrowed, acute. *Stamens* 5, epipetalous, equal, inserted at apical part of corolla tube; filaments filiform, 1.5–2 mm long, slightly expanded towards base, base yellowish purple; anthers oblongoid, 0.5–0.65 × 0.2–0.25 mm,

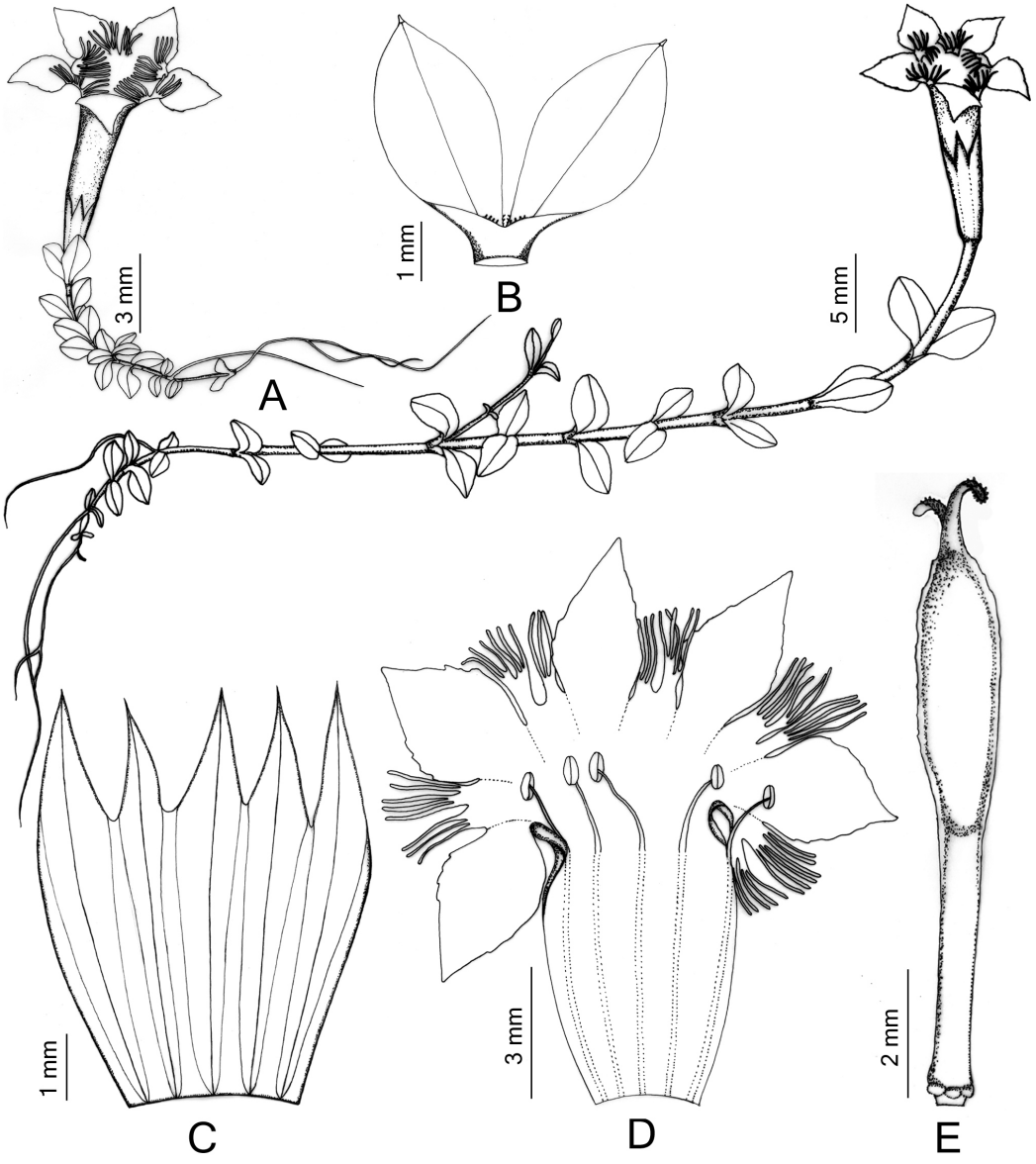

Figure 2. *Gentiana macneilliana* A.K.Halder & D.Maity, sp. nov. A, Habit; B, pair of leaves; C, split calyx (ventral face); D, split corolla (ventral face); E, gynoecium. Drawn by A. K. Halder from *A. K. Halder, B. K. Jha & S. Chakrobortty* 27326.

Figure 3. *Gentiana macneilliana* A.K.Halder & D.Maity, sp. nov. A, Habitat; B and C, habit; D, open flower; E, split calyx (ventral face); F, split corolla (inset: corolla [apical part] of *G. lacinulata* (*Ludlow, Sherriff, Elliot* #14289, BM, BM001014656 [© Natural History Museum]); G, gynoecium. Photographs: A. K. Halder (A–D) and D. Maity (E–G).

dorsifixed, yellowish white. *Ovary* ellipsoid or narrowly obovoid, ± compressed, 2.6–3.8 × c.1 mm, narrowly winged along ventral suture; wing usually serrulate, broad at apex but gradually narrowed towards base; greenish white; style 1.5–1.9 mm long, greenish white; stigma 2-lobed, linear, c.1 mm long, papillose; ovarian stipe stout, 2–5 mm long, yellowish white. *Capsules* narrowly obovoid to obovoid, 3–4 × 1.5–2 mm; fruiting stipe to 1 cm long; *Seeds* numerous, narrowly obovoid to oblongoid, 0.76–0.95 × 0.28–0.37 mm, testa reticulate, brown.

Distribution. Endemic to the type locality in Sikkim.

Habitat and ecology. *Gentiana macneilliana* inhabits alpine regions and is known only from the Kanchenjunga Biosphere Reserve in North Sikkim. It was found growing on moss beds on open alpine slopes at 3900–4000 m a.m.s.l. Several mature individuals and young plants were observed at the type locality. Flowering, July to August; fruiting, August to September. Commonly associated species include *Bistorta affinis* Greene (Polygonaceae), *Carex* sp. (Cyperaceae), *Cassiope fastigiata* D.Don and *C. selaginoides* Hook.f. & Thomson (both Ericaceae), *Corydalis* sp. (Fumariaceae), *Diplarche multiflora* Hook.f. & Thomson (Ericaceae), *Gaultheria pyrolifolia* Hook.f. ex C.B.Clarke (Ericaceae), *Potentilla peduncularis* D.Don, *Potentilla* sp. (Rosaceae), *Salix* sp. (Salicaceae) and *Viola biflora* L. (Violaceae).

Etymology. The specific epithet '*macneilliana*' is given in honour of Dr John McNeill, Royal Botanic Garden Edinburgh (E), the legendary taxonomist and nomenclature specialist, who has given immense support with the nomenclature of Indian *Gentiana*.

Proposed IUCN conservation category. Five populations of this species were recorded during fieldwork within an area of about 2 km^2, where around 38 mature individuals were observed along with some young plants. The area of occupancy and extent of occurence of the species are < 10 km^2 and < 100 km^2, respectively. The habitats are used for grazing. Considering the high risk to these populations from grazing, we propose the IUCN conservation category 'Critically Endangered' (CR B2abiii & D) for this new species.

Notes. *Gentiana macneilliana* is a well-defined member of *Gentiana* sect. *Chondrophyllae* and shares major features of the section, including perennial habit, solitary terminal flowers, symmetrical plicae, and narrow capsule wing (ventral suture), but it is conspicuous and broad at the apex of the capsule, which gradually narrows towards the base, and has a reticulate seed coat (Ho & Liu, 2001).

Although our phylogenetic work places *Gentiana grata* as sister to *G. macneilliana* and they share a stoloniferous habit, basal leaves withered at anthesis, and narrowly funnel-shaped calyx and funnelform corolla, *G. grata* significantly differs from *G. macneilliana* in its unique dichotomous branching pattern of stems (vs 1 or 2 weak branches towards base), rounded to cordate laminar base and ciliolate laminar margin (vs narrowed base and eciliolate margin), widened corolla lobe base and entire margin (vs distinctly contracted

base and erose margin), and most importantly, the insertion of stamens at the middle part of the corolla tube and 2–3 mm long filaments (vs stamens inserted at middle of corolla tube and 1.5–2 mm long filaments). We are confident that when molecular data are available for *Gentiana lacinulata* and *G. muscicola*, their closer relationship with *G. macneilliana* will be confirmed.

Additional specimens examined. India. North Sikkim: below Panchpokhri, 3900 m, 24 vii 2024, *A. K. Halder, B. K. Jha & S. Chakrobortty* 27259; Panchpokhri, 3950 m, 25 vii 2024, *A. K. Halder, B. K. Jha & S. Chakrobortty* 27317; Panchpokhri, 4000 m, 25 vii 2024, *A. K. Halder, B. K. Jha & S. Chakrobortty* 27329; Panchpokhri, 4000 m, 25 vii 2024, *A. K. Halder, B. K. Jha & S. Chakrobortty* 27330. All specimens in CUH, GNBUH and SSFH.

Key to the species (taxa) of Indian Gentiana *sect.* Chondrophyllae

1a. Flowers tetramerous ____ 2
1b. Flowers pentamerous ____ 3

2a. Stem unbranched ____ *G. arunii* D.Maity, S.K.Dey, J.Ghosh & Midday
2b. Stem branched at base ____ *G. tetrasepala* Biswas

3a. Plicae asymmetrical (oblique), reduced, auriculate, attached to right side of corolla lobe ____ *G. prainii* Burkill
3b. Plicae symmetrical (oblique), elaborate between corolla lobes ____ 4

4a. Stem branched at base; branches several to many, filiform; corolla with (4 or) 5 large dark blue spots in throat ____ *G. pluviarum* W.W.Sm.
4b. Characters combination not as above ____ 5

5a. Corolla throat with fimbrae ____ 6
5b. Corolla throat without fimbrae ____ 8

6a. Calyx lobes oblong–obovate, margin broadly membranous __ *G. membranulifera* T.N.Ho
6b. Calyx lobes otherwise (rarely obovate), margin narrowly membranous ____ 7

7a. Calyx lobes oblong or spathulate, base usually distinctly narrowed ___ *G. hugelii* Griseb.
7b. Calyx lobes triangular, base not narrowed ____ *G. coronata* Royle

8a. Plant usually with a single main stem, each node with flower or with a weak branch with axillary and terminal flowers, appearing as a ‘raceme’ *G. decemfida* Buch.-Ham. ex D.Don
8b. Plant with multiple strong branches or simple stem; flower solitary or several flowers differently clustered but never appear as ‘raceme’ (sometimes ‘raceme’-like in *G. argentea* Royle ex D.Don, then leaves silvery and membranous with green longitudinal veins at lower half) ____ 9

9a. Plicae margin fringed with filiform lobes ____ 10
9b. Plicae simple, few dentate or variously dissected but never fringed with filiform lobes ____ 11

10a. Stem simple or with 1 or 2 weak branches towards base; fringe lobes never with expanded tips ____ **G. macneilliana**
10b. Stem dichotomously branched; fringe lobes with expanded tips *G. recurvata* C.B.Clarke

11a. Stem leafless at lower half; flowers several to many, usually in dense terminal cluster ____ 12
11b. Stem leafy throughout; flower solitary or many, but never in dense terminal cluster __ 17

12a. Flower cluster surrounded by large rosette leaves ____ *G. capitata* Buch.-Ham. ex D.Don
12b. Flower cluster not surrounded by large rosette leaves (sometimes lower leaves larger in *G. albescens* (Franch.) Franch. ex Kusn., then leaf margin distinctly membranous ____ 13

13a. All leaves or at least lower ones obovate to flabelliform ____ 14
13b. All leaves ovate–lanceolate ____ 15

14a. Margins of all leaves broadly membranous; stamens inserted at middle of corolla tube *G. albicalyx* Burkill
14b. Margins of lower leaves cartilaginous, upper broadly membranous; stamens inserted at basal part of corolla tube ____ *G. huxleyi* Kusnezow

15a. Leaf margin wide membranous (up to c.0.7 mm in lower leaves) ____ *G. albescens*
15b. At least margin of lower leaves cartilaginous ____ 16

16a. Lower leaves up to 3 cm long; calyx lobes margins broadly (often up to 0.5 mm) membranous, eciliate ____ *G. membranulifera*
16b. Lower leaves up to 6 cm long; calyx lobes margins narrowly (c.0.1 mm) membranous and ciliate ____ *G. nudicaulis* Kurz

17a. Stems much branched from base, densely papillate; stem leaves and calyx lobes orbicular to reniform with deflexed tips ____ *G. crassuloides* Bureau & Franch.
17b. Characters combination not as above ____ 18

18a. Plants often with flowers in lower leaves axils along main stem; leaves silvery and membranous with green longitudinal veins at lower half, upper half green and herbaceous ____ *G. argentea*
18b. Character combination not as above ____ 19

19a. Stem usually unbranched or with few branches towards apex ____ 20
19b. Stem branched from base or both at base as well as towards apex ____ 21

20a. Calyx lobes obovate or oblong; plicae bifid _____ *G. harwanensis* G.Singh
20b. Calyx lobes ovate, lanceolate or triangular; plicae entire _____ *G. riparia* Kar. & Kir.

21a. Stamens distinctly unequal (2 longer and 3 shorter) _____ *G. maeulchanensis* Franch.
21b. Stamens equal(–subequal) _____ 22

22a. Roots fleshy _____ 23
22b. Roots fibrous _____ 24

23a. Stems much longer than basal leaves; basal leaves elliptic or ovate–lanceolate *G. loureiroi* Griseb. subsp. *loureiroi*
23b. Stems almost as long as basal leaves; basal leaves linear or linear–lanceolate *G. loureiroi* subsp. *napulifera* (Franch.) Halda

24a. Stem leaves quadrifariously imbricate _____ *G. quadrifaria* Blume
24b. Stem leaves arranged otherwise, never quadrifariously imbricate _____ 25

25a. Calyx tube distinctly 5-winged (extension of lobes midveins); capsules unwinged ___ 26
25b. Calyx tube unwinged; capsules distinctly winged (strong and broad towards apex) __ 28

26a. Stem leaves ovate–lanceolate _____ *G. stellata* Turrill
26b. Stem leaves obovate or spathulate _____ 27

27a. Calyx lobes 1–1.2 mm long _____ *G. clarkei* Kusn.
27b. Calyx lobes 2–5 mm long _____ *G. prostrata* Haenke

28a. Stem leaves subulate or linear–lanceolate and conduplicate _____ 29
28b. Stem leaves otherwise, not as above _____ 30

29a. Stem leaves subulate and shiny, margin (at least basal half) broadly membranous and ciliolate _____ *G. micans* C.B.Clarke
29b. Stem leaves linear–lanceolate, conduplicate, not shiny, margin cartilaginous, eciliolate _____ *G. saginoides* Burkill

30a. Stem more-or-less densely papillate _____ 31
30b. Stem glabrous, smooth _____ 36

31a. Stem leaves lanceolate, elliptic or linear–elliptic _____ 32
31b. Stem leaves (at least lower leaves) obovate, spathulate, orbicular or reniform _____ 33

32a. Corolla bright to sky blue, often white with yellow throat _____ *G. pedicellata*
32b. Corolla purple _____ *G. pringlei* M.Shabir, P.Agnihotri, J.K.Tiwari & T.Husain

33a. Calyx lobes triangular or linear–lanceolate, erect, appressed to corolla _____ 34
33b. Calyx lobes ovate(–orbicular), recurved _____ 35

34a. Stem leaves mostly oblanceolate–elliptic _____ *G. aquatica* L. var. *aquatica*

34b. Stem leaves obovate to spathulate __ *G. aquatica* var. *pseudoaquatica* (Kusn.) S.Agrawal

35a. Petioles usually abaxially smooth; corolla pale blue, usually with dark-blue streaks in throat; capsule gynophore 1.5–2 cm long _____ *G. bryoides* Burkill
35b. Petioles abaxially densely papillate; corolla uniformly blue or dark blue; capsule gynophore < 1 cm long _____ *G. squarrosa* Ledeb.

36a. Corolla throat uniformly coloured _____ 37
36b. Corolla throat differently spotted or streaked _____ 38

37a. Stem leaves mostly oblanceolate–elliptic; fruiting stipe (gynophore) up to 2.5 cm long *G. aquatica* var. *aquatica*
37b. Stem leaves lanceolate or oblong; fruiting stipe (gynophore) up to 5 cm long *G. macrauchena* C.Marquand

38a. Calyx lobes ovate, strongly recurved _____ *G. glabriuscula* Harry Sm. ex T.N.Ho
38b. Calyx lobes triangular, erect _____ 39

39a. Corolla throat with dark blue streaks _____ *G. micantiformis* Burkill
39b. Corolla throat spotted _____ 40

40a. Plicae deeply 2-cleft, principal lobes with entire margin _____ *G. aperta* Maxim.
40b. Plicae irregularly few denate or laciniate (often principally 2-cleft and both lobes few dentate, appearing laciniate) _____ *G. leucomelaena* Maxim.

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Appendix table 1. Details of the samples used in the present study

Species no.	Taxon	Section	Voucher specimen	Collection locality	GenBank accession no.	
					Nuclear ITS region	Plastid *trn*L–F region
	***Gentiana* species**					
1	*G. acaulis* L.	*Ciminalis*	*Favre* 1003	Gd-St-Bernhard, Valais	KT907603	JF748586
2	*G. albomarginata* C.Marquand	*Chondrophyllae*	*Li Heng* et al. 1342	Guanpo, Wuding, Yunnan	KT907604	KT907744
3	*G. algida* Pall.	*Frigidae*	KSenni_S2468	Nagano, Yatsugadake Mts, Japan	NA	AB219627
4	*G. alsinoides* Franch.	*Chondrophyllae*	*Dickoré* 14099	Deija Mts, Lijiang, Yunnan	KT907605	KT907745
5	*G. altaica* Laxm.	*Chondrophyllae*	NA	NA	Z71931, Z71932	NA
6	*G. altorum* Harry Sm. ex C.Marquand	*Kudoa*	*Favre* 308	Songpan, Sichuan	NA	KT907746
7	*G. amplicrater* Burkill	*Isomeria*	*Wu Zhengyi* et al. *s.n.*	JueEn to Zhula, Xizang	KT907606	KT907747
8	*G. andrewsii* Griseb.	*Pneumonanthe*	*James S. Pringle* 2737	Royal Botanical Gardens, Burlington	KT907607	KT907748
9	*G. angulosa* M.Bieb.	*Calathianae*	*Gutte* 33690	Kreuzpass unterhalb Mleti, Caucasus	KT907608	KT907749
10	*G. angustifolia* Vill.	*Ciminalis*	IARC_A_007	NA	NA	AB453061
11	*G. anisostemon* C.Marquand	*Chondrophyllae*	*Favre* 1244	Yunnan, China	KT907609	KT907750
12	*G. aperta* Maxim.	*Chondrophyllae*	*Dickoré* 3754	Nyainqentanglashan, Lhasa, Xizang	NA	KT907751
13	*G. aquatica* L.	*Chondrophyllae*	*Schneeweiß & Tribsch* 6697	Samtskhe-Javakheti	KT907610	KT907752
14	*G. arethusae* Burkill	*Kudoa*	*Favre & Matuszak* 177a	Baimaxuashan, Yunnan	KT907611	KT907753
15	*G. arisanensis* Hayata	*Chondrophyllae*	*Chen HS*, CHC 2162	Ta-Yu-Ling, Sioulin, Hualien	JQ890596	KT907754
16	*G. aristata* Maxim.	*Chondrophyllae*	*Wang Lisong* et al. 07-70	Changdu to Wuqishanpass, Xizang	KT907612	KT907755
17	*G. asclepiadea* L.	*Pneumonanthe*	*Yuan* 93-20	Izgorjaloto Gjune reserve, Bulgaria	GU251025	AJ580515
18	*G. asterocalyx* Diels	*Chondrophyllae*	*Favre & Matuszak* 106a	Lijiang, Yunnan	KT907613	KT907756
19	G. atlantica Litard. & Maire	*Chondrophyllae*	*Liu* 1095	NA	Z71933	NA
20	*G. atropurpurea* T.N.Ho	*Microsperma*	NA	NA	AY858678	AY858686
21	*G. atuntsiensis* W.W.Sm.	*Frigidae*	*Favre & Matuszak* 060a	Dali, Lijiang	KT907614	KT907757
22	*G. austromontana* J.S.Pringle & Sharp	*Pneumonanthe*	*James S. Pringle* 2734	Roan Mountain, N Carolina	KT907615	KT907758
23	*G. baeuerlenii* L.G.Adams	*Chondrophyllae*	*Adams* 4124	Orroral Valley, Australian Cap. Ter.	KT907616	KT907759
24	*G. bavarica* L.	*Calathianae*	*Favre* 1002	Sanetsch, Valais	KT907617	KT907760
25	*G. bella* Franch. ex Hemsl. (a)	*Chondrophyllae*	*HS Chen* CHC 2850	Chien-hu-shan, Yunnan	KT907618	NA
26	*G. bella* Franch. ex Hemsl. (b)	*Chondrophyllae*	*Nujiang Expedition* 790207	Dimaluo, Yunnan	NA	KT907761
27	*G. bicuspidata* (G.Don) Briq.	*Pneumonanthe*	*Hernandez & de Hole* 947	Palo Bendito, Huayacocotla	KT907619	KT907762
28	*G. boryi* Boiss.	*Chondrophyllae*	*Rivas-Martinez* 1959	Sierra de Bejar, Candelario, Salamanca	KT907620	KT907763
29	*G. brachyphylla* Vill.	*Calathianae*	*Favre* 1000a	Sanetsch, Valais	KT907621	KT907764
30	*G. bredboensis* L.G.Adams	*Chondrophyllae*	*Adams* 4150	Frogs Hole Creek, New South Wales	KT907622	KT907765
31	*G. brentae* Prosser & Bertolli	*Calathianae*	brentae2_5	NA	NA	JF748585
32	*G. burseri* Lapeyr.	*Gentiana*	*Dietrich W* 6285	Gavarnie to Barrage d'Ossous, Pyrénées	KT907623*	X75700
33	*G. cachemirica* Decne.	*Kudoa*	IARC:U 008	NA	NA	AB453078
34	*G. caelestis* (C.Marquand) Harry Sm.	*Kudoa*	*Favre & Matuszak* 193a	Daocheng, Sichuan	KT907624	KT907766
35	*G. caliculata* Lex.	*Pneumonanthe*	*Hinton* et al. 6819	Temascalptepec, Mexico	KT907707	KT907851
36	*G. calycosa* Griseb.	*Pneumonanthe*	*Tanya Harvey* 2013-01	Jefferson Park	KT907625	KT907767
37	*G. capitata* Buch.-Ham. ex D.Don	*Chondrophyllae*	*Nusser* 723	Narga Parbat	KT907626	KT907768
38	*G. carinicostata* Wernham	*Chondrophyllae*	*Veltkamp* 6256-a	Star Mts, W Sepik, Tell Basin	NA	KT907769
39	*G. cephalantha* Franch. ex Hemsl.	*Monopodiae*	*Favre* 325	Sichuan, China	KT907627	KT907770
40	*G. cephalodes* Edgew.	*Chondrophyllae*	*Walter N. Koelz* 32729 (L)	Assam, India	KT907628	NA
41	*G. choanantha* C.Marquand	*Chondrophyllae*	*Favre* 325	Luojishan, Sichuan	KT907629	KT907771
42	*G. cinereifolia* P.Royen	*Chondrophyllae*	*Walter N. Koelz* 32729	Blue Mountains, Lushai Hills, Assam	NA	KT907772

Appendix table 1 (*continued*)

Species no.	Taxon	Section	Voucher specimen	Collection locality	GenBank accession no.	
					Nuclear ITS region	Plastid *trn*L–F region
43	*G. clausa* Raf.	*Pneumonanthe*	*Xizang Expedition* 74-3508	Qianning to Daofu, Sichuan	KT907630	KT907773
44	*G. clusii* Perr. & Songeon	*Calathianae*	*Craven* 2913	Isuani Basin, Mt Victoria	KT907631	KT907774
45	*G. conduplicata* T.N.Ho	*Chondrophyllae*	*James S. Pringle* 2738	Monongahela Nat. Forest, West Virginia	KT907632	KT907775
46	*G. crassicaulis* Duthie ex Burkill	*Cruciata*	*Favre* CH13011	Salanfe Lake, Salvan, Valais	NA	KT907776
47	*G. crassula* Harry Sm.	*Chondrophyllae*	*Favre & Matuszak* 205a	Yading, Sichuan	KT907633	KT907777
48	*G. crassuloides* Bureau & Franch.	*Chondrophyllae*	*Favre & Matuszak* 116a	Lijiang, Yunnan	NA	KT907778
49	*G. cruciata* L.	*Cruciata*	*Kuepfer* 2005-G2 (NEU)	NA	DQ398635	DQ398713
50	*G. cruttwellii* Harry Sm.	*Chondrophyllae*	*van Balgooy* 76	Mt Wilhelm	KT907634	KT907779
51	*G. cuneibarbata* Harry Sm.	*Chondrophyllae*	*Qingzang Team* 10490	Ridong, Chayu County, Xizang	NA	KT907780
52	*G. curviphylla* T.N.Ho	*Chondrophyllae*	*Favre* 220a	Litang, Sichuan	KT907635	KT907781
53	*G. dahurica* Fisch.	*Cruciata*	*Favre* 319	Xiahe, Gansu	KT907636	KT907782
54	*G. davidii* Franch.	*Monopodiae*	*Expedition Team to Northeast* 730	Manaoke, Zhaotong, Yiliang, Yunnan	KT907637	KT907783
55	*G. decora* Diels	*Pneumonanthe*	*K. Mathews s.n.* (WCUH)	NA	EU812468	EU834122
56	*G. decumbens* L.f.	*Cruciata*	*Yuan* 2004-83 (IBSC)	NA	DQ398655	DQ398714
57	*G. delavayi* Franch.	*Microsperma*	NA	NA	Z48080, Z48099	NA
58	*G. deltoidea* Harry Sm.	*Chondrophyllae*	*Chen HS*, CHC 2847	Chien-hu-shan, Yunnan	KT907638	NA
59	*G. depressa* D.Don	*Isomeria*	*Favre* 1269	Kopra Ridge, Annapurna, Pokhara	GU251026	KT907784
60	*G. dinarica* Beck	*Ciminalis*	*Haemmerli s.n.*	Triggalv Mts, Rzki Podi	KT907639	KT907785
61	*G. dolichocalyx* T.N.Ho	*Kudoa*	*Boufford* et al. 39978	Hongyuan, Maiwa Xiang, Sichuan	KT907640	KT907787
62	*G. douglasiana* Bong.	*Chondrophyllae*	*Calder* 35804	Queen Charlotte Isl., British Columbia	KT907641	KT907786
63	*G. duclouxii* Franch.	*Monopodiae*	*Favre & Matuszak* 076	Kunming, Yunnan	KT907642	KT907788
64	*G. emodii* C.Marquand ex Sealy	*Isomeria*	*Ludlow, Sheriff and Hicks* 19721	Tolegang, Tsampa	NA	KT907789
65	*G. epichysantha* Hand. Mazz.	*Chondrophyllae*	*Favre & Matuszak* 131a	Bashuitai, Yunnan	KT907643	KT907790
66	*G. ettingshausenii* F.Muell.	*Chondrophyllae*	*Pullen* 6059	Finisterre Range, Mt Abilala, Madang	NA	KT907791
67	*G. faucipilosa* Harry Sm.	*Chondrophyllae*	*Favre & Matuszak* 37a	Bingzhongluo, Yunnan	KT907644	KT907792
68	*G. flavomaculata* Hayata	*Chondrophyllae*	*Chen HS*, CHC 2364	Kuan-Yun, Sioulin, Hualien	KT907645	KT907793
69	*G. flexicaulis* Harry Sm.	*Chondrophyllae*	NA	NA	Z71937, Z71938	NA
70	*G. forrestii* C.Marquand	*Chondrophyllae*	*Penghua, Liu Ende* et al. 9538	Jiaozishan, Luquan County, Yunnan	KT907646	KT907794
71	*G. franchetiana* Kusn.	*Chondrophyllae*	*Chen HS*, CHC 2860	Kan-hai-tzu, Chien-hu-shan, Yunnan	KT907647	NA
72	*G. frigida* Haenke	*Frigidae*	*K. Gutsche* 42 (MJG)	NA	AJ294648, AJ294588	AF102435
73	*G. froelichii* Jan ex Rchb.	*Frigidae*	NA	NA	Z71969, Z71970	X77884, NA
74	*G. futtereri* Diels & Gilg	*Kudoa*	*Liu* 1056 (HNWP)	NA	NA	DQ398730
75	*G. gelida* M.Bieb.	*Pneumonanthe*	*Meierott* 07/210	Gomborispass, Telavi, Kakheti	KT907648	AB453087
76	*G. glauca* Pall.	*Isomeria*	*Parker CL* 7568	Etivluk River, Lisburne Ridge, Alaska	KT907649	KT907795
77	*G. grandiflora* Laxm.	*Chondrophyllae*	*Maximovicz* 5084	Sibiria Orientalis	KT907650	KT907796
78	*G. grata* Harry Sm.	*Chondrophyllae*	*Favre & Matuszak* 32a	Bingzhongluo, Yunnan	KT907651	KT907797
79	*G. handeliana* Harry Sm.	*Frigidae*	*Liu Ende* et al. 1209080	Chayu to Jinjiu, Xizang	KT907652	KT907798
80	*G. haynaldii* Kanitz	*Dolichocarpa*	*Favre & Matuszak* 194a	Daocheng, Sichuan	AY858671	KT907799
81	*G. heleonastes* Harry Sm.	*Chondrophyllae*	*Favre* 206a	Yading, Sichuan	KT907653	KT907800
82	*G. hesseliana* Hosseus	*Chondrophyllae*	*Maxwell* 90-406	Doi Sahm Meun, Pai	NA	KT907801
83	*G. hexaphylla* Maxim. ex Kusn.	*Kudoa*	*Boufford* et al. 39284	Zhangla cun, Rangtang, Sichuan	KT907654	KT907802
84	*G. hyalina* T.N.Ho	*Dolichocarpa*	NA	NA	Z71941, Z71942	NA
85	*G. intricata* C.Marquand	*Chondrophyllae*	*W. Yunnan, Jinshajiang Exp.* 4522	Habaxueshan, Zhongdian, Yunnan	KT907655	KT907803

Appendix table 1 (*continued*)

Species no.	Taxon	Section	Voucher specimen	Collection locality	GenBank accession no.	
					Nuclear ITS region	Plastid *trn*L–F region
86	*G. itzershanensis* T.S.Liu & C.C.Kuo	*Chondrophyllae*	*Chen HS*, CHC 2230	Heping Dist., Taichung City	KT907656	KT907804
87	*G. jamesii* Hemsl.	*Chondrophyllae*	*Toyokuni and Naka, s.n.*	Takanagahara Mts, Hokkaido	KT907657	NA
88	*G. kaohsiungensis* Chih H.Chen & J.C.Wang	*Chondrophyllae*	*Chen HS*, CHC 1624	Tien-chih, Taoyuan, Kaohsiung County	KT907658	KT907805
89	*G. prostrata* var. *karelinii* Griseb.	*Dolichocarpa*	*Dickoré* 4399	Tangulashan, Geladandong, Xizang	KT907659	KT907806
90	*G. kaufmanniana* Regel & Schmalh.	*Cruciata*	*Yuan* 2004-98 (IBSC)	NA	DQ398649	DQ398719
91	*G. krylovii* Grossh.	*Calathianae*	*Gutte* 34959	Amaty, Nebenthal oberhalb Medeo	KT907660	NA
92	*G. lacerulata* Harry Sm.	*Isomeria*	*Favre* 1261	Kyanjing Gompa, Lirung Valley, Langtang	KT907661	KT907807
93	*G. latidens* (House) J.S.Pringle & Weakley	*Pneumonanthe*	*James S. Pringle* 2733	Herrin Knob Overlook, Jackson County	KT907662	KT907808
94	*G. lawrencei* Burkill	*Kudoa*	*Favre* 315	Langmusi, Sichuan	DQ317492	KT907809
95	*G. leucomelaena* Maxim.	*Chondrophyllae*	*Boufford* et al. 31587	Leijilashan, Xizang	KT907663	KT907810
96	*G. lhassica* Burkill	*Cruciata*	*Wang Lisong* et al. 07-53	Qusong, Budanglashankou, Xizang	DQ398629	KT907811
97	*G. ligustica* R.Vilm. & Chopinet	*Ciminalis*	NA	Mont Saccarel, France	AY773259, AY773260	X77886
98	*G. linearis* Froel.	*Pneumonanthe*	*James S. Pringle* 2735	Whitefield, Coos County, New Hampshire	KT907664	KT907812
99	*G. lineolata* Franch.	*Microsperma*	*Li Heng* et al. 0651	Guanpo, Wuding, Yunnan	KT907665	KT907813
100	*G. linoides* Franch. ex Hemsl.	*Chondrophyllae*	*Chen HS*, CHC 2866	Na-pa-hai, Yunnan	KT907666	NA
101	*G. loureiroi (*G.Don) Griseb.	*Chondrophyllae*	*Peng hua, Bai bo* 199	Liyue to Wenbu, Jingdong, Yunnan	KT907667	KT907814
102	*G. lutea* L.	*Gentiana*	*Favre* 1005	Sanetsch, Valais	KT907668	KT907815
103	*G. lycopodioides* Stapf	*Chondrophyllae*	990.283.911	Latimotjong Mts, Sulawesi	KT907669	KT907816
104	*G. macgregorii* Hemsl.	*Chondrophyllae*	*Hoogland* 7132	Sugaloaf Mt, W. Highlands, Papua New Guinea	KT907670	KT907817
105	*G. macneilliana*	*Chondrophyllae*	*Dmaity* 27326	Sikkim India	PQ732971	Submitted
106	*G. macneilliana*	*Chondrophyllae*	*Dmaity* 27329	Sikkim India	PQ732972	Submitted
107	*G. macrauchena* C.Marquand	*Chondrophyllae*	*Chen HS*, CHC 2853	Der-chin, Yunnan	KT907671	NA
108	*G. macrophylla* Pall.	*Cruciata*	*Xizang Expedition* 6419	Weixi, Yunnan	DQ398652	DQ398723
109	*G. maeulchanensis* Franch.	*Chondrophyllae*	*Wang hong* et al. 01-0062	Ganhaizi, Qiaojia, Zhaotong, Yunnan	KT907672	KT907818
110	*G. mairei* H.Lév.	*Chondrophyllae*	*Favre* 1005	Sanetsch, Valais	KT907673	KT907819
111	*G. manshurica* Kitag.	*Pneumonanthe*	2005-2701D	NA	GQ864018	GQ864091
112	*G. melandriifolia* Franch.	*Monopodiae*	GXJ2011-054	China	KU512333	NA
113	*G. micantiformis* Burkill	*Chondrophyllae*	*Xizang Expedition* 7346	Duilaqu, Yadong, Xizang	KT907674	KT907820
114	*G. mirandae* Paray	*Pneumonanthe*	*Hernandez and Trigos* 1188	Unknown	KT907675	KT907821
115	*G. monochroa* T.N.Ho	*Isomeria*	*Qing Zangbudian* 751342	Duoxiongshan, Milin, Paiqu, Xizang	KT907676	NA
116	*G. nerterifolia* P.Royen	*Chondrophyllae*	*Craig* 84	Sirius Ridge, Telefomin, Sepik district	KT907677	KT907823
117	*G. newberryi* A.Gray	*Pneumonanthe*	*Tanya Harvey* 2013-02	Hand Lake, Oregon	KT907678	KT907824
118	*G. nivalis* L.	*Calathianae*	*Jochum* 1201	Ferpècle, Valais	KT907679	KT907825
119	*G. nubigena* Edgew.	*Frigidae*	*Wang Lisong* et al. 07-55	Qusong, Budanglashankou, Xizang	KT907680	KT907826
120	*G. occidentalis* Jakow.	*Ciminalis*	NA	NA	AJ000925, AJ000926	X76229
121	*G. officinalis* Harry Sm.	*Cruciata*	*Yuan* 92-293 (NEU)	NA	NA	DQ398697
122	*G. olgae* Regel ex Schmalh.	*Cruciata*	*s.n.*	Munich bot. Gard. Origin: Tianshan	KT907681	KT907827
123	*G. olivieri* Griseb.	*Cruciata*	264	NA	NA	DQ398716
124	*G. orbicularis* Schur	*Calathianae*	*Favre* 1001	Sanetsch Valais	KT907682	KT907828
125	*G. oreodoxa* Harry Sm.	*Kudoa*	*Wu Zhengyi* et al. 5109	Dongjiulashan pass, Xizang	DQ398657	KT907829
126	*G. ornata* (D.Don) Wall. ex Griseb.	*Kudoa*	*Favre* 1272	Khayar Lake, Annapurna, Pokhara	KT907683	KT907830
127	*G. oschtenica* Woronow	*Calathianae*	*Beck and Lewis* (B)	Canary Islands, Spain	KT907684	KT907831

Appendix table 1 (*continued*)

Species no.	Taxon	Section	Voucher specimen	Collection locality	GenBank accession no.	
					Nuclear ITS region	Plastid *trn*L–F region
128	*G. pachyphylla* Merr.	*Chondrophyllae*	*de Wilde, de Wilde-Duyfjes* 16206	Gunung Leuser, Sumatra	NA	KT907832
129	*G. pannonica* Scop.	*Microsperma*	*Favre* 1280	Seehorn, Salzburg	KT907685	KT907833
130	*G. panthaica* Prain & Burkill	*Chondrophyllae*	*Favre & Matuszak* 061a	Dali, Yunnan	KT907686	KT907834
131	*G. papillosa* Franch.	*Chondrophyllae*	*Chen HS*, CHC 2867	Su-cha-yun, Yunnan	KT907687	NA
132	*G. paradoxa* Albov	*Pneumonanthe*	IARC:U 023	NA	NA	AB453090
133	*G. parryi* Engelm.	*Pneumonanthe*	Y91-S4 (NEU)	NA	Z48096	DQ398731
134	*G. pedata* Harry Sm.	*Chondrophyllae*	*Yang Guoping* 07-16	Puer, Jingdong, Xujiabai, Yunnan	KT907688	KT907835
135	*G. pedicellata* (Wall. ex D.Don) Griseb.	*Chondrophyllae*	*3rd Bot. Exp. To E Himalaya* 10097	Samtengang to Kyebaka	KT907689	KT907836
136	*G. penetii* (Litard. & Maire) Romo	*Calathianae*	*Favre & Matuszak* 33a	Bingzhongluo, Yunnan	NA	JF748609
137	*G. phyllocalyx* C.B.Clarke	*Phyllocalyx*	*Favre* 301	Jiuzhaigou, Sichuan	KT907690	KT907837
138	*G. piasezkii* Maxim.	*Chondrophyllae*	*Favre* 301 (KUN)	China: Sichuan	KT907691	KT907838
139	*G. pneumonanthe* L.	*Pneumonanthe*	*Favre* 328	Lugu Hu, Yunnan	KT907692	X77889, NA
140	*G. praeclara* C.Marquand	*Microsperma*	*Yang Guoping* 07-11	Puer, Jingdong, Xujiabai, Yunnan	KT907693	KT907839
141	*G. praticola* Franch.	*Chondrophyllae*	*3rd Bot. Exp. To E Himalaya* 10097	Samtengang to Kyebaka	KT907694	KT907840
142	*G. producta* T.N.Ho	*Chondrophyllae*	NA	NA	Z71958	NA
143	*G. prolata* Balf.f.	*Kudoa*	*Xizang Expedition* 74-2715	Yadong, Palidingya, Xizang	KT907695	NA
144	*G. prostrata* Haenke	*Chondrophyllae*	*Grant J.* 97-02901	Donnelly creek, Alaska	KT907696	KT907841
145	*G. pseudosquarrosa* Harry Sm.	*Chondrophyllae*	*J.H.Chen* et al. 31614	Jiangda (Gyamda) to Dege, Xizang	KT907697	KT907842
146	*G. puberulenta* J.S.Pringle	*Pneumonanthe*	*Pringle* 2744	Tucker Prairie, Callaway County, Missouri	KT907698	KT907843
147	*G. pubigera* C.Marquand	*Chondrophyllae*	*KIB & Roy. Bot. Gar. Edin. exp.* 85-400	Lijiang, Yulongshan, Houshan, Yunnan	KT907699	KT907844
148	*G. pumila* Jacq.	*Calathianae*	*Haemmerli M. s.n.*	Wiener Schneeberg	KT907700	KT907845
149	*G. punctata* L.	*Gentiana*	*Triponez* 1000	Nufenenpass, Valais	KT907701	KT907846
150	*G. purpurea* L.	*Gentiana*	*Triponez* 1001	Val di Blenio, Passo Greina, Ticino	KT907702	KT907847
151	*G. pyrenaica* L.	*Chondrophyllae*	NEU n. 399315	Zigana Pass, Trabzon 2156 m	KT907703	KT907848
152	*G. rigescens* Franch. ex Hemsl.	*Monopodiae*	2005-2704B	NA	GQ864022	GQ864095
153	*G. robusta* King ex Hook.f.	*Cruciata*	*Yuan* 92-57 (NEU)	NA	DQ398643	DQ398702
154	*G. rostanii* Reut. ex Verlot	*Calathianae*	*Haemmerli s.n.*	Hautes Alpes, Mt Gondran	KT907704	KT907849
155	*G. rubicunda* Franch.	*Chondrophyllae*	*Wang hong* et al. 03-1098	Qiaojia, Qiaoshan, Yunnan	KT907705	AB453058
156	*G. rubricaulis* Schwein.	*Pneumonanthe*	*Pringle* 847	Pickerel Lake, Dickinson County, Michigan	KT907706	KT907850
157	*G. saponaria* L.	*Pneumonanthe*	*Bert Pittman* 11280501	Cedar Creek, Richland, S Carolina	KT907708	KT907852
158	*G. scabra* Bunge	*Pneumonanthe*	*Sun, B.Y.* 2001-102	Gangwon-do	KT907709	KT907853
159	*G. scabrida* Hayata	*Chondrophyllae*	*Chen HS*, CHC 2463	Yun-Hai, Alishan, Chiayi	JQ890594	KT907854
160	*G. sceptrum* Griseb.	*Pneumonanthe*	*Tanja Harvey*	Olallie Meadows	KT907710	KT907855
161	*G. schleicheri* (Vacc.) Kunz	*Calathianae*	*Favre* 1004	Gd-St-Bernard, Valais	KT907711	KT907856
162	*G. sedifolia* Kunth	*Chondrophyllae*	*Terrier Ch.* 60803	Lac de Soirococha, Camballa	Z71963, Z71964	KT907857
163	*G. septemfida* Pall.	*Pneumonanthe*	*Haemmerli & Imhof s.n.*	Zigana Pass, Trabzon 2156 m	KT907712	X77896
164	*G. sikokiana* Maxim.	*Pneumonanthe*	*Tagawa* 8771	Oharano, Owase-she, Mie, Honshu	KT907713	KT907858
165	*G. simulatrix* C.Marquand	*Chondrophyllae*	*Chen HS*, CHC 2842	Na-pa-hai, Yunnan	KT907714	NA
166	*G. sinoornata* Balf.f.	*Kudoa*	*Favre & Matuszak* 224a	Litang, Sichuan	KT907715	KT907859
167	*G. siphonantha* Maxim. ex Kusn.	*Cruciata*	*Tian XM* et al. QLS-TXM-044	Qinghai	KT907716	KT907860
168	*G. spathacea* Kunth	*Pneumonanthe*	*Troll* 2	Acultzingo	KT907717	KT907861
169	*G. spathulifolia* Kusn.	*Chondrophyllae*	*Favre* 304	Songpan, Sichuan	KT907718	KT907862
170	*G. squarrosa* Ledeb.	*Chondrophyllae*	*Chen HS*, CHC 2370	Tenchaoshan, Honshu	KT907719	KT907863
171	*G. stellata* Turrill	*Chondrophyllae*	*Dickoré* 5986	Arun Valley, Everest, Xizang	KT907720	KT907864
172	*G. stellulata* Harry Sm.	*Chondrophyllae*	*Chen HS*, CHC 2865	Na-pa-hai, Yunnan	KT907721	NA

Appendix table 1 (*continued*)

Species no.	Taxon	Section	Voucher specimen	Collection locality	GenBank accession no.	
					Nuclear ITS region	Plastid *trn*L–F region
173	*G. stipitata* Edgew.	*Kudoa*	*Favre & Matuszak* 222a	Litang, Sichuan	NA	KT907865
174	*G. straminea* Maxim.	*Cruciata*	*Favre* 313	Langmusi, Sichuan	KT907722	KT907866
175	*G. striolata* T.N.Ho	*Kudoa*	*Favre* 221a	Litang, Sichuan	KT907723	KT907867
176	*G. suborbisepala* C.Marquand	*Microsperma*	*Chen HS*, CHC 2878	Da-bao-shan, Yunnan	KT907724	NA
177	*G. syringea* T.N.Ho	*Chondrophyllae*	*Favre* 318	Langmusi, Sichuan	KT907725	KT907868
178	*G. szechenyii* Kanitz	*Kudoa*	*Liu Ende* et al. 1209071	Chayu to Jinjiu Town, Xizang	KT907726	KT907869
179	*G. tarokoensis* Chih H.Chen & J.C.Wang	*Chondrophyllae*	*Chen HS*, CHC 2083	Ching-shui-shan, Sioulin, Hualien	KT907727	KT907870
180	*G. tatsiensis* Franch.	*Chondrophyllae*	*Wang Lisong* et al. 07-13	Ranmahu, Macun, Ranma, Basu, Xizang	KT907728	KT907871
181	*G. tentyoensis* Masam.	*Chondrophyllae*	*Chen HS*, CHC 2697	Tzu-en, Sioulin, Hualien	KT907729	KT907872
182	*G. tergestina* Beck	*Calathianae*	*Gutte* 26.6.1985	Divaca	KT907730	NA
183	*G. terglouensis* Hacq.	*Calathianae*	*Haemmerli s.n.*	Kärnten, Hochobir	KT907731	KT907873
184	*G. tetraphylla* Maxim. ex Kusn.	*Kudoa*	*s.n.*	Huanglong, Sichuan	KT907732	KT907874
185	*G. tetrasticha* C.Marquand	*Chondrophyllae*	NA	NA	Z71967, Z71968	NA
186	*G. tianschanica* Rupr. ex Kusn.	*Cruciata*	*Ivaschenko & Valles* 2173	Shimkend, Aksu-Jabagly	KT907733	KT907875
187	*G. tibetica* King ex Hook.f.	*Cruciata*	NA	NA	DQ398640	DQ398726
188	*G. tongolensis* Franch.	*Microsperma*	*Favre & Matuszak* 219a	Litang, Sichuan	NA	KT907876
189	*G. trichotoma* Kusn.	*Frigidae*	*Lang Xiecheng* et al. 1015	Kangding to Xinduqiao, Sichuan	KT907734	KT907877
190	*G. triflora* Pall.	*Pneumonanthe*	NA	NA	DQ398661	NA
191	*G. urnula* Harry Sm.	*Isomeria*	*Qingzang Team* 6703	Longgeer District, Zhongba County, Xizang	Z48071, Z48090	KT907878
192	*G. utriculosa* L.	*Calathianae*	*Haemmerli M. s.n.*	Gorski Kotar, Risnjak	KT907735	KT907879
193	*G. veitchiorum* Hemsl.	*Kudoa*	*Favre* 314	Langmusi, Sichuan	AY858677	NA
194	*G. verna* L.	*Calathianae*	*Favre s.n.*	Mauvoisin, Valais	KT907736	KT907880
195	*G. vernayi* C.Marquand	*Microsperma*	*Qingzang Team* 151454	Zedang to SongMountain, Xizang	AY858670	KT907881
196	*G. waltonii* Burkill	*Cruciata*	*Liu Ende* et al. 1209035	Laiyi, Jindong Town, Xizang	DQ398626	KT90788
197	*G. walujewii* Regel & Schmalh.	*Cruciata*	NA	NA	DQ398646	DQ398718
198	*G. wingecarribiensis* L.G.Adams	*Chondrophyllae*	*Adams* et al. 2606	Wingecarribee swamp, New South Wales	KT907737	KT907883
199	*G. wissmannii* J.B.Williams	*Chondrophyllae*	*JMB Smith* 33	Cathedral Rocks, Ebor New South Wales	KT907738	KT907884
200	*G. yakushimensis* Makino	*Kudoa*	NA	NA	NA	AB453083
201	*G. yokusai* Burkill	*Chondrophyllae*	*Xizang Expedition* 12558	Yanyuan, Guabiequ, Xiaojinhe, Sichuan	KT907739	KT907885
202	*G. yunnanensis* Franch.	*Microsperma*	*Favre & Matuszak* 183b	Between Shangrila and Daocheng	KT907740	KT907886
203	*G. zekuensis* T.N.Ho & S.W.Liu	*Cruciata*	*Zhou* 1958 (HNWP)	NA	NA	NA
204	*G. zollingeri* Fawc.	*Chondrophyllae*	*Chen HS*, CHC 2372	Iozan, Honshu	KT907741	KT907887
	***Gentianinae* (outgroup)** *Crawfurdia* Wall.					
205	*C. angustata* C.B.Clarke	–	*Favre* 229(KUN)	China: Yunnan	GU251013	KF563978
206	*C. campanulacea* Wall. & Griff. ex C.B.Clarke	–	*Favre* 210	China: Riverside behind Gongshan, 2000 m, NW Yunnan	GU251014	KF563979
207	*C. crawfurdioides* (Marquand) H.Sm.	–	*Wu* et al. 4180(KUN)	China: Yunnan	KJ570863	KJ570877
208	*C. delavayi* Franch.	–	*Favre* 216	China: Mt Cangshan 3100 m, Yunnan	GU251015	AY563391
	Kuepferia Adr.Favre					
209	*K. damyonensis* (C.Marquand) Adr.Favre	–	*Exp Team to Qinghai-Tibet Plateau* 10232 (KUN)	China: Tibet	KF563951	KF563987
210	*K. decorata* (Diels) Adr.Favre	–	*Yuan* 2003-38 (KUN)	China: Tibet	KF563970	KF564008
211	*K. doxiongshanensis* (T.N.Ho) Adr.Favre	–	*Yuan* 2003-33 (KUN)	China: Tibet	KF563952	KF563988
212	*K. otophora* (Franch.) Adr.Favre	–	*Favre and Matuszak* 056a (KUN)	China: Yunnan	KF563957	NA

NA, not available.

Appendix table 2. Comparison of major morphological features of *Gentiana macneilliana* A.K.Halder & D.Maity, sp. nov., *G. lacinulata* T.N.Ho, *G. muscicola* C.Marquand and *G. grata* Harry Sm.

Character	*G. macneilliana* sp. nov.	*G. lacinulata* T.N.Ho	*G. muscicola* C.Marquand	*G. grata* Harry Sm.
Stem	Simple or with 1 or 2 weak branches towards base	Simple or with few branches towards base	Simple	Few times dichotomously branched at various levels
Stolon	Medium	Short	Long	Short
Stem leaves				
Petiole	0.5–1.5 mm long	(1–)1.5–3 mm long	2–2.5 mm long	0.5–1 mm long
Shape	Elliptic to ovate–elliptic	Elliptic or ovate–elliptic	Ovate or ovate–elliptic	Ovate–elliptic or ovate
Size	2–5 × 1.5–2 mm	3.5–6 × 1.5–2 mm	4–5 × 3–4 mm	3–7 × 1–2.5 mm
Base	Narrowed	Narrowed	Rounded to cordate	Rounded to cordate
Margin	Eciliolate, narrowly revolute	Eciliolate	Eciliolate	Ciliolate
Apex	Apex acute, usually mucronate (mucro 0.05–0.2 mm long)	Obtuse	Acute	Acute
Pedicel	0.5–8 mm long	1–3 mm long	2.5–3.1 mm long (from herbarium sheet)	5–15 mm long
Calyx				
Shape	Narrowly funnel-shaped	Tubular	Tubular	Tubular
Size	5–6.5 mm long	6–7 mm long	4.5–5.5 mm long	3–4 mm long
Tube	4–4.5 mm long	4–4.5 mm long	3–3.5 mm long	2–2.5 mm long
Lobe shape	Triangular	Filiform to filiform–subulate or linear–triangular	Filiform to filiform–subulate	Filiform–subulate
Lobe size	1–2 × 0.65–1 mm	2–2.5 mm long	1.5–2 mm long	1–1.5 mm long
Corolla				
Colour	Outside dark blue at upper half, lower half yellowish green, lavender inside	Blue–purple above, with pale yellow–green base	Purple or pale violet	Pale blue or blue
Shape	Funnelform	Funnelform	Funnelform	Funnelform
Tube	0.6–1.2 cm long	1.25–1.45 cm long	0.75–0.85 cm long	0.9–1.0 cm long
Lobe shape	Ovate	Suborbicular	Ovate–lanceolate to ovate–triangular	Ovate–elliptic or ovate
Lobe size	2.3–3.3 × 1.9–2.7 mm	2.5–3 mm long	2.5–3.5 mm long	2.5–3.5 mm long
Lobe apex	Acuminate	Obtuse–rounded or rounded	Obtuse or subacute	Obtuse
Lobe margin	Erose	Erose	Entire	Entire
Lobe base	Distinctly contracted	Distinctly contracted	Not contracted	Not contracted
Plicae				
Ratio to corolla lobes	Plicae more than 1/2 as long as corolla lobes	Plicae less than 1/3 as long as corolla lobes	Plicae less than 1/2 as long as corolla lobes	Plicae more than 1/2 as long as corolla lobes
Size	1.5–2.6 mm long	0.7–1 mm long	0.7–1 mm long	1.5–3 mm long
Anther				
Shape	Oblongoid	Ellipsoid	Ellipsoid	Ellipsoid
Size	0.5–0.65 × 0.2–0.25 mm	0.7–1 mm long	0.6–0.8 mm long	0.8–1 mm long
Filament	1.5–2 mm long, inserted at apical part of corolla tube	1.5–2 mm long, inserted at apical part of corolla tube	2–2.5 mm long, inserted at apical part of corolla tube	2–3 mm long, inserted at middle of corolla tube
Style	1.5–1.9 mm long	1.5–2 mm long	3–4 mm long	1.5–2 mm long
Ovary				
Shape	Ellipsoid or narrowly obovoid	Ellipsoid or oblongoid	Ellipsoid	Narrowly obovoid
Size	2.6–3.8 × c.1 mm	3.5–4 mm long	2.5–3 mm long	2.5–3 mm long