

## On the current status of the genus *Gentiana* L. (Gentianaceae) in India

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### Abstract

Present work is an overview and critical assessment of published data and herbarium records on the diversity, endemism and distribution of the genus *Gentiana* L. (Gentianaceae) in India. Out of the recognized 73 taxa, 27 are confined to the Western Himalayan region, while Eastern Himalaya is enriched with 31 taxa; 14 taxa are common to both the Himalayan flanks and one species viz., *G. kurumbae* Kumar, Kumar & Udayan is endemic to Western Ghats. The taxa are chiefly distributed in temperate, sub-alpine and alpine zones of the Indian Himalayan Region between 3000 - 6000 m asl, with a few exceptions in sub-tropical forests.

**Key words:** *Gentiana*, Gentianaceae, Diversity, Indian Himalayan Region

### INTRODUCTION

The genus *Gentiana* L. along with *Tripterospermum* Blume, *Metagentiana* T.N. Ho & S.W. Liu and *Crawfordia* Wall. has been grouped in the sub-tribe Gentianinae of tribe Gentianeae and comprises ca. 350 – 400 species amounting to 20 – 23 % of the total taxa under Gentianaceae (Struwe & Albert 2002; Mabberley 2005; Ho & Liu 2001). The name *Gentiana* was coined by Linnaeus in 1753 after Gentius, the King of Illyria. *Gentiana*, equivalent to subgenus *Eugentiana* Kusnezow, characterized by tubular corolla with plicae between the corolla lobes, gland at the base of ovary and flattened or narrowly winged filaments towards base is mainly distributed in Southeast Asia, Europe, and North America (Pan *et al.* 2016). The centre of diversity for this genus may be considered in China, where it is represented by nearly 250 species (Long 1995; Ho & Liu 2001) and in India, the genus is represented by 73 taxa (66 species, 4 subspecies and 3 varieties), (Gupta *et al.* 2012; Maity 2014; Kumar *et al.* 2015) chiefly distributed in Indian Himalayan region except one species *G. kurumbae* which is known from the Western Ghats.

Dating from 2000 years back, *Gentiana* sp. have remained in use in traditional medicine systems in Asia (Zhao *et al.* 2010; Zhou *et al.* 2010) and in Europe and because of their remarkable medicinal functions, phytochemistry and pharmacology, the species of the genus have been enormously investigated since the 1960s and more than 500 secondary metabolites have been isolated and identified from the whole plant or plant parts. The chemical constituents of the genus include iridoids, triterpenoids, flavonoids, alkaloids, and other types of secondary metabolites (Pan *et al.* 2016) attribute to its remarkable bioactivities, such as hepatoprotective,

anti-inflammatory, DNA repair, antimicrobial, antioxidant, radioprotective, hypotensive, hypoglycaemic and immunomodulatory activities.

Comprehensive taxonomic studies on the genus have been made by various workers such as, Bunge (1829); G. Don (1837); D. Don (1825); Griseb. (1839, 1845); Kusnezow (1894-1904); Marquand (1931, 1932, 1937); Löve and Löve (1956); Toyokuni (1963, 1965); Grossgeim (1967); Löve & Kjellquist (1972); Long (1995) and Chen and Wang (1999) at global level and in India, the genus has been reported and inventoried by various workers from Indian Himalayan region in their floristic and revisionary accounts (Royle 1835; Clarke 1875, 1983; Burkill 1907; Nasir & Ali 1972; D. Don 1836, 1837; Smith 1961; Burt 1965; Kachroo *et al.* 1977; Sharma & Kachroo 1981; Sunita and Bhattacharyya 1982; Blatter 1984; Polunin & Stainton 1984; Chowdhary & Wadhwa 1984; Garg 1987; Stainton 1988; Hajra & Balodi 1995; Swami & Gupta 1998; Aswal & Mehrotara 1999; Singh & Rawat 2000; Singh & Prakash 2002; Uniyal *et al.* 2007; Sekar & Srivastava 2009; Pusalkar & Singh 2012).

Taking into account the medicinal importance of the genus, we present an overview and critical assessment of available literature and published data concerning diversity, distribution range and endemism for the genus *Gentiana* L. in India.

## METHODOLOGY

To fulfill the objective of enumeration of the taxa of *Gentiana* L. and their distribution pattern in India, extensive literature studies and herbarium consultation was done. Data from published literature and unpublished records of the herbaria were used to check the existing species and to infer the distributional ranges of the existing taxa. Major national (BSD, CAL, DD, GUH, KASH, LWG, RRLH) and international herbaria (BM, E, K, P, PE, US) having Indian collections of *Gentiana* were consulted for this purpose. The taxa of *Gentiana* are counted and listed in state-wise representation. For distribution study the Indian Himalayan regions are divided into Eastern Himalaya (West Bengal, Sikkim, Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland) and Western Himalaya (Jammu & Kashmir, Himachal Pradesh, Uttarakhand). The taxa have been listed alphabetically with altitude and distribution in the Indian states and the adjacent countries.

## RESULTS AND DISCUSSION

A total of 66 species, 4 subspecies (*G. capitata* subsp. *harwanensis*, *G. loureiroi* subsp. *napulifera*, *G. recurvata* subsp. *prainii*, *G. verna* subsp. *potica*) and 3 varieties (*G. aquatica* var. *pseudoaquatica*, *G. kurroo* var. *lowndesii*, *G. prostrata* var. *karelinii*) have been recorded from India (Table 1). The genus with wide distributional range in the Himalayan region is found in both the Western and Eastern Himalayas. Western Himalaya harbours 23 species, one subspecies and 3 varieties, which are confined to this region, whereas Eastern Himalaya is enriched with 28 species and 3 subspecies, and 14 species are found common to both the flanks of the Himalayas (Figure 1). One species (*G. kurumbae*) is endemic to the Western Ghats and 13 taxa (17.5 %) are endemic to India. Though Garg (1987) in her revisionary studies from Western Himalaya has recorded 27 taxa of *Gentiana* but our findings suggest that the diversity of taxa in the Eastern and Western Himalayas is 45 and 41 taxa respectively. In the Western Himalaya, Jammu & Kashmir and Himachal Pradesh are more or less equally diverse with 30 and 32 taxa respectively whereas Uttarakhand with 29 taxa is found to be less diverse. Additionally, Uttarakhand harbours two

**Table 1.** Distribution of the genus *Gentiana* L. in India [Abbreviation for Indian state names: AP = Arunachal Pradesh; ASM = Assam; HP = Himachal Pradesh; J&K = Jammu & Kashmir; SK = Sikkim; MGL = Meghalaya; MNP = Manipur; MZ = Mizoram; NGL = Nagaland; UTK = Uttarakhand; WB = West Bengal; TN = Tamil Nadu]

Sr. no.	Name of Taxa	Altitude in Meters	Distribution	
			India	Adjacent countries
1.	<i>G. albicalyx</i> Burkill	2600-4500	UTK, SK, WB	Bhutan, China, Nepal
2.	<i>G. albomarginata</i> C. Marquand	1900-3300	HP, UTK	--
3.	<i>G. algida</i> Pall.	1200-4200	J&K, HP, UTK	Bhutan
4.	<i>G. alii</i> (Omar & Qaiser) T.N. Ho	3350-4400	J&K	Pakistan
5.	<i>G. altigena</i> Harry Sm.	3700-4200	AP, SK, ASM	China
6.	<i>G. amplirater</i> Burkill	3900-4800	SK	Nepal, TAR
7.	<i>G. aquatica</i> L. var. <i>aquatica</i>	4600-5200	J&K, HP, UTK	China
8.	<i>G. aquatica</i> var. <i>pseudoaquatica</i> (Kusn.) S. Agrawal	3000-4300	J&K, HP	Pakistan, Nepal, Tibet China
9.	<i>G. argentea</i> (Royle ex D.Don) Royle ex D.Don	1600-4400	J&K, HP, WB, UTK, SK	Nepal
10.	<i>G. bryoides</i> Burkill	3800-4500	AP, WB, SK	Bhutan, China, Nepal
11.	<i>G. cachemirica</i> Decne.	3650-4800	J&K, HP, UTK	--
12.	<i>G. capitata</i> Buch.-Ham. ex D.Don	2800-4200	J&K, HP, UTK, SK, AP, WB	Bhutan, China, Myanmar, Nepal
13.	<i>G. capitata</i> subsp. <i>harwanensis</i> (G. Singh) Halda	1700- 2850	J&K	--
14.	<i>G. carinata</i> (D.Don) Griseb.	4000 - 4700	J&K, HP, UTK	Afghanistan, China Pakistan, Nepal
15.	<i>G. cephalodes</i> Edgew.	1800-3000	HP, UTK	Bhutan, Myanmar, Nepal
16.	<i>G. clarkei</i> Kusn.	4600-5300	J&K, HP, UTK	China
17.	<i>G. coronata</i> (D.Don ex Royle) Griseb.	3000-5350	J&K, HP, UTK	Pakistan, Tibet
18.	<i>G. crassuloides</i> Bureau & Franch.	2700-4500	J&K, HP, UTK, SK	Bhutan, Nepal,
19.	<i>G. decemfida</i> Buch.-Ham. ex D.Don	650-1500	HP, UTK, SK	Pakistan, Nepal, Myanmar
20.	<i>G. decumbens</i> L.f.	1200-2700	HP	China
21.	<i>G. depressa</i> D.Don	3000-4500	SK	Bhutan, China, Nepal
22.	<i>Gentiana doxiongshangensis</i> T.N.Ho	3900-4300	NGL, MGL, WB, ASM, MNP, Tripura	China, Bhutan
23.	<i>G. elwesii</i> C.B. Clarke	4200	NGL, MGL, Tripura, MNP, WB, SK, ASM	Bhutan, China, Nepal
24.	<i>G. emodi</i> C. Marquand ex Sealy	4270-5030	SK	China, Bhutan
25.	<i>G. gilvostrata</i> C. Marquand	3000-3900	NGL, MGL, WB, SK	Bhutan, Myanmar
26.	<i>G. himalayensis</i> T.N.Ho	4000-4200	SK	Bhutan, China, Nepal
27.	<i>G. hugelii</i> Griseb.	2650-4400	J&K, HP, UTK	Afghanistan, TAR, Pakistan
28.	<i>G. huxleyi</i> Kusn.	3800-4000	UTK, SK	Bhutan, China, Nepal, Pakistan
29.	<i>G. kaufmanniana</i> Regel & Schmalh.	3000	J&K, HP	Afghanistan, Pakistan
30.	<i>G. kurroo</i> Royle	2000-3000	J&K, HP, UTK	Pakistan
31.	<i>G. kurroo</i> var. <i>lowndesii</i> (Blatter) T.N. Ho	2000-2600	J&K, HP	Afghanistan, Pakistan
32.	<i>G. kurumbae</i> Kumar, Kumar & Udayan	75-250	Kerala	--
33.	<i>G. lacerculata</i> Harry Sm.	3300-4500	ASM, SK	TAR, Nepal, Bhutan

Sr. no.	Name of Taxa	Altitude in Meters	Distribution	
			India	Adjacent countries
34.	<i>G. leucomelaena</i> Maxim.	1900-5000	J&K, HP, UTK, SK	China, Nepal, Pakistan
35.	<i>G. loureiroi</i> (G.Don) Griseb.	300-3200	AP, MZ, SK	China, Bhutan, Myanmar
36.	<i>G. loureiroi</i> subsp. <i>napulifera</i> (Franch.) Halda	1300- 2000	SK, MGL, NGL, ASM	China
37.	<i>G. maeulchanensis</i> Franch.	2500-3600	SK	Bhutan, Myanmar
38.	<i>G. membranulifera</i> T.N. Ho	3000 - 3500	J&K, HP, UTK	Afghanistan, TAR, Pakistan
39.	<i>G. meiantha</i> (C.B.Clarke) Harry Sm.	4000	SK	Nepal
40.	<i>G. micans</i> C.B. Clarke	4300-4800	SK	Bhutan, China, Nepal
41.	<i>G. micantiformis</i> Burkill	4200-4500	HP, UTK, SK	--
42.	<i>G. nubigena</i> Edgew.	3000-5300	J&K, HP	Bhutan, Nepal
43.	<i>G. nudicaulis</i> Kurz	1000-2700	ASM, MNP, MZ, MGL, NGL, SK	--
44.	<i>G. obconica</i> T.N.Ho	3960-5500	SK	China, Bhutan, Nepal
45.	<i>G. olivieri</i> Griseb.	600-2300	J&K, HP	China
46.	<i>G. ornata</i> (D.Don) Wall. ex Griseb.	3300-5000	SK	Bhutan, China, Nepal
47.	<i>G. parryae</i> C. Marquand	1300-1700	ASM	--
48.	<i>G. pedicellata</i> (D.Don) Wall.	750-3700	J&K, HP, UTK, AP, SK, WB, ASM, MGL, MZ, NGL	Bhutan, China, Nepal, Myanmar, Pakistan, Sri Lanka
49.	<i>G. phyllocalyx</i> C.B.Clarke	3000-5500	SK	Burma, China, TAR, Myanmar, Nepal
50.	<i>G. prolata</i> Balf.f.	3400-4500	ASM, SK	Bhutan, China, TAR, Nepal, Bhutan
51.	<i>G. prostrata</i> Haenke	3650-4400	J&K, HP, UTK	--
52.	<i>G. prostrata</i> var. <i>karelinii</i> (Griseb.) Kusn.	4000-4600	J&K, HP	Bhutan, TAR
53.	<i>G. quadrifaria</i> Blume	1000- 2700	J&K, ASM, Kerala, MGL, TN, WB	Nepal, Bhutan
54.	<i>G. recurvata</i> C.B.Clarke	3000-4000	SK	China, Myanmar, Nepal
55.	<i>G. recurvata</i> subsp. <i>prainii</i> (Burkill) Halda	3800-4500	SK	Bhutan, China
56.	<i>G. riparia</i> Kar. & Kir.	600-1200	SK	China,
57.	<i>G. robusta</i> King ex Hook.f.	3500-4800	SK	China, Nepal
58.	<i>G. saginoides</i> Burkill	350	UTK	--
59.	<i>G. sikkimensis</i> C.B.Clarke	2700-5000	AP, SK	Bhutan, China, Myanmar, Nepal
60.	<i>G. springateana</i> D. Maity	4500- 4800	SK	--
61.	<i>G. stellata</i> Turriill	4000-6000	J&K, HP, UTK	Bhutan, China, Nepal
62.	<i>G. stipitata</i> Edgew.	3200-4600	HP, UTK	China, Nepal
63.	<i>G. squarrosa</i> Ledeb.	1000-4200	J&K, SK	China, Nepal, Pakistan
64.	<i>G. straminea</i> Maxim.	2000-5000	SK	China, Nepal
65.	<i>G. tetrasticha</i> C. Marquand	4200-5300	SK	China
66.	<i>G. tetrasepala</i> Biswas	3800-4700	UTK	--
67.	<i>G. tianschanica</i> Rupr. ex Kusn.	1200-3900	J&K, HP, UTK	China, Nepal, Pakistan
68.	<i>G. tibetica</i> King ex Hook.f.	2100-4200	HP, SK	Bhutan, China, Nepal
69.	<i>G. tubiflora</i> (G.Don) Griseb.	4000-5300	J&K, HP, UTK, SK	Bhutan, China, TAR, Nepal,
70.	<i>G. urnula</i> Harry Sm.	3900-5700	SK	Bhutan, China, Nepal
71.	<i>G. veitchiorum</i> Hemsl.	2500-4800	J&K, UTK, SK	Bhutan, China, Myanmar
72.	<i>G. venusta</i> (G.Don) Wall. ex Griseb.	3000-5800	J&K, HP, UTK	Pakistan, Nepal, TAR
73.	<i>G. verna</i> subsp. <i>pontica</i> (Soltok.) Hayek	2000- 4650	SK	--

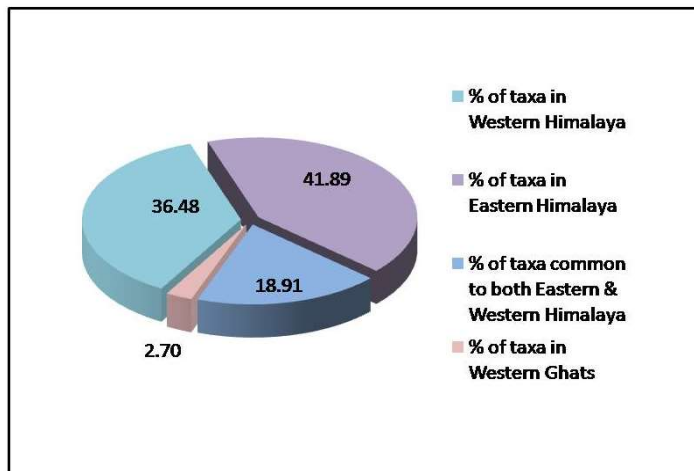


Fig. 1. Distribution of infra-specific taxa of *Gentiana* L. in India

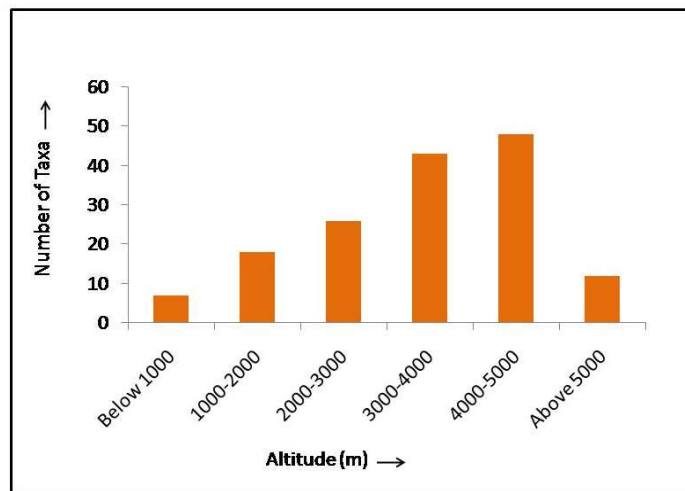


Fig. 2. Altitudinal distribution of the genus *Gentiana* L. in India

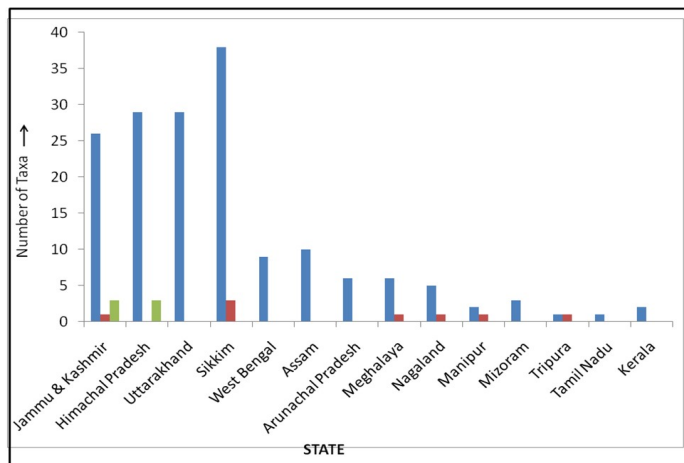


Fig. 3. Distribution of genus *Gentiana* L. in different states in India

species, namely *G. seginoides* and *G. tetrasepala* that are endemic at the global level and interestingly, both these species have been recently rediscovered after a period of more than a century (Rawat 2009; Rawat *et al.* 2016). In the Eastern Himalaya, Sikkim has been identified as the most favorable habitat for the genus where 42 taxa occur, out of which 19 taxa are exclusively confined to this state. Thus, Sikkim Himalaya can be considered as a hotspot for *Gentiana* species.

The luxuriant growth of *Gentiana* is directly related to the specific climatic make-up and geography of the ecological niche. The distribution when plotted against the altitudinal gradient reveals a hump-shaped curve as depicted in Figure 2. Maximum concentration of the taxa is found at an altitudinal gradient between 4000 – 5000 m amsl (48 taxa). Most of the taxa are found in sub-alpine and alpine zones of the Himalayas and forms a group of high altitude flowering plants suggesting a unimodal relationship between species richness and altitude. Some richness was found to be affected by increasing altitude and was highest in the mid-altitudinal ranges viz. 2000 – 3000, 3000 – 4000, and 4000 – 5000 (Figure 3). Few species, such as *G. clarkei*, *G. nubigena*, *G. tetrasticha*, *G. tubiflora*, *G. urnula*, and *G. venusta* are found above 5000 m amsl., and one species *G. stellata* is found distributed at an altitude of 6000 m amsl. The deduction of species in higher altitudinal gradient could be attributed to eco-physiological constraints, such as extremely low temperature, short duration of growing season and geographical barriers. Further, the lower altitude is prone to frequent anthropogenic disturbances such as construction of roads, human inhabitation and agricultural practices, which result in the replacement of natural vegetation with man-made ecosystems consisting of plantation and agriculture. The deduction can also be attributed to unstable mountains and frequent rock falls and avalanche, although, pastures among fixed block at the base of screes offer relatively stable habitats.

In the present scenario, the taxonomic study of *Gentiana* has been undertaken for the real time assessment and the status of the genus. Since, several taxa of this genus are critically endangered and enlisted in Red Data Book (Behera & Raina 2012; Maity 2014; Kumar *et al.* 2015) it is of utmost need and importance to evaluate and assess the diversity along with population trends to enable research for determining optimal conditions for the survival and conservation of these highly important medicinal plant species.

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