NDC E-BIOS (Online) Volume 5, pp 15-23 (2025) ISSN: 2583-6447
DOI: https://doi.org/10.5281/zenodo.19291267

ORIGINAL ARTICLE

TAXONOMIC ACCOUNT OF GYMNOSPERMS OF ZEMU AND LHONAK VALLEY, SIKKIM

Sentu Kumar Dey
Department of Botany, South Calcutta Girls' College, 72, Sarat Bose Road, Kolkata 700025
Correspondence: deysentukumar@gmail.com

ABSTRACT

The Zemu and Lhonak Valleys of Sikkim Himalayas represent one of the most floristically rich yet least explored regions of the Eastern Himalayas. Situated within the Kanchenjunga Biosphere Reserve, this area harbours diverse gymnosperm taxa forming important components of the montane and subalpine vegetation. The present study documents and taxonomically evaluates the gymnosperm flora based on extensive field surveys conducted between 2012 and 2015, along with critical examination of historical and contemporary herbarium materials preserved at CAL, BSHC, and CUH. A total of **eight taxa under four families** (Cupressaceae, Ephedraceae, Pinaceae, and Taxaceae) have been recorded from the region, including detailed notes on distribution, diagnostic characters, and nomenclatural citations. Artificial keys for genera and species are provided for easy identification.

Keywords: Gymnosperms, Zemu Valley, Lhonak Valley, Sikkim Himalayas, taxonomy, floristics.

Communicated: 7.11.2025 Revised: 12.11.2025 Accepted: 1.12.2025

INTRODUCTION

Sikkim, often referred to as the *"Botanists' Paradise"*, forms a crucial part of the **Eastern Himalayas biodiversity hotspot** and harbours exceptional floristic diversity (Hooker, 1849; Srivastava, 2012). The region is home to 137 endangered plant species, with 71 reported from the Eastern Himalayas alone. Within Sikkim, the **Zemu and Lhonak Valleys,** forming a continuous high-altitude ecosystem within the **Kanchenjunga Biosphere Reserve,** constitute one of the richest centres of plant endemism and diversity.

Geographically, the study area (27°51′–28°56′ N and 88°08′30″–88°33′ E) covers approximately **828 km²,** encompassing rugged terrain, glaciers (notably Zemu and Lhonak), high-altitude lakes, and alpine meadows. Elevations range from **3,300–8,595 m**, creating a complex mosaic of habitats. The area receives **200–500 cm** of annual rainfall, with humidity

exceeding 70% throughout most of the year (Bandyopadhyay & Singh, 1998; Tambe *et al.*, 2011).

Vegetation is dominated by **evergreen coniferous forests** between 3,300–4,000 m, featuring *Abies densa*, *Tsuga dumosa*, *Larix griffithii*, and species of *Juniperus*. The region also supports *Ephedra gerardiana var. sikkimensis* in alpine scrub zones. Local inhabitants (Lepcha, Bhutia, and Nepali communities) depend heavily on forest resources for livelihood, fuel, medicine, and agriculture.

Although early collections were made by **Smith & Cave (1911),** no comprehensive account focusing exclusively on the gymnosperms of this region has been published. The present study aims to (i) document gymnosperm taxa of the Zemu and Lhonak Valleys, (ii) provide diagnostic keys for identification, and (iii) update nomenclature following the **International Code of Nomenclature** (McNeill *et al.*, 2012).

MATERIALS AND METHODS

Field surveys were conducted in the **Zemu and Lhonak Valleys, Sikkim Himalayas**, during **2012–2015** through **12 expeditions** (average duration ~12 days each) in the **pre-monsoon (March–April)**, **monsoon (June–August)**, and **post-monsoon (October–November)** seasons. Each collection generally comprised **three specimens per gathering**. Collected materials were **pressed, dried, fumigated, poisoned, and mounted** following standard herbarium techniques. Voucher specimens are deposited in the **Calcutta University Herbarium (CUH)**, with duplicates at the **Herbarium of the Sikkim State Forest Department**.

Identification of specimens was carried out using **relevant taxonomic literature** and verified through comparisons with authenticated materials housed at **CAL (Howrah)**, **BSHC (Gangtok)**, and **CUH (Kolkata)**. Morphological examinations were performed under **dissecting and zoom microscopes**, and **floral dissections** were made where necessary. Representative taxa are illustrated with line drawings.

Specimens are cited as **exsiccata**, including historical collections by **Smith & Cave (1911)** and subsequent materials deposited by the **Botanical Survey of India**. The **classification of angiosperms** follows **Takhtajan (1997)** with modifications from **Hutchinson (1973)**, **Cronquist (1981)**, and **Thorne (2000)**. Diagnostic **keys to genera and species** are provided where relevant. For each taxon, **nomenclature, diagnostic characters, distribution (including altitude), and taxonomic notes** are included.

During fieldwork, observations on **topography, habitat characteristics, and dominant vegetation** were recorded and supplemented with published sources (Hajra & Mudgal 1997; Maity & Chauhan 2002).

TAXONOMIC ACCOUNT

CUPRESSACEAE

JUNIPERUS Linn.

Key to the species:

1. Leaves dimorphic, both needle and scale like……..……***J. pseudosabina***
– Leaves monomorphic, only needle like……**2**
2. Shrub to small tree; branches pendulous or curved……***J. recurva***
– Prostrate shrub, branches straight or slightly curved……***J. squamata***

J. pseudosabiana Fischer & Meyer, Index Sem. Hort. Petrop. 1842: 15, 65. 1842; Hook. *f*. in Hook. *f*., Fl. Brit. India 5: 646. 1888; Grierson & Long, Fl. Bhutan 1(1): 55. 1984; Ligue *et al*. in Wu & Raven (eds.), Fl. China 4 : 77. 1999.
Juniperus indica Bertol., Misc. Bot. 23: 228, t. 1. 1862.
Juniperus wallichiana Hook. *f*. & Thoms. (ex Parl. in DC., Prodr. 16(2): 482. 1868, pro syn.) ex Brandis, For. Fl. Ind.: 537. 1874.
J. psudosabiana auct. non Fisch. & Mey.: Hook. *f*. in Hook. *f*., Fl. Brit. India 5: 646. 1888.

Bushy, erect or procumbent, dioecious, robust shrub to tree, to 20 m high; stems straight, 4–angled rarely terate; leaves dimorphic, needle–like in lower shoot, scale like, ovate imbricated in terminal branchlets, 4–8 mm long, acuminate at apex; male cones ovoid or subglobose; female cones bluish black or brownish black when ripe.

Distribution: INDIA: Himalayas: Jammu & Kashmir, Himachal Pradesh, Uttaranchal, Sikkim; KAZAKSTAN; KYRGYZSTAN; TAJIKISTAN; UZBEKISTAN; MONGOLIA; AFGHANISTAN; PAKISTAN; NEPAL; BHUTAN; CHINA. [2000–4900 m].
Exsiccata: Zemu & Lhonak, 11000–16000 ft. (3300–4850 m), *Smith & Cave* 1091, 1563, 1676 [all at CAL].

J. recurva Buch. – Ham. ex D. Don, Prodr. Fl. Nepal. 2: 55. 1825; Hook. *f*. in Hook. *f*., Fl. Brit. India 5: 647. 1888; Grierson & Long, Fl. Bhutan 1(1): 54. 1984; Ligue *et al*. in Wu & Raven (eds.), Fl. China 4: 72. 1999. **[Pl. 1- A].**
Juniperus exelsa auct. non Bieb.: Brandis, For. Fl. Ind.: 538, t. 68. 1874.
J. macropoda auct. non Boiss.: Hook. *f*. in Hook. *f*., Fl. Brit. India 5: 647. 1888.
Monoecious or sometimes dioecious, shrub or tree, to 20 m high; sometimes prostrate shrub; branches recurved at apex; branchlets pendulous; leaves arranged in whorls, homomorphic, needle–like, appressed, greenish white abaxially; male cones axillary, ellipsoid–ovoid, ovoid or oblongoid; female cones axillary, globose.

Distribution: INDIA: Himalayas: Jammu & Kashmir, Himachal Pradesh, Uttaranchal, Sikkim; Assam, Meghalaya; AFGHANISTAN, PAKISTAN; NEPAL; BHUTAN; TIBET; CHINA; MYANMAR. [1800–4600m].
Exsiccata: Zemu & Lhonak, 10000–15000 ft. (3000–4550m), *Smith & Cave s.n.*; very common throughout the Biosphere Reserve specially on alpine meadows.

J. squamata Buch. – Ham. ex D. Don in Lambert, Descr. Pinus 2: 17. 1824; Grierson & Long, Fl. Bhutan 1(1) : 54. 1984; Liguo *et al*. in Wu & Raven (eds.), Fl. China 4: 73. 1999. **[Pl. 1-B].**
J. recurva var. *squamata* (Buch. – Ham. ex D. Don) Parlatore in DC., Prodr. 16(2): 482. 1868; Hook. *f*. in Hook. *f*., Fl. Brit. India 5: 647. 1888.

Bushy, erect or prostrate shrub or small tree, to 1.5 m; stems ascending or horizontally spreading, straight or curved; leaves broader, straight or often incurved, 3–10 × 1–1.5 mm; male cone ovoid or oblongoid; female cone ovoid, black or bluish black.

Distribution: INDIA: Himalayas: Jammu & Kashmir, Himachal Pradesh, Uttaranchal, Sikkim; AFGHANISTAN; PAKISTAN; NEPAL; BHUTAN; TIBET; CHINA; MYANMAR. [2300–4900 m].
Exsiccata: Lhonak, 14000–16000 ft. (4200–4850m), *Smith* & *Cave s. n.* [all at CAL].

EPHEDRACEAE
***EPHEDRA* Linn.**
E. gerardiana Wall. ex Meyer, Mem. Acad. Imp. Sci. Saint–Petersbourg, ser. 6. Sci. Math., Seconde Pt. Sci. Nat. 5: 292 (Vers. Mongr. Gatt. Ephedra 102). 1846; Grierson & Long, Fl. Bhutan 1(1) : 56. 1984; Liguo *et al*. in Wu & Raven (eds.), Fl. China 4: 100. 1994.

var. sikkimensis Stapf. in Akad. Wiss. Wien, Math. Naturwiss. Kl. Denkchr. 56(2): 76. 1889; Grierson & Long, Fl. Bhutan 1(1): 56. 1984.
Ephedra vulgaris auct. non-Richard: Hook. *f*. in Hook. *f*., Fl. Brit. India 5: 640. 1888.
E. saxatilis Royle ex Florin var. *sikkimensis* (Stapf) Florin in Kungl. Svenska Vetenskapsakad. Handl., ser. 3, 12(1) : 28. 1933.

Tufted, shrub, to 30 (–1.5) cm high; stems woody, greenish–brown; leaves opposite, 2–3.5 mm, ovate, scale like, sessile; male flowers in opposite clusters; bracts in 3 or 4 pairs; female cone solitary or shortly pedunculate, subglobose, flowers in opposite pairs; seeds ovoid, obovoid–oblongoid, red, fleshy.

Distribution: INDIA: Himalayas: Jammu & Kashmir, Himachal Pradesh, Uttaranchal, Sikkim; TAJIKISTAN; AFGHANISTAN; PAKISTAN; NEPAL; BHUTAN; CHINA; EUROPE. [2300–5300m].
Exsiccata: Thangu, *Raju* 8142; Thangu, 4200m, *Maity* 25800 (also seen in Lhonak valley).

PINACEAE
Key to the genera:

1. Plants with densely leafy lateral short branchlets; leaves in bundles …. ***Larix***
– Plants without short lateral densely leafy branchlets; leaves never in bundles……...……**2**
2. Leaf scars peg like……..... ***Picea***
– Leaf scars orbicular or elliptic, never peg like…… **3**
3. Female cones of previous years persistent…… ***Tsuga***
– Female cones of previous years disintegrated……. ***Abies***

***ABIES* Miller**

A. spectabilis (D. Don) Mirb. in Mem. Mus. Hist. Nat. Paris 13: 70. 1825; Hook. *f*. in Fl. Brit. India 5: 654. 1888; Hook. *f*. in Hook. *f*., Fl. Brit. India 5: 654. 1888; Liguo *et al*. in Wu & Raven (eds.), Fl. China 4: 51. 1999. **[Pl. 1- C].**

Pinus spectabilis D. Don in Lambert, Descr. Gen. Pinus 2: 3, t. 2. 1824; Prodr. Fl. Nepal. 55. 1825.

Pinus spectabilis D. Don, Prodr. Fl. Nepal. 2: 55. 1825.

Pinus tinctoria Wall. ex D. Don, *tom. cit*.: 3. 1824, *pro syn*.

Abies webbiana (Wall. ex D. Don) Lindl. in Penny Cycl. 1: 30. 1833. *nom. illegit*; Hook. *f*. in Hook. *f*., Fl. Brit. India 5: 654. 1888.

Pinus webbiana Wall. ex D. Don, Prodr. Fl. Nepal. 55. 1825, *pro syn*.

Large, lofty tree, to 50 m tall; stems yellowish–gray with brown or reddish brown, furrowed; leaves ascending on upper side, linear, 2–6 cm long, green above, white below, margin inrolled; female cones erect, oblongoid, dark purple, maturing to dark brown or blue–brown.

Distribution: INDIA: Himalayas: Jammu & Kashmir, Himachal Pradesh, Uttaranchal, Sikkim; AFGHANISTAN; NEPAL; BHUTAN; CHINA. [2300–4000m].

Exsiccata: Zemu, 9000–12000 ft. (2700–3600m), *Smith & Cave* 1391 [at CAL].

***LARIX* Miller**

L. griffithii Hook. *f*., Himal. Jour. 1: 255–256, 2: 44. 481. 1854; in Hook. *f*., Fl. Brit. India 5: 655. 1888; Grierson & Long, Fl. Bhutan 1(1): 46. 1984; Liguo *et al*. in Wu & Raven (eds.), Fl. China 4: 33. 1999.

Larix griffithiana Carr., Traite Gen. Conif. 278. Jan. 1855.

Pinus griffithiana (Carr.) Voss in Mitt. Deutsch. Dendr. Ges. 16: 93. 1908.

P. griffithii (Hook. *f*.) Parlatore in DC., Prodr. 16(2): 411. 1868; non McClelland. 1854.

Medium sized, deciduous tree, to 20 m high; bark gray–brown; leaves, acicular in dense clusters, 25–55 × 1–1.8 mm; male cones ovoid, cylindric or cylindric–ellipsoid, 5–11 × 2.2–3 cm, brown or light brown, bracts ovate or obovate–lanceolate.

Distribution: INDIA: Himalayas: Sikkim; Assam, Meghalaya; NEPAL; BHUTAN; TIBET; CHINA. [1400–4100m].

Exsiccata: Lachen, Zemu, Lachung, 8000–10000 ft. (2400–3000m), *Smith & Cave* 2600, 2771; very common from Zema II towards Logbridge.

***PICEA* A. Dietrich**

P. spinulosa (Griff.) A. Henry, Gard. Chron., ser. 3, 39: 219. 1906; Grierson & Long, Fl. Bhutan 1(1): 48. 1984; Liguo *et al*. in Wu & Raven (eds.), Fl. China 4: 31. 1999.

Abies spinulosa Griff., J. Trav. 259. 1847.

P. morinda auct. non Link.: Hook. *f*. in Hook. *f*., Fl. Brit. India 5: 653. 1888.

Tall, tree, to 60 m high; branchlets pendulous; leaves spreading on lower side, acicular, flattened or subflattened, broadly rhombic or tetragonous in cross section, 1.5–3.5 cm × 1.1–1.8 mm, slightly keeled on both surfaces pungent; male cone ovoid, drooping; female cone cylindric, pendulous.

Distribution: INDIA: Himalayas: Sikkim; NEPAL; BHUTAN; CHINA. [2400–3600 m]. Exsiccata: Lachen to Logbridge, *Raju & Singh* 5887; Zema to Logbridge, *Singh & Dash* 19937 [all at BSHC]; Zemu, 8000–9000 ft. (2400–2700m), *Smith & Cave* 1021, 2731 [all at CAL].

Plate 1: A- *Juniperus recurva*, B- *Juniperus squamata*, C- *Abies spectabilis* (inset: cone)

***TSUGA* (Endl.) Carr.**

T. dumosa (D. Don) Eichler in Engl. & Prant., Nat. Pflanzenfam. 2(1): 80. 1887; Grierson & Long, Fl. Bhutan 1(1) : 50. 1984; Liguo *et al*. in Wu & Raven (eds.), Fl. China 4: 40. 1999.
Pinus dumosa D. Don in Lambert, Descr. Pinus 2: 55. 1824.
Abies dumosa (D. Don) Mirbel in Mem. Mus. Hist. Nat. Paris 13: 70. 1825.
Pinus brunoniana Wall., Pl. As. Rar. 3: 24. t. 247. 1832.
Abies brunoniana (Wall.) Lindl. in Penny Cyclop. 1: 30. 1833.

Tsuga brunoniana (Wall.) Carr., Traite, Gen. Conif., 1: 188. 1867; Hook. *f.* in Hook. *f.*, Fl. Brit. India 5: 654. 1888.

Tall, monoecious, evergreen tree, to 40 m high; bark brownish gray or gray-brown, thick, longitudinally fissured; leaves linear–oblong or linear–lanceolate, 10–30 × 1.5–3 mm, grooved adaxially, white beneath, margin recurved; cones ovoid to subglobose.

Distribution: INDIA: Himalayas: Uttaranchal, West Bengal, Sikkim; NEPAL; BHUTAN; CHINA; MYANMAR; VIETNUM. [2100–3600 m].
Exsiccata: Lachen, *Chakraborty* 2289; Zemu, 8–10000 ft. (2400–3000m), *Smith & Cave* 2742 [at CAL].

DISCUSSION

The gymnosperm flora of the Zemu and Lhonak Valleys, though numerically limited, forms an ecologically and biogeographically significant component of the high-altitude vegetation of the Eastern Himalayas. The dominance of conifers such as *Abies spectabilis*, *Tsuga dumosa*, *Larix griffithii*, and *Picea spinulosa* between 2,400–4,000 m defines the montane and subalpine forest belts of northern Sikkim. These species not only stabilize steep mountain slopes and regulate hydrological balance but also serve as crucial habitats for several faunal elements, including pheasants, red panda, and musk deer.

The genus *Juniperus*, represented by three taxa (*J. pseudosabina*, *J. recurva*, and *J. squamata*), is characteristic of higher altitudes (3,000–4,800 m) and transitions gradually into alpine scrub and grassland communities. The distributional range of these taxa corresponds closely with cold-arid habitats and rocky slopes, where they function as pioneer species aiding soil stabilization and ecological succession.

Ephedra gerardiana var. sikkimensis occupies an even more specialized niche within the dry alpine zones of Thangu and Lhonak. Its restricted occurrence suggests adaptation to xeric conditions and extreme cold, making it a sensitive indicator of climatic variation in the trans-Himalayan ecosystem. The rediscovery of this taxon from Lhonak after its early record by Stapf (1889) is notable and reinforces the floristic continuity of the region over more than a century.

Comparison with earlier collections by Smith & Cave (1911) reveals a remarkable persistence of most taxa despite localized anthropogenic pressures, grazing, and tourism-induced disturbances. However, subtle range shifts in *Juniperus* and *Ephedra* populations were observed, possibly linked to recent climatic warming trends documented for Sikkim (Tambe et al., 2011). The absence of large-scale habitat loss, coupled with the inaccessibility of many high-altitude sites, may have contributed to the continued survival of these gymnosperms.

From a phytogeographical perspective, the composition of the gymnosperm flora of the Zemu–Lhonak sector exhibits strong Himalayan–Central Asian affinities, sharing several species with

Nepal, Bhutan, and southwestern China. This highlights the region's role as a corridor of floristic exchange between the Eastern Himalayas and the Tibetan Plateau.

Overall, the study underlines that although gymnosperm diversity is lower compared to the angiosperm-rich temperate flora, these taxa represent some of the oldest lineages of seed plants, providing insight into the evolutionary history of Himalayan vegetation. Their conservation is therefore of both ecological and evolutionary importance.

CONCLUSION

The present study provides an updated and comprehensive taxonomic account of gymnosperms in the Zemu and Lhonak Valleys of Sikkim Himalayas, documenting eight taxa under four families—Cupressaceae, Ephedraceae, Pinaceae, and Taxaceae. Despite the limited number of species, their ecological dominance and significance in alpine and subalpine ecosystems are profound.

These conifers and allied gymnosperms play key roles in maintaining the structural integrity and ecological balance of high-mountain forests, influencing microclimate regulation, carbon sequestration, and soil conservation. The persistence of historically recorded species underscores the resilience of these taxa but also calls for regular monitoring in light of ongoing climatic changes.

Given their restricted habitats, slow regeneration rates, and sensitivity to temperature and moisture fluctuations, conservation strategies should prioritize in situ protection of natural stands, regulation of grazing and tourism, and ex situ propagation of rare taxa such as *Ephedra gerardiana var. sikkimensis* and *Juniperus squamata*. Collaborative research combining field botany, molecular taxonomy, and ecological monitoring will be essential to understand population dynamics and to formulate effective conservation management plans.

In conclusion, the gymnosperms of the Zemu and Lhonak Valleys, though few in number, represent a vital and ancient component of Sikkim's montane biodiversity. Their continued survival reflects both the ecological stability and the conservation potential of this fragile Himalayan landscape.

ACKNOWLEDGEMENTS

The author expresses sincere gratitude to **Dr. D. Maity**, Department of Botany, University of Calcutta, for his valuable guidance and constant encouragement throughout the course of this work. Grateful thanks are extended to the **Department of Forests, Environment and Wildlife Management, Home Department, Government of Sikkim,** the **Superintendent of Police, Gangtok**, and the **17th Mountain Division, Indian Army**, for granting the necessary permissions and providing logistical support during field visits. Thanks, are also due to the **Botanical Survey of India (CAL and BSHC)** for granting access to herbarium materials and

related facilities. The author is very much thankful to the Principal, South Calcutta Girls' College for the continuous encouragement and support

REFERENCES

Bandopadhyay, S. and Singh, T. P. 1998. Climatology with reference to Sikkim. In: Rai, S. C., Sundriyal, R. C. and Sharma, E. (eds.), *Sikkim Perspectives for Planning and Development*. Sikkim Science Society, Tadong, Sikkim. pp. 49–58.

Cronquist, A. 1981. *An Integrated System of Classification of Flowering Plants*. Columbia University, New York.

Hooker, J. D. 1872–1897. *The Flora of the British India.* Vols. 1–7. L. Reeve & Co. Ltd., Kent.

Hooker, J.D. & Thomson, T. 1854. On *Maddenia* and *Diplarche*, new genera of Himalayan plants. *Hooker's Journal of Botany and Kew Garden Miscellany* 6: 380 – 384, t.11, 12.

Hutchinson, J. 1973. *The Families of Flowering Plants Arranged According to a New System Based on Their Probable Phylogeny*. Oxford (3rd ed.).

Maity, D. & Chauhan, A. S. 2002. Kachanjunga Biosphere Reserve. In: Singh, N. P. and Singh, K. P. (eds.), *Floristic Diversity and Conservation Strategies in India* Vol. 5. Botanical Survey of India, Kolkata. pp. 2585–2625.

McNeill, J., Barrie, F. R., Buck, W. R., Demoulin, V, Greuter, W., Hawksworth, D. L., Herendeen, P. S., Knapp, S., Marhold, K., Prado, J., Prud'homme Van Reine, W. F., Smith, G. F., Wiersema J. H. &Turland, N. J. (eds.). (2012) *International Code of Nomenclature for algae, fungi, and plants (Melbourne Code)*. Regnum Vegetabile 154. A.R.G. Gantner.

Srivastava, P. K. 2012. Value–addition opportunities in Sikkim and technologies for processing of organic produce. In: Tamang, Pushpa, Shrivastava, A. K. and Lepcha, S. R. (eds.), *Sikkim Biodiversity, Significance and Sustainability*. Sikkim State Council of Science & Technology, Govt. of Sikkim, Gangtok. pp. 238 – 251.

Takhtajan, A. L. 1997. *Diversity and Classification of Flowering Plants*. Columbia University Press, New York.

Tambe, S., Arrawatia, M. L., Bhutia, N. T. and Swaroop, B. 2011. Rapid, cost effective and high-resolution assessment of climate-related vulnerability of rural communities of Sikkim Himalayas, India. *Curr. Sci.* 101(1):1-9.
