A catalogue of the higher plants of the Adhwani temperate forest and its fringe areas (western Himalaya, India)

Ajendra Sing Bagri (✉ ajendrabagri@gmail.com)

Pt LMS Govt. PG Degree College Rishikesh, Dehradun, Uttarakhand. <https://orcid.org/0000-0003-0179-0588>

Neeraj Singh

Hemvati Nandan Bahuguna Garhwal University Srinagar Garhwal Uttarakhand <https://orcid.org/0000-0003-4567-3463>

Gulshan Kumar Dhingra

Pt LMS Govt. PG Degree College Rishikesh, Dehradun Uttarakhand.

Prabhawati Tiwari

Hemvati Nandan Bahuguna Garhwal University Srinagar Garhwal Uttarakhand. <https://orcid.org/0000-0001-5067-4239>

Research Article

Keywords: Himalayan forests, Uttarakhand, Phytodiversity, Invasive plants, Indigenous uses

Posted Date: January 25th, 2022

DOI: <https://doi.org/10.21203/rs.3.rs-1283977/v1>

License: © ⓘ This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

Abstract

The present study deals with floristic inventory of higher plants (angiosperms and gymnosperms) at a biodiversity rich temperate forest area (Adhwani forest; 30°06'1"–30°06'7" N and 78°72'3" –78°72'6" E; 1700–2200 m asl) in western Himalaya, India. A total of 477 species of flowering plants belonging to 105 families and 315 genera were recorded from the Adhwani forest and its fringe areas. The information on plant life form, flowering & fruiting, local elevational distribution, indigenous uses and availability status are provided. An account of the invasive and alien species occurring in the area is also provided.

Gentiana cephalodes Edgew. (Gentianaceae) and *Buddleja crispa* Benth. (Buddlejaceae) revealed as new distribution record to the flora of district Garhwal. Asteraceae (47 species and 33 genera) was the dominant family followed by Fabaceae, Poaceae, Lamiaceae, Rosaceae and Ranunculaceae. *Desmodium* (9 species) was dominant genus in the study area followed by *Crotolaria*, *Cyperus* and *Euphorbia* (6 species each). The herbs dominate the life forms of the area with 317 species (66.45%) followed by shrubs (14.46%), trees (12.99%) and climbers (6.07%). The flora of the area represents 3 IUCN index species viz. *Quercus lamellosa* (NT), *Quercus oblongata* (NT), *Ulmus wallichiana* (VU) and 90 invasive alien species. The presented catalogue with comprehensive information on of higher plants will be helpful to the plant scientists, planners and forest department for developing strategies and management of this biodiversity rich forest area.

1. Introduction

Uttarakhand, a great repository of flora and fauna, represents western Himalayan landscape of Indian Himalaya. It has unique topographic feature and wide elevational range with ca. 70% forest cover. The forest area of the state can be categorized into very dense forest (5046.76 km²), moderately dense forest (12,805.24 km²) and open forest (6,451.04 km²) on the basis of forest canopy density¹. The forest vegetation of the state extends from tropical dry deciduous forests in the foothills to dry temperate forests at timber line and alpine meadows up to snow line. The temperate forests of the region consists of oak forests, moist deodar forests, mixed coniferous forests, blue pine forests, fir forests, Rhododendron forests, chir-pine forests, etc. The most common coniferous species of the temperate forests are silver fir (*Abies pindrow*), blue pine (*Pinus wallichiana*), Himalayan cedar (*Cedrus deodara*), Himalayan cypress (*Cupressus torulosa*), spruce (*Picea smithiana*), Himalayan yew (*Taxus wallichiana*) and chir-pine (*Pinus roxburghii*). In Indian Himalaya, forests in the vicinity of human settlements play an important role in the life and livelihood of local people. The dependence on the forest in the vicinity for the basic needs like fodder, fuel wood, timber, medicines, etc. is part of livelihood and economy². Extraction of natural resources from forests often leads to forest degradation.

The botanical exploration in the state got acceleration after establishment of Botanical Garden in Saharanpur (in 1887) and Forest Research Institute in Dehradun (in 1906). Various workers have contributed valuable information to the flora of the Uttarakhand since long past^{3–17}. The state

representing about 4,700 species of flowering plants and embodies more than one-fourth of the total vegetation of India¹⁶.

Floristic survey to document the floral elements is one of the important steps towards the biodiversity assessment of any region. Thorough collection, identification and documentation of plants from any ecoregion is an essential step to evaluate the total biodiversity wealth at regional scale¹⁸.

Comprehensive and updated floristic checklist help researchers, policy makers, naturalists and forest personnel in understanding the vegetation of particular area and in carrying out management activities.

The objectives of this study was to document the flowering plants (angiosperms and gymnosperms) with their local name, flowering & fruiting phenology, elevational distribution, availability status and utility values in the area (Adhwani forest area).

2. Materials And Methods

2.1 Study area

The present study was carried out in a temperate forest (Adhwani forest) of Garhwal Himalaya, Uttarakhand, India. It lies between 30°06'1"–30°06'7" N and 78°72'3" –78°72'6" E with elevation range 1700–2200 m asl. Climatic condition of the Adhwani forest is characterized by cold winter and pleasant summer with annual temperature range between 3–29°C and annual rainfall between 100 cm to 150 cm. The area is dominantly covered by large coniferous tree (*Pinus roxburghii* Sarg.) at the lower elevation and in periphery while broadleaved species (*Quercus oblongata* D.Don, *Rhododendron arboreum* Sm., etc.) are dominate towards deeper and ridge top stands. The area surrounded by many villages including Kathood, Thapli, Kaljikhali, Manjakot and Pokhri. The inhabitants of these villages are dependent on this forest for various needs especially medicine, fodder and timber resources. Motor road (Danda Nagraja motor) also pass through the forest.

2.2 Methodology

Extensive field surveys were conducted in different localities i.e. road sides, village edges, streams sides of Adhwani forest area between 2017 and 2020 to assess the floristic diversity of higher plants (gymnosperms and angiosperms). The plant specimens were collected, pressed, dried and identified with the help of floras^{9,13} and Herbaria (GUH, DD and BSD). Information about local name, life form, fruiting & flowering period, elevational distribution and availability status was gathered during the field surveys. The availability status (i.e. common, uncommon and rare) of each species was determined on the basis of field observation. Common status given to the species occurred abundantly in the area, uncommon status represents the species occurred in patches or scattered form while rare status mentions the species which were recorded in only population or with a few individuals in the area. Information on local uses of plants was collected from local informants of the area including local healers, *vaidyas* (traditional medical practitioners), elder men and women. Plants were classified according to Bentham and Hooker's system of classification¹⁹. Taxonomical categories (genera and species) within the family were

arranged alphabetically. Only one recent accepted name of each taxa given here (excluding synonyms) following online plant databases (<http://www.theplantlist.org/>, <https://www.tropicos.org/home>, <https://www.ipni.org/> assessed on 29 Dec 2020).

3. Results And Discussion

A total of 477 plant species (473 angiosperms and 4 gymnosperms) belonging to 105 families (103 angiosperms and 2 gymnosperms) and 315 genera (312 angiosperms and 3 gymnosperms) were recorded from the study area (**Appendix 1**). Dicotyledons were represented by 408 species, 263 genera and 94 families, whereas monocotyledons by 65 species, 49 genera and 9 families. The occurrence 477 plant species (higher plants) in single temperate forest area (Adwani forest) suggests that the Adwani forest has sustained very rich plant diversity. However, anthropogenic pressure may threat the diversity of the area. The habitat degradation, over grazing, forest fire and over exploitation can cause forest degradation in the future.

Gentiana cephalodes Edgew. [Specimen examined: Uttarakhand, Pauri district, Adhwani Forest, 2000 m, 20-07-2018, A.S. Bagri and N. Singh; 20982 (GUH)] of Gentianaceae and *Buddleja crispa* Benth. [Specimen examined: Uttarakhand, Pauri district, Adhwani Forest, 1710 m, 30-09- 2018, N. Singh and A.S. Bagri; 308860 (LWG)] of Buddlejaceae revealed as new distribution record to the flora of district Garhwal¹³.

Among the families, Asteraceae with 47 species revealed as dominant family followed by Fabaceae, Poaceae, Lamiaceae, Rosaceae, Ranunculaceae, Solanaceae, Cyperaceae and Urticaceae (Table 1). *Desmodium* (9 species) was the dominant genera followed by *Crotolaria*, *Cyperus* and *Euphorbia* (6 species each), *Ficus*, *Polygala*, *Swertia* (5 Species each), *Clematis*, *Gentiana*, *Rubus* (4 species each), *Anaphalis*, *Androsace*, *Berberis*, *Cornus*, *Persicaria*, *Rumex*, *Salix*, *Tagetes* and *Viola* (3 species each). The herbs with 317 species (66.45%) dominate the life forms of the area (Fig. 1) followed by shrubs (14.46%), trees (12.99%) and climbers (6.07%). The findings are agreed with Suyal et al.²⁰, Sharma et al.²¹, Rawat et al.²² who also reported Asteraceae as the dominant family in the adjoining area.

Table 1
Dominant families of the study area

Familes	Species %	Genera %
Asteraceae	9.81	10.12
Fabaceae	7.51	5.52
Poaceae	6.89	8.28
Lamiaceae	6.26	6.13
Rosaceae	3.76	3.68
Ranunculaceae	2.51	1.54
Cyperaceae	2.09	1.53
Gentianaceae	1.88	0.93
Rubiaceae	1.88	2.15
Solanaceae	1.88	1.53
Total	44.47	41.41

As per indigenous uses maximum 296 species are used as medicinal, followed by fodder (151 species), and edible species (37 species). *Asparagus adscendens*, *Barlaria cristata*, *Begonia picta*, *Phyllanthus emblica*, *Thalactrium foliolosum*, *Tinospora sinensis*, *Valerina jatamansii* and *Zanthoxylum armatum* are some of the commonly used medicinal plants in the area. Common wild edible resources were *Cornus capitata*, *Myrica esculenta*, *Rhododendron arboreum*, *Rubus ellipticus*, *R. paniculatus* while *Cannabis sativa*, *Daphne papyracea* and *Grewia optiva* were commonly used fiber resources in the area. *Euonymous echinatus*, *Quercus* spp., *Ulmus wallichiana*, *Toona serrata* were used as fodder resources, *Boehmeria rugulosa*, *Pinus* spp., *Toona serrata* and *Salix* spp. as timber (**Appendix 1**).

The flora of the area represents 3 IUCN index species viz. *Quercus lamellosa* (NT), *Quercus oblongata* (NT), *Ulmus wallichiana* (VU) and 90 invasive and alien species (from 37 families) were reported from the area. Majority of the invasive and alien species belongs to family Asteraceae (10 species), Cyperaceae and Solanaceae (**Appendix 1**). The findings are agreed with ²³⁻²⁵ who also reported Asteraceae and Solanaceae among the top families.

Majority of the species 408 (85.17%) were of common occurrence while 41 (8.55%) uncommon and 30 (6.26%) rare (Fig. 2). The findings are agreed erlier studies from the nearby areas^{20-23,26}. Rare occurrence status was observed for *Astilbe rivularis*, *Fraxinus micrantha*, *Polygala tatarinowii*, *Sorbus acuparia*, *Swertia cordata*, *Ulmus wallichiana*, etc.

4. Conclusion

It is the first checklist of the flowering plants of Adwani forest of western Himalaya. Adwani forest has rich plant diversity with extremely high importance as medicine, fodder, fiber, timber, wild edible, etc. The unplanned use of forest resources and habitat degradation due to anthropogenic activities is threatening diversity in this forest area. This study has provided comprehensive information on altitudinal distribution of higher plants in Adwani forest which will be helpful to the plant scientists, planners and particularly to the state forest department for developing strategies and action plans for the management of this biodiversity rich forest. Forest product: timber non-timber can further enhance the rural livelihood of the adjacent villages with the sustainable use of forests. Forest based small industries i.e. bee-keeping, furniture industry, dairy, wild fruit and flowers processing centre have potential to control the migration of local villagers. Forest resources are abundantly present inside the forests which are economically viable and which have high potential for the economic development of the adjacent villages as well as the state.

Declarations

Competing interests: The authors declare the following competing interests: 1.To make a checklist of study area. 2.To collect the different local uses of plants. 3.During our field survey we have found few new records for the local flora so we want found some more information...is there any other unknown species missing in the record of local flora .i.e. flora of Garhwal or flora of uttrakhand.

Acknowledgments

The authors gratefully acknowledge the assistance extended by many local inhabitants during the field study. We are also thankful to the Head, Department of Botany & Microbiology, HNB Garhwal University, Srinagar (Garhwal) and Principal, Pt. LMS Govt. PG College Rishikesh (Dehradun) for providing the necessary laboratory facilities. We are grateful to Prof. J.K. Tiwari, Dr. Dinesh Singh Rawat and Mr Ankit Singh Rawat for their helps in plant identification.

CONTRIBUTORS

Mr A.S. Bagri is pursuing his PhD in Botany from HNB Garhwal University, Srinagar (Garhwal), Uttarakhand, India. In the current study, he has ontributed in field work, data analysis and manuscript writing.

Mr Neeraj Singh is pursuing his PhD in Botany from HNB Garhwal University, Srinagar (Garhwal), Uttarakhand, India. He has contributed in field work and data collection.

Dr G.K. Dhingra is currently working as a Professor at Deaprtment of Botany, Pt. LMS Govt. PG College, Rishikesh. In the current study, he has guided the research work.

Dr. P. Tiwari is currently working as a Professor at Department of Botany & Mcrobiolgy, HNB Garhwal University, Srinagar (Garhwal), Uttarakhand. She has conceived the idea and guided the field work.

References

1. FSI (Forest Survey of India). Indian State of Forest Report. Forest Survey of India. Ministry of Environment and Forests, Govt. of India. 2019.
2. Kala, C.P. Local preferences of ethnobotanical species in the Indian Himalaya: implications for environmental conservation. *Curr. Sci.*, 2007, **93** (1), 1828–34.
3. Kanjilal, U.N. Forest Flora of the Chakrata, Dehradun and Saharnpur forest divisions, Uttar Pradesh. 3rd Ed. Delhi: Manager of publications, Government of India Press. 1928.
4. Rau, M.A. High Altitude Flowering Plants of West Himalaya. Botanical Survey of India, Calcutta. 1975.
5. Raizada, M.B. Supplement of Duthie's Flora of the Upper Gangetic Plaine and of the Adjacent Siwaliks and Sub Himalayan Tracts. Bishan Singh Mahendra Pal Singh, Dehradun. 1976. **1-2**.
6. Raizada, M.B. & Saxena, H.O. Flora of Musoorie. Bishen Singh & Mahendra Pal Singh, Dehradun. 1978, **1**.
7. Semwal, J.K., Gaur, R.D. & Purohit, A.N. Floristic pattern of an alpine zone Tunghnath in central Himalaya. *Acta Bot. Indica.*, 1981. **9**, 110–14.
8. Polunin, O. & Stainton, A. Flowers of the Himalaya. Oxford University Press, New Delhi. 1984.
9. Naithani, B.D. Flora of Chamoli. 2 Vols. Botanical Survey India, Howarah, India. 1984-85.
10. Hajra, P.K. & Rao, R.R. Distribution of vegetation types in northwest Himalaya with brief remarks on floral resource conservation. *Proc. Indian. Acad. Sci. (Plant Sci.)*, 1990, **100**, 263–277.
11. Gaur, R.D., Rawat, D.S. & Dangwal, L.R. Status of some vulnerable plant species from Garhwal Himalaya. In: Dhar, U. (Ed.), Himalayan Biodiversity: Conservation Strategies. Kosi, Almora: G.B. Pant Institute of Himalayan Environment and Development. 1993, 191–204.
12. Rawat, G.S. Protected areas and conservation of rare endemic plants in the Himalaya. In: Pangtey, Y.P.S. & Rawat, R.S. (Eds.), High Altitudes of the Himalaya: Biogeography, Ecology and Conservation. Gyanodaya Publ., Nainital, India. 1994, 89–101.
13. Gaur, R.D. Flora of the District Garhwal: North West Himalaya (with Ethnobotanical Notes). Transmedia, Srinagar (Garhwal), India. 1999.
14. Rawat, D.S., Bhandari, B.S. & Gaur, R.D. Vegetation Wealth of Garhwal Himalaya. In: Kandari, O.P. & Gusain, O.P. (Eds.), Nature, Culture and Society. Transmedia, Srinagar (Garhwal), India. 2001, 69–92.
15. Samant, S. S. & Dhar, U. Diversity, endemism and economic potential of wild edible plants of Indian Himalaya. *Int. J. Sust. Dev. World Ecol.*, 1997, **4**, 179–191.
16. Uniyal, B.P., Sharma, J.R., Choudhery U. & Singh D.K. Flowering plants of Uttarakhand (A checklist). Bishen Singh Mahendrapal Singh, Dehradun, India. 2007.
17. Pusalkar K.P, Srivastava, K.S. and Singh, P. Flora of Uttarakhand, Gymnosperms and angiosperms (Ranunculaceae to Morinaceae). Botanical Survey India. 2018, **1**.

18. Rawat, D.S., Tiwari, J.K., Tiwari, P. & Singh, H. Floristic diversity of western Ramganga valley, Uttarakhand, India. *J. Econ. Taxon. Bot.* 2016, **40**(3-4), 104–25.
19. Bentham, G., Hooker, J.D. *Genera Plantarum*. London, various publishers. 1862-1883, **1-3**.
20. Suyal, S., Sharma, C.M., Gairola, S., Ghildiyal, S.K., Rana, C.S. & Butola, D.S. Phytodiversity (angiosperms and gymnosperms) in Chaurangikhal forest of Garhwal Himalaya, Uttarakhand, India. *Indian J. Sci. Technol.*, 2010, **3**(3), 267–275.
21. Sharma, C.M., Butola, D.S., Ghildiyal, S.K. & Gairola, S. Phytodiversity along an altitudinal gradient in Dudhatoli forest of Garhwal Himalaya, Uttarakhand, India. *Int. J. Med. Arom. Plants*, 2013, **3**(4), 439–451.
22. Gairola, S., Sharma, C.M., Rana, C.S., Ghildiyal, S.K. & Suyal, S. Phytodiversity (angiosperms and gymnosperms) in Mandal-Chopta forest of Garhwal Himalaya, Uttarakhand, India. *Nat. Sci.*, 2010, **8**(1<bvertical-align:super;></bvertical-align:super;>, 1–17.
23. Sekar, K.C., Manikandan, R. & Srivastava, S.K. Invasive alien plants of Uttarakhand Himalaya. *Proc. Natl. Acad. Sci. India, Sect. B.* 2012, **82**(3), 375–383.
24. Rawat, D.S., Tiwari, J.K. & Tiwari, P. Invasive alien flora of western Ramganga valley, Uttarakhand. *Phytotaxonomy*, 2016, **16**, 111–114.
25. Rawat, D.S., Tiwari, J.K., Tiwari, P., Ballabha, R. & Rana C.S. Plant diversity in the Lobha range of Kedarnath forest division in Garhwal Himalaya, Uttarakhand, India. *Ann. Plant Sci.*, 2013, **2**(8), 302–320.

Figures

Figure 1

Species percentage according to different life forms in Adwani forest area.

Figure 2

Occurance percentage of plants in Adwani forest area.

Figure 3

A & B. Far View of forest. **C.** Centre of the forest entry gate of Adheshwar Mahadev. **D.** Road (Danda Nagraja Road) pass through forest. **E.** Woman Carrying bundle of Timber. **F.** Livestock grazing in the forest

Figure 4

A. *Gentiana cephalodes*. **B.** *Buddleja crispa*. **C.** *Juglans regia* **D.** *Cornus macrophylla* **E.** *Symplocos paniculata*. **F.** *Aesculus indica* **G.** *Polygala tatarinowii* **H.** *Berberis lycium* **I.** *Androsace rotundifolia*

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [Appendix1.docx](#)