Research Journal of Medicinal Plant

ISSN 1819-3455

Academic Journals Inc.

www.academicjournals.com

OPEN ACCESS Research Journal of Medicinal Plants

ISSN 1819-3455
DOI: 10.3923/rjmp.2016.375.381

Review Article
Fritillaria roylei Hook. in Western Himalaya: Species Biology, Traditional Use, Chemical Constituents, Concern and Opportunity

[1]Vinod K. Bisht, [1]Bir S. Negi, [1]Arvind K. Bhandari and [2]Laxman S. Kandari

[1]Herbal Research and Development Institute, Mandal, 246401 Gopeshwar, Uttarakhand, India
[2]Department of Forestry, Himgiri Zee University, Sherpur, Chakrata Road, 248197 Dehradun, Uttarakhand, India

Abstract
Fritillaria roylei is an endangered herb, thrive well in sub-alpine and alpine pastures of Himalayan region and valued for medicinal properties. The species is important constituent of *Astavarga*, *Chyavanprash* and other *Ayurvedic* preparations. The herb has anti-asthmatic, anti-rheumatic, anti-tussive properties and is widely used for the treatment of different diseases. Presently, as a result of biotic and abiotic pressures, *F. roylei* has become critically endangered in Western Himalaya. In an effort to arrest the declining population of this species, it is imperative that suitable conservation strategies along with sustainable utilization are earnestly undertaken. An attempt has been made to compile and highlight all possible information on the species biology, population and biochemistry, concerns and opportunities of the herb. In addition, effective conservation measures to restore the dwindling population of this herb in its natural surroundings are also discussed. This study will assist in understanding the ecological complexity of *F. roylei* so that necessary steps can be taken to check its exploitation.

Key words: *Fritillaria roylei*, chemical composition, species biology, ethno-medico-botany

Received: July 26, 2016 **Accepted:** August 19, 2016 **Published:** September 15, 2016

Citation: Vinod K. Bisht, Bir S. Negi, Arvind K. Bhandari and Laxman S. Kandari, 2016. *Fritillaria roylei* Hook. in Western Himalaya: Species biology, traditional use, chemical constituents, concern and opportunity. Res. J. Med. Plants, 10: 375-381.

Corresponding Author: Vinod K. Bisht, Herbal Research and Development Institute, Mandal, 246401 Gopeshwar, Uttarakhand, India

Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Fritillaria roylei Hook. is among the 36 species of globally significant medicinal plants of Western Himalaya (www.undp.org). The herb locally known as kakoli (Himalayan *Fritillary*) thrives generally in sunny meadows of sub-alpine and alpine pastures. The bulbs of the herb are important constituents of *Astavarga*, *Chyavanprash*, *Mahatraiphala Ghritham*, *Jeevanthyadi Ghrutham* and *Danwantharam Thailam*, the *Ayurvedic* preparations in Indian system of medicine (ISM)[1,2]. Presently, *F. roylei* is among the 18 species which are in active trade[3] and the demand for this species is increasing while, supply is gradually decreasing[4]. Besides the harvesting of this species is banned in Uttarakhand, India[5], the illegal collection is continued and presently most of the supply of bulbs comes from Har-Ki-Doon, Uttarakashi and Panwali Kantha, Tehri Garhwal, Uttarakhand and India[3]. However, the collection of bulbs from wild is legally allowed to the natives of Himachal Pradesh[6].

Very little scientific information is available regarding *F. roylei* such as trade volume, cultivation technique, impact of climate change on the species germination behavior in nature etc.[7-9]. Being an endangered and potential herb and restoring its population in nature is the key concern. Thus, effective *in situ* conservation, interventions of policies and strategies for promotion of cultivation and to harness optimum returns from cultivation is prerequisite. The present communication is a comprehensive compilation of available information on species distribution, biology, indigenous use and future opportunities of the herb. To sustain supply, effective conservation measures, priorities and interventions of policies for conservation and mass scale cultivation is also discussed.

The Western Himalaya is structurally complex with altitudes ranging from 300 to over 6000 m a.s.l and supports rich biodiversity. The mountains rise abruptly, resulting in a diversity of ecosystems that range from alluvial grasslands, subtropical broad leaved forests to dominance of conifers in the temperate zone to alpine meadows above the tree line. Native communities of the area depend on their immediate medicinal plants resources for their primary healthcare need. The inhabitant of the study area was most familiar with the medicinal plants of the surrounding area.

It is now well understood that proper knowledge about plants of a given region is essential for the proper and effective utilization of these resources.

Biology: Family Liliaceae is cosmopolitan in distribution with 50 genera and about 600 species worldwide with majority of them found in tropical regions (www.wikipedia.org). This family includes a diversity of herbs and climbers with annual or evergreen aerial shoot and rhizomes and bulbs. In India, family Liliaceae comprises of important medicinal plants such as *Fritillaria* spp., *Lilium* spp., *Gloriosa superba*, *Paris polyphylla* etc. The genus *Fritillaria* was initially placed under the tribe Tulipeae by Hutchinson[10] then under tribe Lilieae by Dahlgren *et al.*[11].

The centre of diversity for the genus *Fritillaria* is East Mediterranean region. The possible centre of evolution of the genus is Iran[12]. According to Rix[13] the genus *Fritillaria* is represented by 165 species worldwide while, Saklani *et al.*[14] reported 130 species, Ronsted *et al.*[15] reported 100 species and Kamari and Phitos[16] reported 145 species worldwide. Turkey represents largest number of taxa (33) followed by China (30) Greece (24) and California (18)[16]. India represents only 6 taxa[1] and two of them (*F. roylei* and *F. cirrhosa*) are found in Uttarakhand[17].

Fritillaria roylei is perennial, glabrous and bulbous herb, 15-60 cm high and have mottled stem. The leaves are opposite or whorled, linear-lanceolate, flowers are solitary, noddingbu and yellowish-green to brownish-purple with chequered pattern in yellowish-green or dull-purple. Flowers are bell shaped, hanging looking down, borne singly on the stem but sometimes in a group of two or more. Petals are narrow ovate 4-5 cm long. Leaves are 5-10 cm long, linear lanceolate often long pointed, arranged oppositely or in whorls of 2-6. The marked morphological variations in populations is due to the differences in ecological niche, altitude, micro-environment and genetic variability[8]. Flowering takes place during June-July and fruiting during July-August. Seeds are arranged in two rows in each valve. Bulbs are globose, small and covered with membranous scales. The species is adopted to complete the vegetative and reproductive phenophases in short season (April-September). The seeds contain deep morphophysiological dormancy[18].

The structure of pollen grain in *Fritillaria* has been studied[19-21]. The chromosome number in *F. roylei* is 24 and shares its karyotype with most other species of the genus[22,23]. *Fritillaria roylei* exhibits intraspecific variation in the amount of condensed chromatin (Heterochromatin)[24].

Distribution in Western Himalaya: In Western Himalaya, *F. roylei* is distributed from Kashmir to Uttarakh and within the altitudinal range of 2400-4000 m a.s.l.,[1] while, in Uttarakhand it is also reported between 2800-4000 m a.s.l.[25] between 2900-4200 m a.s.l.[9] and between 3250-6919 m a.s.l.,[26] (Table 1, Fig. 1a). It grows well in light sandy or medium loam well drained acidic soil. The open sunny areas with moderate slope and having rich humus are the habitats preferred by

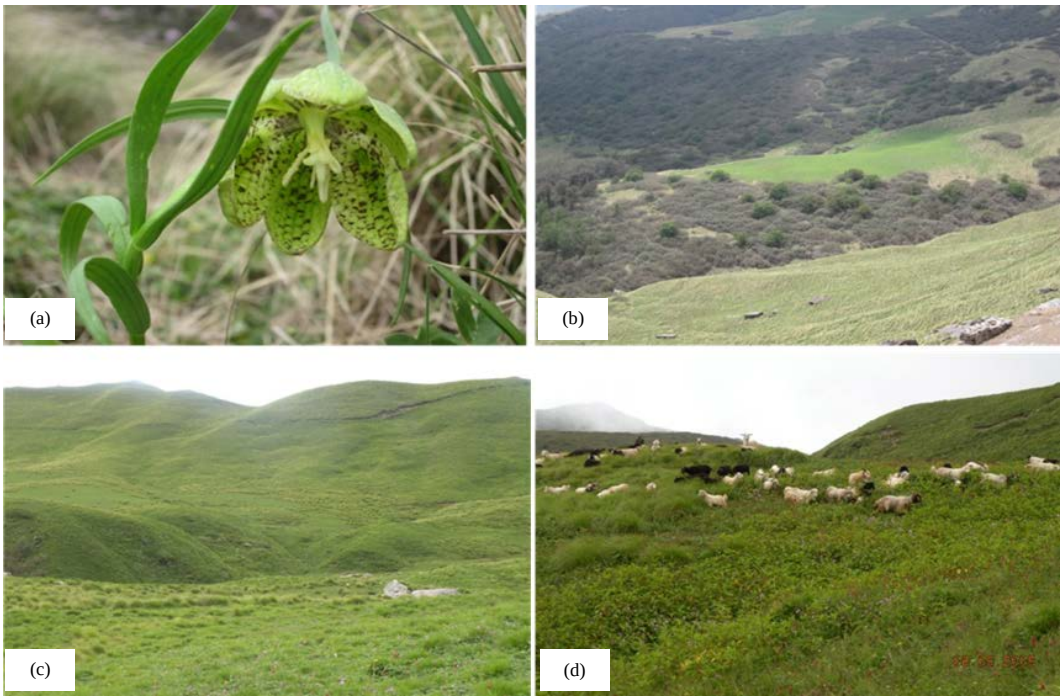

Fig. 1(a-d): (a) *Fritillaria roylei* in natural habitat, (b, c) Natural habitats of *F. roylei* and (d) Grazing at natural habitat of *F. roylei*

Table 1: Distribution of *F. roylei* in Western Himalaya

Area	Altitude (m a.s.l.)	Habitat	Density (plant m^{-2})	TBC ($cm^2 m^{-2}$)	Reference
Dayara alpine meadow, Uttarakhand, India	3000-3400	Open meadow	3.80	6.48	Chauhan *et al.*[3]
Dronagiri alpine meadow, Uttarakhand, India	3200-3500	Partial shade	2.40	2.43	
Kedarnath alpine meadow, Uttarakhand, India	2900-3500	Open meadow	4.20	4.81	
Kunwari pass alpine meadow, Uttarakhand, India	3000-3200	Open meadow	1.10	9.54	
Rudranath alpine meadow, Uttarakhand, India	3000-3200	Partial shade	3.80	4.28	
Tungnath alpine meadow, Uttarakhand, India	3200-3600	Partial shade	0.40	18.92	
Valley of flowers National Park, Uttarakhand, India	3000-4200	Open meadows	1.80	12.94	
Valley of flowers National Park, Uttarakhand, India	3250-6919	Open meadows	6.14	-	Kala[26]
Kedarnath wildlife sanctuary, Uttarakhand, India	1160-7068	-	-	-	
Kibber wildlife sanctuary, Uttarakhand, India	3600-6700	-	-	-	
Karakoram wildlife sanctuary, Uttarakhand, India	-	-	-	-	
Pin Valley National park, Uttarakhand, India	3300-6632	-	-	-	
Hemis National park, Uttarakhand, India	3300-6930	-	-	-	
Changtbang wildlife sanctuary, Uttarakhand, India	-	-	-	-	
Minimarg, Gurez valley, Jammu and Kashmir, India	3300-3900	-	0.12	-	Dad and Reshi[55]

TBC: Total basal cover

Fritillaria roylei (Fig. 1b, c). In Uttarakhand, it is found naturally in different alpine meadows such as Kedarnath, Rudranath, Valley of flowers, Dayara, Dronagiri and Tungnath. In Jammu and Kashmir and India, the herb was found to thrive in Minimarg and Gurez valley (Fig. 2).

Phyto-chemistry: The bulbs contain three major alkaloids, peimine [($C_{27}H_{45}O_3N$, melting point 224°C, molecular weight 431.66), Synonym: (3b,5a,6a)-cevane-3,6,20-triol, Zhebeinine, Wanpeinine A], peiminine [($C_{27}H_{43}O_3N$, melting point 135°C, molecular weight 429.64), Syonym: Verticinone, Kashmirine, Fritillarine, Zhebeinone, 3beta,20-Dihydroxy-5alpha-cevan-6-one] and peimisine [($C_{27}H_{41}O_3N$, melting point 270°C, molecular weight 427.62) Synonym: Ebeiensine, Peimissine, veratraman-6(5H)-one, (3β)-17,23-Epoxy-3-hydroxy veratraMan-6(5H)-one] peimiphine ($C_{27}H_{46}O_3N$, melting point 127°C) peimidine ($C_{27}H_{45}O_2N$, melting point 222°C), peimitidine ($C_{27}H_{44}O_3N$, melting point 188°C), fritimine ($C_{38}H_{62}O_3N_2$, melting point 167°C), fritillarin ($C_{28}H_{62}O_3N$, melting point 167°C), verticin ($C_{19}H_{32}O_2N$, melting point 224°C) and

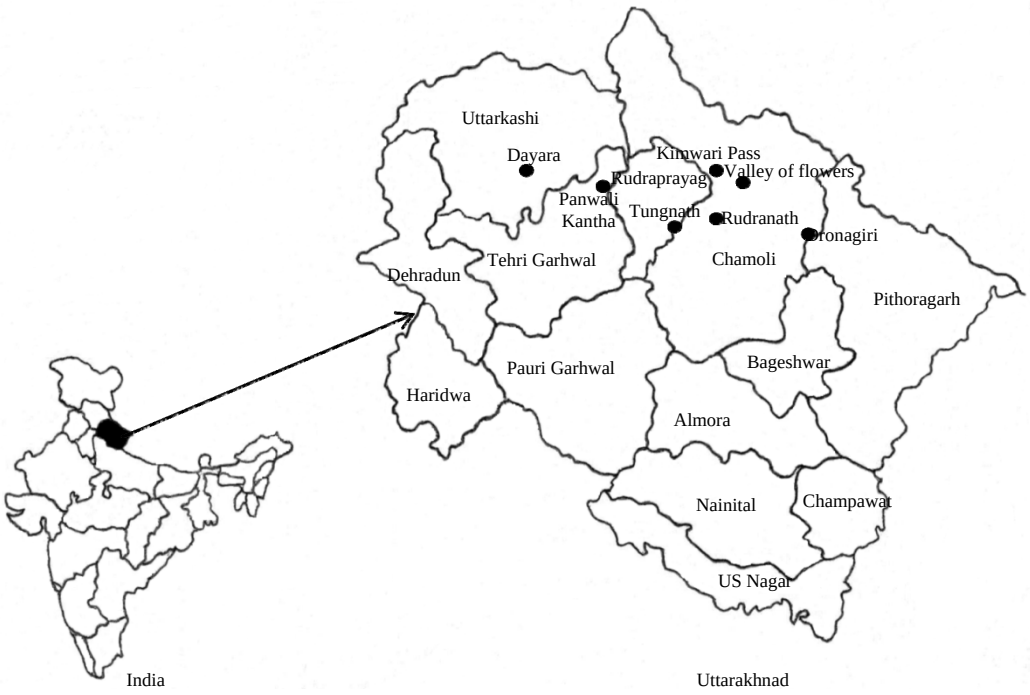

Fig. 2: Map of Uttarakhand indicating sites of *F. roylei*

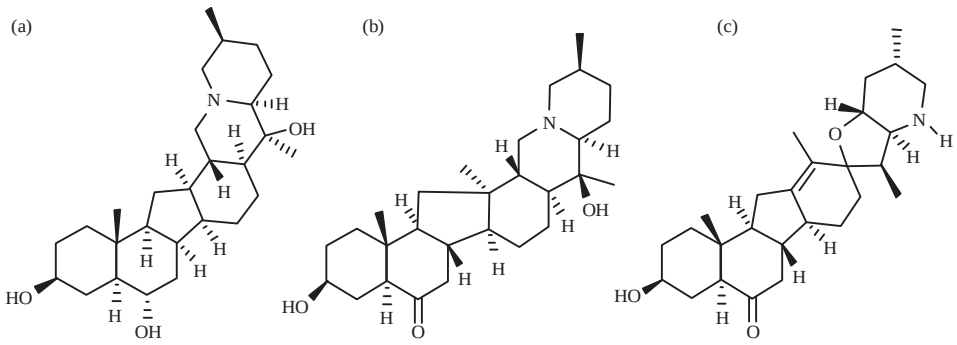

Fig. 3(a-c): Chemical structures of isolated compounds in *F. roylei*, (a) Peimine, (b) Peiminine and (c) Peimisine

verticilline ($C_{19}H_{33}O_2N$, melting point 148-150°C). The bulbs also contain a neutral constituent, propeimin ($C_{29}H_{48}O_3N$, melting point 188-189°C) and a sterol[1,27-32] ($C_{27}H_{46}O$, melting point 137°C) (Fig. 3).

Ethno-medico-botany: It possesses anti-asthmatic, anti-rheumatic, galactogogue, febrifuge, haemostatic, ophthalmic and oxytocic[1,8,33], anti-tussive, anti-viral, anti-microbial[34,35], anti-tumor[36], Anti-ulcer[37] and anti-hypertensive properties[38]. The bulbs of *F. roylei* (usually collected in 3rd year) are used traditionally in the treatment of asthma, bronchitis, burns, stomach troubles and as a stimulant[25]. In Indian system of medicine, it is also used as aphrodisiac[2]. The roots are used for healing wounds, corms in *Ayurvedic* and *Unani* medicine. In Jammu and Kashmir, India, *F. roylei* is used traditionally for rheumatism, asthma, tuberculosis and as a tonic[39]. The bulb of the species is boiled with orange peel and given in the treatment of tuberculosis and asthma[40]. In Uttarakhand, India the bulb powder is given with milk as tonic for body weakness[41]. It is also believed that *F. roylei* is very strong cough suppressant (Anti-tussive) and source of expectorant drug in traditional Chinese medicine[42]. In Indian Himalayan region, the roots of the species are used for the treatment of asthma, bronchitis and stomach disease[43]. It is also used for the treatment of bronchial disorder and pneumonia in Chinese system of medicine. The bulbs are an

important constituent of a Chinese drug, Szechuan-Pei-Mu used as anti-pyretic, expectorant and lactagogue[1]. In Pakistan, the powder of dry bulbs mixed with butter is used to treat urinary tract infections and to soften and soothe the skin[44]. The bulb of the species is also useful in the treatment of fever, hemorrhage and milk deficiency[2].

Statement of problem: The growth and distribution of a particular plant species is depends on its adaptability attributes and growth conditions[45]. Habitat degradation, illegal and unscientific collection, climate change and anthropogenic activities has created a heavy pressure on the population of *F. roylei* in Western Himalaya. Following various biotic and abiotic pressures, the populations of *F. roylei* showed marked decline of 58-77% during the last few decades in Western Himalaya[9]. This decline is attributed to obstruction in reproductive phase with early snowfall which prevents seed maturation and regeneration[46] and grazing[47] (Fig. 1d). Conservation Assessment and Management Prioritization (CAMP) assigned global status of this herb under endangered category[48]. Moreover, IUCN assigned critically endangered status for North-West Himalaya and endangered status for Jammu and Kashmir state of India[49,50]. For Uttarakhand, the species assigned critically endangered status[51]. Further continued harvesting of the herb from the wild to meet the demands of the herbal pharmaceuticals is another concern.

Strategies for future prospects: Documentation and conservation through systematic approach and its traditional knowledge system is the most important aspect. The Convention on Biological Diversity (CBD) states that the systematic study for conserving medicinal plants plays a vital role in environment management and development through traditional as well as scientific practices[52]. It is well established that the cultivation of such potential and endangered herb is prerequisite[48]. Also, regeneration protocols for *F. roylei* through *in vitro* bulblet method[53] and seed[8] are available. These two direct approaches may contribute significantly to the population restoration and sustainable availability, beside the cultivation has moderate level of difficulties. Thus, strategy for the future prospects of this species is to be worked out. This may include (i) *In situ* conservation, (ii) *Ex situ* cultivation, (iii) Sustainable harvesting and (iv) Policy interventions for conservation, development and harvesting (CDH) plan. To achieve this goal the following conservation methods should be considered: (i) A thorough survey on *F. roylei* should be carried out to gather details information about its natural habitats, preferences, adaptability, growing season, interferences, vegetative and reproductive phenology, (ii) Policies and strategies for harnessing optimum economic returns from cultivation, (iii) *In situ* conservation through Medicinal Plants Conservation Area networks (MPCA), National Parks (NPs), sanctuaries and *Ex situ* conservation through botanical garden and herbal garden etc., (iv) Development of appropriate agro-technology for mass scale commercial cultivation and (v) Proper training on scientific methods of conservation, development, harvesting and management etc. to the persons engaged in the harvesting[54].

CONCLUSION

Considering the high demand due to medicinal values and the critically endangered status of the herb and priority for its *in situ* conservation and *ex situ* cultivation should be a prerequisite. Population assessment using standard ecological methods should be carried out for the quantification of the existing stock of this species in its natural habitats. Unscientific and illegal collection should be strictly prohibited from natural habitats. These strategies will be useful in the conservation and sustainable availability of this potential herb.

REFERENCES

1. Anonymous, 1956. The wealth of India, Raw Materials. Vol. 4, CSIR., New Delhi, India, Pages: 63.
2. Kaul, M.K., 2010. High altitude botanicals in integrative medicine-case studies from Northwest Himalaya. India J. Traditional Knowledge, 9: 18-25.
3. Chauhan, R.S., B.P. Nautiyal and M.C. Nautiyal, 2013. Trade of threatened Himalayan medicinal and aromatic plants-socioeconomy, management and conservation issues in Garhwal Himalaya, India. Global J. Med. Res., 13: 8-17.
4. Ved, D.K. and G.S. Goraya, 2008. Demand and supply of medicinal plants in India. Bishen Singh Mahendra Pal Singh Dehradun and Foundation for Revitalisation of Local Health Tradition (FRLHT), Bangalore, India.
5. Anonymous, 2008. Important government orders for sustainable development of medicinal and aromatic plants (In Hindi). Bhesaj Development Unit, Horticulture Department, Dehradun, Uttarakhand, India, pp: 17.
6. Badola, H.K. and J.S. Butola, 2004. Threatened medicinal plant cultivation succeeds in Himachal Himalaya. Biological Conservation Newsletter, National Museum of Natural History, Washington, pp: 229.
7. Shimizu, T., Y. Hatanaka, H. Zentoh, T. Yashima, E. Kinoshita, Y. Watano and T. Shimizu, 1998. The role of sexual and clonal reproduction in maintaining population in *Fritillaria camtschatcensis* (L.) Ker-Gawl. (Liliaceae). Ecol. Res., 13: 27-39.

8. Chauhan, R.S., M.C. Nautiyal, J.A.T. da Silva, P. Prasad and H. Purohit, 2011. Habitat preference, ecological parameters and conservation of *Fritillaria roylei* Hook., an endangered medicinal herb of the Astavarga group. Biorem. Biodiv. Bioavail., 5: 73-76.
9. Chauhan, R.S., M.C. Nautiyal, R.K. Vashistha, P. Prasad, A.R. Nautiyal, A. Kumar and J.A.T. da Silva, 2011. Morpho-biochemical variability and selection strategies for the germplasm of *Fritillaria roylei* Hook (Liliaceae)-an endangered medicinal herb of western Himalaya, India. J. Plant Breed. Crop Sci., 3: 430-434.
10. Hutchinson, J., 1959. The Families of Flowering Plants. 2nd Edn., Oxford University Press, Oxford, UK.
11. Dahlgren, R., G. Clifford and P. Yeo, 1985. The Families of the Monocotyledons: Structure, Evolution and Taxonomy. 1st Edn., Springer Verlag, Berlin.
12. Takhtajan, A., 1987. Systema Magnoliophytourm. Nauka, Leningrad, pp: 287-309.
13. Rix, M., 2001. Fritillaria: A Revised Classification: Together with an Updated List of Species. Fritillaria Group of the Alpine Garden Society, Edinburgh, Pages: 14.
14. Saklani, A., M.R. Sahoo and S.K. Kutty, 2011. The genus *Fritillaria* (Liliaceae): A review of its phytochemical and pharmacological perspectives. Int. J. Res. Pharmacol. Phytochem., 1: 96-111.
15. Ronsted, N., S. Law, H. Thornton, M.F. Fay and M.W. Chase, 2005. Molecular phylogenetic evidence for the monophyly of *Fritillaria* and *Lilium* (Liliaceae; Liliales) and the infrageneric classification of *Fritillaria*. Mol. Phylogenet. Evol., 35: 509-527.
16. Kamari, G. and D. Phitos, 2006. Karyosystematic study of *Fritillaria messanensis* S.L. (*Liliaceae*). Willdenowia, 36: 217-233.
17. Naithani, B.D., 1985. Flora of Chamoli. Vol. 2, Botanical Survey of India, Howrah, India, pp: 651-652.
18. Muraseva, D.S., T.I. Novikova and A.A. Erst, 2015. *In vitro* propagation and conservation of rare species *Fritillaria meleagris* L. from floral explants. Contemp. Problems Ecol., 8: 754-763.
19. Schulze, W., 1980. Beitrage zur taxonomie der Liliifloren. VI. Der umfang der Liliaceae. Wiss Z. Friedrich-Schiller-Univ. Math. Naturw. Reihe., 29: 607-636.
20. Kosenko, V.N., 1991. Pollen morphology of the genus *Fritillaria* (*Liliaceae*). Bot. Zh., 76: 1201-1210.
21. Kosenko, V.N., 1999. Contributions to the pollen morphology and taxonomy of the Liliaceae. Grana, 38: 20-30.
22. Kamari, G., 1991. The genus *Fritillaria* L. in Greece: Taxonomy and karyology. Bot. Chronika, 10: 253-270.
23. Kamari, G., 1996. *Fritillaria* species (*Liliaceae*) with yellow or yellowish-green flowers in Greece. Bocconea, 5: 221-238.
24. Dolezel, J., J. Greilhuber and J. Suda, 2007. Flow Cytometry with Plants: An Overview. In: Flow Cytometry with Plant Cells. Analysis of Genes, Chromosomes and Genomes, Dolezel, J., J. Greilhuber and J. Suda (Eds.). Wiley-VCH, Weinheim, Germany, pp: 41-65.
25. Singh, G. and G.S. Rawat, 2011. Ethnomedicinal survey of Kedarnath wildlife sanctuary in western Himalaya, India. Indian J. Fundamental Applied Life Sci., 1: 35-46.
26. Kala, C.P., 2005. Indigenous uses, population density and conservation of threatened medicinal plants in protected areas of the Indian Himalayas. Conserv. Biol., 19: 368-378.
27. Chi, Y.F., Y.S. Kao and K.J. Chang, 1940. The alkaloids of *Fritilaria roylei*. II. isolation of peiminine. J. Am. Chem. Soc., 62: 2896-2897.
28. Wu, Y.H., 1944. The constituents of *Fritillaria roylei*. J. Am. Chem. Soc., 66: 1778-1780.
29. Chou, T.Q., 1947. Some minor alkaloids of Pei-Mu, *Fritillaria roylei*. J. Am. Chem. Soc., 36: 215-217.
30. Chatterjee, A., K.P. Dhara, C. Pascard and T. Prange, 1976. Kashmirine, a new steroidal alkaloid from *Fritillaria roylei*, Hook (Liliaceae). Tetrahedron Lett., 33: 2903-2904.
31. Jiang, R.W., S.C. Ma, P.P.H. But, H. Dong and T.C.W. Mak, 2001. Sipeimine, a steroidal alkaloid from *Fritillaria roylei* Hooker. Acata Cryst., C57: 170-171.
32. Jiang, Y., P. Li, H.J. Li and H. Yu, 2006. New steroidal alkaloids from the bulbs of *Fritillaria puqiensis*. Steroids, 71: 843-848.
33. Kirtikar, K.R. and B.D. Basu, 1984. Indian Medicinal Plants. Vol. 4, Bishen Singh Mahendra Pal Singh, Dehradun, India, Pages: 766.
34. Lam, T.L., M.L. Lam, T.K. Au, D.T.M. Ip, T.B. Ng, W.P. Fong and D.C.C. Wan, 2000. A comparison of human immunodeficiency virus type-1 protease inhibition activities by the aqueous and methanol extracts of Chinese medicinal herbs. Life Sci., 67: 2889-2896.
35. Xu, H.B., X.B. Sun, F.C.H. Wen, J.H. Zhou, T. Ding, L.W. Sun and Y. Li, 2000. [An preliminary comparative study on physiological activity of *Fritillaria pallidiflora* Schrek. and *F. delavayi* Franch]. China J. Chin. Materia Medica, 25: 391-394, (In Chinese).
36. Ping, L., X. Guojun, X. Luoshan and W. Yixian, 1995. Active constituents of the bulbs of *Fritillaria ebeiensis* and their antitumour activity in mice. Phytother. Res., 9: 460-462.
37. Muto, Y., H. Ichikawa, O. Kitagawa, K. Kumagai and M. Watanabe *et al*., 1994. Studies on antiulcer agents. I. The effects of various methanol and aqueous extracts of crude drugs on antiulcer activity. Yakugaku Zasshi, 114: 980-994.
38. Kang, D.G., H. Oh, D.K. Cho, E.K. Kwon, J.H. Han and H.S. Lee, 2002. Effects of bulb of *Fritillaria ussuriensis* Maxim. on angiotensin converting enzyme and vascular release of NO/CGMP in rats. J. Ethnopharmacol., 81: 49-55.
39. Srivastava, T.N., S. Rajasekharan, D.P. Badola and D.C. Shah, 1986. An index of the available medicinal plants, used in Indian system of medicine from Jammu and Kashmir State. Ancient Sci. Life, 6: 49-63.
40. Shaheen, H., Z.K. Shinwari, R.A. Qureshi and Z. Ullah, 2012. Indigenous plant resources and their utilization practices in village populations of Kashmir Himalayas. Pak. J. Bot., 44: 739-745.

41. Bisht, V.K., L.S. Kandari, J.S. Negi, A.K. Bhandari and R.C. Sundriyal, 2013. Traditional use of medicinal plants in district Chamoli, Uttarakhand, India. J. Med. Plant Res., 7: 918-929.
42. Zhang, Y.H., X.L. Yang, , P. Zhang, X.F. Zhou and H.L. Ruan *et al*., 2008. Cytotoxic alkaloids from the bulbs of *Fritillaria hupehensis*. Chem. Biodiver., 5: 259-266.
43. Kala, C.P., 2015. Medicinal and aromatic plants of tons watershed in Uttarakhand Himalaya. Applied Ecol. Environ. Sci., 3: 16-21.
44. Khan, S.M., S. Page, H. Ahmad, H. Shaheen, Z. Ullah, M. Ahmad and D.M. Harper, 2013. Medicinal flora and ethnoecological knowledge in the Naran Valley, Western Himalaya, Pakistan. J. Ethnobiol. Ethnomed., Vol. 9. 10.1186/1746-4269-9-4
45. Bisht, V.K., C.P. Kuniyal, B.P. Nautiyal and P. Prasad, 2015. Integrated analysis of the trees and associated under-canopy species in a subalpine forest of western Himalaya, Uttarakhand, India. J. Mount. Sci., 12: 154-165.
46. Nautiyal, B.P., V. Parkash, R.S. Chauhan, H. Purohit and M.C. Nautiyal, 2001. Assessment of germinability, productivity and cost benefit analysis of *Picrorhiza kurrooa* cultivated at lower altitude. Curr. Sci., 81: 579-585.
47. Nautiyal, M.C., B.P. Nautiyal and V. Prakash, 2004. Effect of grazing and climatic changes on alpine vegetation of Tungnath, Garhwal Himalaya, India. Environmentalist, 24: 125-134.
48. Kuniyal, C.P., V.K. Bisht, J.S. Negi, V.P. Bhatt and D.S. Bisht *et al*., 2015. Progress and prospect in the integrated development of Medicinal and Aromatic Plants (MAPs) sector in Uttarakhand, Western Himalaya. Environ. Dev. Sustain., 17: 1141-1162.
49. IUCN., 2001. IUCN Red List Categories and Criteria, Version 3.1. International Union for Conservation of Nature and Natural Resources, Glan, Switzerland, ISBN-13: 978-2831706337, Pages: 30.
50. Kumar, G.P., R. Kumar, O.P. Chaurasia and S.B. Singh, 2011. Current status and potential prospects of medicinal plant sector in trans-Himalayan Ladakh. J. Med. Plants Res., 5: 2929-2940.
51. Bisht, V.K., J.S. Negi and A.K. Bhandari, 2016. Check on extinction of medicinal herbs in uttarakhand: No need to uproot. Natl. Acad. Sci. Lett., 39: 233-235.
52. Uniyal, S.K., A. Kumar, B. Lal and R.D. Singh, 2006. Quantitative assessment and traditional uses of high value medicinal plants in Chhota Bhangal area of Himanchal Pradesh, Western Himalaya. Curr. Sci., 91: 1238-1242.
53. Joshi, S.K., U. Dhar and H.C. Andola, 2007. *In vitro* bulblet regeneration and evaluation of *Fritillaria roylei* Hook-a high value medicinal herb of the Himalaya. Acta Horticult., 756: 75-84.
54. WWF., IUCN. and WWF., 1993. Guidelines on the Conservation of Medicinal Plants. International Union for Conservation of Nature, Geneva, Switzerland.
55. Dad, J.M. and Z.A. Reshi, 2015. Floristic composition and diversity patterns of vascular plants in mountain meadow of Gurez Valley, Kashmir, India. Taiwania, 60: 8-17.