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# Dwindling status of *Epimedium elatum* (Morren & Decne) and its geographical distribution in Kashmir Himalaya, India

Sajad Ahmad Lone<sup>1,2</sup>, Saleem Mushtaq<sup>2</sup>, Qazi Parvaiz Hassan<sup>2,4\*</sup>,  
Suphla Gupta<sup>3,4</sup>

<sup>1</sup>Department of Botany, Govt College for Women, Nawakadal, Srinagar, J&K, 190002, India, <sup>2</sup>Biotechnology division, CSIR-Indian Institute of Integrative Medicine, Sanatnagar, 190005, India, <sup>3</sup>Plant Biotechnology division, CSIR-Indian Institute of Integrative Medicine, Jammu-180001, India, <sup>4</sup>Academy of Scientific and Innovative Research (AcSIR), Anusandhan Bhawan, New Delhi, 110001, India

## ABSTRACT

*Epimedium elatum* (Morren & Decne) of family Berberidaceae is a rare perennial medicinal plant, endemic to high altitude forests of Northwestern Himalayas in India. Ethnobotanically, it has been used as an ingredient for treatment of bone-joint disorders, impotence and kidney disorders in Kashmir Himalayas. Phytochemically, it is rich in Epimedin ABC and Icarin; all of these have been demonstrated to possess remarkable biological activities like PDE-5 inhibition (treatment of erectile dysfunction), anticancer, antiosteoporosis antioxidant and antiviral properties. The present investigation reports its traditional usage, comprehensive distribution and conservation status from twenty ecogeographical regions in Kashmir Himalayas, India. The species was reported from Gurez valley for the first time. Numerous threats like excessive grazing, deforestation, habitat fragmentation, tourism encroachment, landslides and excessive exploitation have decreased its natural populations in most of the surveyed habitats. Consequently, its existence may become threatened in near future if timely conservation steps are not taken immediately by concerned stakeholders involved in medicinal plant research. Moreover, use of plant tissue culture techniques is recommended for development of its *in vitro* propagation protocols. Therefore, introduction of this medicinal plant in botanical gardens, protected sites and development of monitoring programmes are needed for its immediate conservation in Northwestern Himalayas, India.

**KEYWORDS:** Icarin, aphrodisiac, kashmir himalayas, conservation, endangered species.

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### \*Corresponding Authors:

Parvaiz Qazi,  
Biotechnology division, CSIR-  
Indian Institute of Integrative  
Medicine, Sanatnagar, 190005,  
India  
Email Id: qphassan@iiim.ac.in  
Sajad Ahmad Lone,  
Department of Botany, Govt  
College for Women, Nawakadal,  
Srinagar, J&K, 190002, India  
Email Id: Sjdalone46@gmail.com

## INTRODUCTION

Northwestern Himalayas in India is one of the hotspots of biodiversity due to extensive variation in land-scapes, ecodaphic conditions, forest types and climatic conditions [1]. It has a rich variety of medicinal & aromatic plants (1748), known globally for their ethnobotany, phytochemical diversity, and pharmacological properties [2]. Unfortunately, continuous exploitation from the wild has depleted their natural populations over the years due to unending demand from industry and local markets [3]. Most of endemic medicinal plants are now facing risk of extinction in their native habitats [1, 4 and 5]. To initiate conservation arrangements for such endangered species, there is urgent need to identify their declining populations in different geographical areas [6]. During last few decades, many medicinal plants have been categorized either as vulnerable, threatened or critically endangered in Kashmir Himalayas like *Podophyllum hexandrum*, *Picrorhiza kurroa*, *Aconitum heterophyllum*,

*Rheum emodi*, *Arnebia benthami*, *Mecanopsis aculeate*, *Trillium govianum* [5,7 and 8]. Therefore, there is vital need to assess declining populations of these key medicinal plants of Kashmir Himalayas in India.

*Epimedium elatum* (Morren & Decne) is one such medicinal plant of Kashmir valley facing very high extinction risk. It is a medicinal herb (Fig.1), endemic to shady thick forests in India and Pakistan [9-15]. The plant has representative 'three branches and nine leaves' morphology in Himalayas, a character universal to all *Epimedium* species. Traditionally, it has been used in treating many ailments of bone and joint disorders [12]. It contains a high content of key phytochemicals like epimedin B & C, icariin, and icaraside-I [11-13 and 16]. Pharmacologically, extracts or chemical components from *E.elatum* have been assessed for their antimicrobial [10 and 11], antioxidant [11 and 16] and PPAR- $\gamma$  (peroxisome proliferator-activated receptor-gamma) ligand-binding activities [10]. A perusal of literature indicates that Kashmir Himalayan

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region has witnessed depletion of its endemic medicinal flora due to overharvesting, overgrazing, illegal trade and other anthropogenic pressures [6, 8 and 17]. As such, occurrence of *E.elatum* may turn into threatened (IUCN category) in near future if appropriate conservation strides are not taken instantaneously. Incidentally, a study was needed to identify its declining populations in different regions of Kashmir Himalayas for developing quick conservation strategies. Therefore, present investigation attempted to provide dwindling status and extended distribution of *E.elatum*, along with its traditional usage prevalent in Kashmir Himalayas for the concerned stakeholders involved in medicinal plant research in India. The foremost aim of the study was to focus on therapeutic potential of *E.elatum* and need for its conservation to preserve its natural germplasm from getting extinct in Northwestern Himalayas in India.

## MATERIAL AND METHOD

### Study Area

The study area comprises of pleasant and sub-alpine regions between 33°20–34°54' N latitudes and 73°55'–75°3' E longitudes in the Northwestern Himalayas in India (Fig.2). Information on its taxonomy and distribution was documented by reviewing the pertinent literature and scrutinizing herbarium sheets at University of Kashmir, Hazratbal, Srinagar J&K. Extensive exploration was made between June to September of 2013-2015 (flowering & fruiting time) based on reported localities (herbarium archives, written floras, research papers and internet search engines). Multiple parameters were recorded such as no of populations in 1km<sup>2</sup> area, herbivory and vulnerability score (0-3), and area of occupancy (Table 1). The plants were identified by taxonomists and the herbarium specimens were deposited respectively in Herbarium of University of Kashmir (KASH), Hazratbal, Srinagar and CSIR-Indian Institute of Integrative Medicine (CSIR-IIIM Jammu, J&K, India [14 and 15].



**Figure 1:** *E.elatum* (Morr & Decne) of Berberidaceae family is shown here growing under cultivation at Yarikhah field station, CSIR-IIIM Jammu. Both underground & aerial parts are used for ethnomedicinal purposes

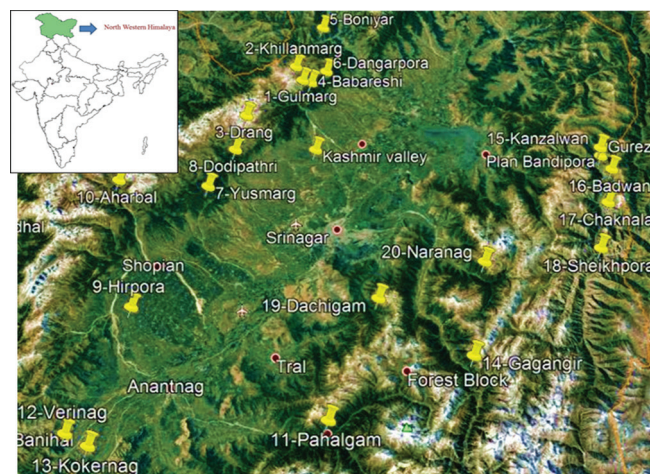
## Ethnobotanical Surveys

Ethnobotanical data was collected between summer of 2013 and 2015 following a standard operating procedure. Questionnaire was prepared and elderly Hakeem's of the particular tribal community (Gujjar & Bakkarwals) were interviewed. In addition, the specimen plant was shown to them & they mentioned its uses and same were properly documented.

## RESULTS & DISCUSSION

### Traditional usage of *E.elatum* in Kashmir Himalayas

In the present investigation, we surveyed different geographical areas in Kashmir Himalayas to verify its ethnomedicinal usage. Dried powder from aerial and rhizome parts (Fig.1) was used alone or in mixture with other medicinal extracts for health management of erectile dysfunction, body weakness, increasing body stamina, treating kidney disorders, and bone-joint disorders. Ethnobotanical surveys in the Northwestern Himalayas of Kashmir forests revealed that *E.elatum* has been used traditionally as an ingredient in many medicines to treat cold related cough, severe running nose, toothache, tooth-decay, bones and joints diseases [12]. *E.elatum* was found to be an important component of various secret winter herbal teas and tonics, used by tribal communities in forests of Jammu and Kashmir. Its ethnomedicinal usage for treatment of bone related disorders was also confirmed after consulting local Hakeem's in Gurez valley. Fresh aerial parts of *E.elatum* are harvested in large numbers from high altitudes and used as cattle fodder. Particularly, goats were found to have a special liking for this plant during grazing, confirming its name "horny goat weed". However, we found certain local Gujjar and Bakkarwal communities quite reluctant to share its traditional usage in areas like Yusmarg, Gulmarg and Aru (Pahalgam) regions of Jammu and Kashmir, India.



**Figure 2:** Distributional map of *E.elatum* (Morr & Decne) in Northwestern Himalayas, India. The plant was collected from twenty ecozones in Kashmir Himalayas, which are shown here in the Google Earth map from serial no 1-20

**Table 1: Location, availability, ecological features and vulnerability-herbivory score for *Epimedium elatum*. In last category, each parameter was subjectively rated from 0 (not vulnerable) to 3 (highly vulnerable). \*A00-Area of occupancy**

Site	Locality or region	Code	Climate zone	Aspect	Altitude	No of populations (1km <sup>2</sup> )	Vulnerability score	Herbivory score	*A00 Km <sup>2</sup>
Gulmarg	Gulmarg Baramulla	GL	Alpine	NW	2725	30-38	0	0	6
Baba reshi	Tangmarg Baramulla	BR	Sub-alpine	NW	2694	10-16	2	2	4
Drang	Tangmarg Baramulla	DR	Sub-alpine	NW	2301	3-6	3	3	4
Dangarpora	Sheeri Baramulla	DG	Alpine	NW	2592	2-6	3	3	1-2
Boniyar	Uri Baramulla	BY	Sub-alpine	NW	2148	4-10	2	2	3
Yusmarg	Yusmarg Budgam	YS	Sub-alpine	NW	2383	2-6	3	3	2
Dodipathri	Dodipathri Budgam	DP	Alpine	NW	2432	13-15	2	3	4
Naranag	Naranag Ganderbal	NAR	Sub-alpine	NE	2272	20-33	0	0	4
Gagangir	Gagangir Ganderbal	GG	Sub-alpine	NE	2435	3-6	3	3	2
Dachigam	Harwan Srinagar	DGM	Sub-alpine	SE	2912	12-16	0	0	6-10
Pahalgam	Pahalgam Anantnag	PGM	Alpine	SE	2206	3-6	3	3	2
Kokernag	Kokernag Anantnag	KNG	Sub-alpine	SE	2343	3-6	2	3	2
Verinag	Verinag Anantnag	VNG	Alpine	NW	1935	8-10	2	2	2
Khillanmarg	Gulmarg Baramulla	KMG	Sub-alpine	NE	3133	12-15	3	3	4
Chaknala	Gurez Bandipora	CNG	Sub-alpine	NE	2508	2-6	3	3	1
Sheikhpora	Gurez Bandipora	SPG	Sub-alpine	NE	2646	14-17	1	1	4
Badwan	Gurez Bandipora	BDG	Sub-alpine	NE	2431	6-8	2	2	2
Kanzalwan	Gurez Bandipora	KZG	Sub-alpine	SE	2521	9-12	2	2	2
Hirpora	Hirpora Shopian	HP	Alpine	SE	1818	1	3	3	1
Aharbal	Aharbal Kulgam	AB	Sub-alpine	NE	2425	25-39	0	0	4-10

Therefore, more ethnobotanical surveys with some economic incentives for these tribal communities are necessary to explore its secretive traditional usage prevalent in Kashmir Himalayas. These surveys can enrich its chances of becoming a potent therapeutic medicinal herb in India. Research can play an important role to explore its medicinal potential, and develop quick conservation strategies. Thus, more research efforts are needed from concerned stakeholders involved in medicinal plant exploration in India.

Interestingly, ethnopharmacological use of *Epimedium* species is well written and properly documented in certain Traditional Chinese Medicine (TCM) books like 'Chinese Materia Medica' [18]. The aphrodisiac property (sexual tonic) of these medicinal plants was revealed accidentally by a Shepherd (goat herder) who noticed far more sexual activity in his goats on eating these plants in some Chinese village [18]. That is why these plants are commonly known as horny goat weeds in China. They have been used for treatment of *erectile dysfunction* from last two thousand years in China, Japan, and Korea [18]. Pharmacopoeia Commission of China (2010) [19] has reported several biological effects to *Herba Epimedii* like reinforcing the kidney, bones, limbs, coldness, muscle contracture, and hypertension [18]. Many marketable products containing *Herba Epimedii* ingredients are sold as 'health supplements' due to their sex enhancing effects [18]. Notable species like *E. sagittatum*, *E. grandiflorum*, *E. koreanum*, *E. myrianthum*, *E. acuminatum* and *E. leptorrhizum* are used traditionally to treat impotence, spermatorrhoea, osteoporosis, menopause disorder, rheumatic arthritis and chronic tracheitis [18, 20-22].

Previously, there was no ethnomedicinal evidence for *E. elatum* in the Northwest Himalayas in India. But, local researchers are now keen to document its ethnobotany, phytochemistry, cytogenetics etc [11-16]. More ethnobotanical surveys should be done in Kashmir Himalayas for documenting its traditional usage for future medicinal effectiveness in Indian system of medicine.

### Conservational Status in Kashmir Himalayas

Medicinal plants in Kashmir Himalayas are facing conservational threats due to years of ruthless overexploitation and excessive demand from national and international markets [1 and 5]. Agrotechnology of >1% and propagation protocols of only >10% medicinal plant species is available globally [23]. That is why; most of the medicinal plants are facing extinction risks due to lack of such regeneration mechanisms. During the botanical surveys, it was evident that *E. elatum* is a rare medicinal plant with little population size in surveyed habitats (Table 1). Its low number of populations and restricted distribution in particular pockets reflects critically rare status. We could not locate its mature individuals in 10 locations in Northwestern Himalayas in India (Table 2). In some habitats like Aharbal, Gulmarg, Dachigam, and Naranag, healthy plant accessions with normal stem height (3-4 feet) were observed, all protected by dense vegetation (temperate coniferous forests), deep shade, and cool moist environment. Nevertheless, in other habitats, overgrazing was the most severe factor affecting its natural populations in YS-DP, DG-DR, HP, PGM-KNG and GG forest ranges of Kashmir valley (Fig.3). Vulnerability scores from 0 (Low) to 3 (High) and area of occupancy (1 km<sup>2</sup>) for all twenty accessions is specified in Table 1.

In most of these habitats, population size of *E. elatum* was small, consisting of 5-10 or in some rare cases, 2-3 mature individuals. The average stem height of these accessions ranged from 10-45 cm, that too under the protection of thorny bushes, which are inaccessible to grazing animals in high altitude J&K forests. This medicinal plant was found in the isolated rock crevices at difficult mountain terrains. It has survived only in certain pockets of these habitats (forests), and hence needs immediate conservation. The dwarf character in the *Epimedium* species is induced by open sunny conditions or under the influence of partial shade [24]. We also observed short stem height (dwarf character) in the *E. elatum* germplasm transplanted



at CSIR-IIIM (J&K) field stations. Quan et al., (2011) reported similar findings in *E.wushanense* and *E.pubescens* under wild and cultivated conditions. Epimedium species have been exploited for medicinal purposes in China from last 4 decades, due to which, some are now categorized as vulnerable or endangered according to their recent IUCN Red List categorization [25 and 26]. Therefore, immediate research efforts are needed to assess detailed conservational status of *E.elatum* in Indian Himalayas.

As per the ecological field observations, *E.elatum* performs better on a northwest shady slope, offering a desired microsite for its greater densities. In view of species performance across the populations, GL, NAR, DGM & AB were found best naturally adapted populations due to their high population size (Table 1). In view of the high disturbance to its natural habitat, the species might get extinct from wild (YS-DP, DG-DR, HP, PGM-KNG and GG forest ranges) in Kashmir Himalayas in India. Therefore, the introduction of this medicinal plant in botanical gardens, protected sites, and development of monitoring programmes are needed for its immediate conservation by concerned stakeholders involved in medicinal plant research in India.

### Occurrence and Extension of Distribution in Kashmir Himalayas

Recent literature reports that Epimedium species are scattered mainly in different provinces of China and is considered their modern center of diversity and differentiation [18]. They are represented sparsely in Caucasian mountain forests, Alps in Europe and certain far away regions of Northern Africa [27 and 28]. *E.elatum* is the monotypic plant species of Epimedium genus in Northwestern Himalayas of India and Pakistan. In latter, its distribution is almost unknown, but has been witnessed in the Pallas valley, Utror-Gabral valleys and district Swat of Pakistan [29-31]. In Jammu and Kashmir, *E.elatum* was reported to be growing only in three ecozones of Kashmir valley like Pahalgam, Gulmarg and Harwan [32 and 33]. During our thorough investigation, we reported its presence in 8 districts in Kashmir province (Table 1). Herbarium specimens of *Podophyllum hexandrum* deposited at Kashmir University herbarium proved advantageous in finding possible areas for screening distributional availability of this prized but unexplored medicinal plant. Most of its natural populations are facing severe threats such as grazing, excessive harvesting, habitat fragmentation and small population size (Fig.3). Hence, species needs immediate conservation to preserve its existing natural germplasm from further deterioration.

Experimentally, it has been proved that species with specific habitat requirements and restricted distribution have much larger possibilities of extinction than species with a wide habitat range [34]. Research has reported that specificity of the microhabitat frequently becomes a limiting factor in dispersal and availability of rare medicinal herbs [3]. To withstand local climatic conditions, endemic plants often occupy rocky cliffs and drier habitats in Indian Himalayas [3, 5, 35 & 36]. For the

**Table 2: Locations surveyed for *Epimedium elatum* where its occurrence was not observed after surveying 2-8 km<sup>2</sup>**

Site	Locality or region	Code	Climate zone	Aspect	Surveyed area (km <sup>2</sup> )
Chandanwari	Pahalgam	CDW	Alpine	SW	5 km
Aru	Pahalgam	AU	Subalpine	SW	4-8
Tangmarg	Baramulla	TMG	Subalpine	NW	4-10
Lower Munda	Qazigund	LM	Subalpine	NW	2-4
Jawarhar Tunnel	Qazigund	JT	Alpine	NW	2-3
Dawar forests	Gurez	DWR	Subalpine	NW	2-4
Sonmarg	Ganderbal	SMG	Subalpine	NW	3-7
Kangan forests	Ganderbal	KGN	Subalpine	NW	2-4
Nilnag	Yusmarg	NAG	Subalpine	NE	2-6
Doodganga	Yusmarg	DGG	Subalpine	NE	2-4



**Figure 3: Anthropogenic factors such as grazing and habitat fragmentation affecting natural populations of *E.elatum* (a)-Dangarpora-Sheeri Baramulla forest; (b)- Sheikhpora-Gurez Bandipora forests; (c)-Drang-Tangmarg forests; (d)-Yusmarg-Budgam forests**

long-term viability of rare and endangered species, a minimum population size is necessary [37 and 38]. Our research efforts have proved that *E.elatum* is facing extremely severe threats in Kashmir Himalayas. Therefore, medicinal plant needs immediate captive cultivation. Research has proven that plants produce higher levels of active components when grown within their suitable agro-climatic environment [3]. *E.elatum* also produces higher content of key bioactive markers such as Epimedin ABC and Icarin [11 and 14]. Therefore, efforts are needed to promote it as a potential medicinal herb for the future in the Indian Himalayas.

### Associated Species

All populations of this medicinal plant were found growing under the forest canopy of Abies and Pinus. Most associated species were identified by taxonomists as *Pinus wallichiana*, *Abies pindrow*, *Parrotiopsis jacquemontiana*, *Sambucus wightiana*, *Aconitum heterophyllum*, *Viburnum erubescens*, *Inula racemosa*, *Picrorhiza kurrooa*, *Podophyllum hexandrum*, *Trillium govananum*, *Thalictrum foliolosum*, *Aquilegia fragrens*, *Dioscorea deltoidea*, *Viburnum grandiflorum*, *Berberis lyceum* & *Rumex nepalensis*. Among most of these associated species,



**Figure 4:** *Podophyllum hexandrum* and *E. elatum* growing together in Gulmarg. Both were mostly seen commonly associated species during the study

*Podophyllum hexandrum* was found to be the common partner of *E. elatum* in most habitats like PGM, DGM, NAR, KNG, VNG, GL, GG and Gurez except Checknala (Fig.4).

### Phenology

Epimedium plants are known to prefer shade for production of maximum aerial herbage and thick underground rhizome [18 & 24]. A wide phenotypical difference was observed in *E. elatum* populations due to a variety of climate, topography and varied ecological habitats in Kashmir Himalayas. Flowering and fruiting time were shown to vary in *E. elatum* populations across high to low altitude areas in Kashmir valley [14&15]. At lower altitudes such as Dachigam National park (Srinagar) and Verinag forests, it was found to flower in the month of April, whereas at higher altitudes, such as Khillanmarg (Gulmarg), Sheikhpura (Gurez), Dangarpura (Sheeri Baramulla), it flowered in the months of June to July. The main reasons attributed to these phenological differences could be altitude, the moisture of the habitat, temperature and amount of shade. Therefore, efforts are needed to investigate the detailed phenology of this medicinal plant for understanding its breeding behavior, adaptation biology in Northwestern Himalayas, India.

### CONCLUSION

Most of the key medicinal plants of Indian Himalayas [such as *Podophyllum hexandrum* & *Trillium govanianum*] are facing severe conservational threats. Therefore, collection of ethnomedicinal knowledge of these key medicinal plants is important for their conservation assessment and similarly, their large scale propagation is needed for their commercial usage by industrialists, pharmacologists, botanists and phytochemists. The present data on ethnomedicinal usage of *E. elatum* along with its availability status in Kashmir Himalayas will aid in proper collection of its ethnobotany, extend its distribution in India and help in designing immediate conservation strategies. Few elite populations of *E. elatum* (GL, NAR, AB, BR & DGM) can be used for its bulk propagation, and for

enhancing its pharmaceutical value in India. However, for becoming all-important medicinal herb of Indian Himalayas, a number of further studies are required for its quality control studies. More ecological surveys are required to assess its overall distributional range, ethnomedicinal usage and IUCN Redlist status in the Himalayas. Plant tissue culture protocols should be developed to revive this medicinal plant and attempts should be made to produce its secondary metabolites *in vitro* for their better pharmaceutical usage, thereby reducing demand on wild populations. More studies are required at various levels; assessing its endangered status, ecological behavior, reproductive biology, regional and local distribution patterns, *in-situ* harvesting pressure and the development of effective agro-technology.

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