Saussurea species in Indian Himalayan Region: diversity, distribution and indigenous uses

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Abstract

In spite of the high economic value of the *Saussurea* species in the Indian Himalayan Region (IHR), the potential of most of the species is yet to be investigated. Therefore, an attempt has been made to study the diversity, distribution, habitat preference, nativity, endemism, status and indigenous uses of *Saussurea* species in the IHR. A total of 62 species were recorded from the IHR; of these, 37 species were native to the Himalayan region, 8 were endemic and 21 were near endemic to the IHR. Twenty-seven of the 28 species that were known to have indigenous uses also had medicinal value and are used for the treatment of various diseases/ailments. Many species, e.g., *S. affinis (Ganga Mula*), S. auriculata (Pachak Kut), S. bracteata (Prerak Mul), S. costus (Kuth), S. gossypiphora (Kasturi Kamal)* and *S. obvallata (Brahm Kamal)*, have multiple uses. The genus showed high habitat specificity in that 16 species were recorded to be restricted to one or two habitats only. As many as 44 species were identified as rare in the study region. Considering the high industrial demand for raw materials and the endangered status of *S. costus, S. gossypiphora, S. obvallata* and *S. simpsoniana (Fen Kamal)*, these species should be prioritized for conservation (*in situ* and *ex situ*) throughout the IHR. Population assessment of the rare-endangered, native, endemic and economically important species using standard ecological methods has been suggested for the quantification of the existing stock of these species in their natural habitats. Further, phytochemical investigations for the identification of active ingredients are suggested. Propagation and cultivation techniques are lacking for most of the species of *Saussurea* except for *S. costus, S. obvallata* and *S. medusa* (*Snow Lotus*). Furthermore, the native communities need to be sensitized to the sustainable use and conservation value of the species in this genus.

**Local names given in parentheses throughout are in the Pahari language, spoken by native communities in the Himalayan region.*

Introduction

It is well known that the Indian Himalayan Region (IHR) has a great range of plant diversity. The region alone supports about 18,440 species of plants (Angiosperms: 8,000 spp., Gymnosperm: 44 spp., Pteridophytes: 600 spp., Bryophytes: 1,736 spp., Lichens: 1,159 spp. and Fungi: 6,900 spp.).[1] According to Samant *et al.*,[2] out of the total species of vascular plants, 1,748 species are medicinal. *Asteraceae* is the fourth largest family of vascular plants, comprising over 30,000 species (1,100 genera), and is distributed almost worldwide. In India, the family is estimated to have about 900 species under 167 genera.[3,4] Plants of the family are perennial and most species are herbaceous in nature, with trees and shrubs representing only about 2% of the total.

Saussurea is named after Horace Benedict de Saussure (1740-1799), a Swiss philosopher. It is an important genus of the family comprising an estimated 410 species, native to cool temperate and arctic regions of Asia, Europe, and North America, with the highest diversity in alpine habitats in the Himalayas and Central Asia. Of the estimated species, 61 are found in India.[3,5,6] The genus is quite varied and is well known to have medicinal, religious and other economic values, i.e. food, flavoring material, rubber, oil, insecticides, dye, ornamental value, etc.

Plants of the *Saussurea* genus range in height from the 5-10 cm tall dwarf alpine species to tall, thistle-like plants up to 3 m tall. The leaves are produced in a dense basal rosette, and spiral up the flowering stem. The flowers form in a dense head of small capitula, often completely surrounded in dense white to purple woolly hairs; the individual florets are also white to purple. The woolly hairs in high altitude species of the family are the densest, and aid in thermoregulation of the flowers, minimizing frost damage at night, and also preventing ultraviolet light damage from the intense high altitude sunlight.[7]

S. costus (*Kuth*, Figure 1A), native to the Himalayan Region,[2] is one of the most commercially viable species of this genus and is in high demand for treating many diseases like bronchial asthma, rheumatism, cholera, jaundice, leprosy, etc.[8] Besides this species, *S. gossypiphora* (*Kasturi Kamal*, Figure 1B) and *S. obvallata* (*Brahm Kamal*, Figure 1C) are very popular for medicinal and religious purposes in the IHR. A review of literature reveals that the information available for a few species of *Saussurea* in the region is fragmentary.

To our knowledge, there is hardly any documentation available which contains comprehensive information on the diversity, distribution, habitat preference, nativity, endemism, status and indigenous uses of the species of *Saussurea* in the IHR. In view of the economic importance of the genus for the inhabitants of the region, this study was undertaken to: i) examine the diversity, distribution pattern and indigenous uses of the species of *Saussurea* in the IHR; ii) assess and analyze species for their habitat preference, nativity, endemism and status; and iii) suggest appropriate strategies for the conservation management of the species.

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Key words: *Saussurea*, diversity, distribution, indigenous uses, habitat preference, nativity, endemism, status, conservation.

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Materials and Methods

Survey, sampling and identification of the species

While exploring the floristic diversity of the West Himalayas between 1993 and 2003 and the North-West Himalayas between 2004 and 2006, we recorded observations on distribution, altitudinal range, habit and habitat of the *Saussurea* species. Knowledge of indigenous uses was gathered through interviews with local inhabitants. This was augmented by an extensive survey of literature on the species of *Saussurea* occurring in the IHR.[2,6-25]

Determination of nativity, endemism and IUCN status of the species

Nativity of the species has been identified[2,26] and determination of endemism was based on

the distribution range of the species.[2,27] The species restricted to the IHR have been considered as endemic whereas those with extended distribution to neighboring countries/states have been considered as near endemic. IUCN status of the species was determined based on occurrence of the species in natural habitats.

Review of propagation and cultivation

An extensive survey of literature was carried out to determine the current status of propagation and cultivation of *Saussurea* species in the IHR. For the review of literature, traditional libraries at a variety of different institutions, as well as various websites, were utilized.[8,28-42]

Results and Discussion

Diversity, distribution and habitat preference

In the present study, 62 species of *Saussurea* were recorded from the IHR. All the species were herbaceous in nature and distributed between 550 m and 5,700 m. The greatest species diversity (33 spp.) was recorded in the zone between 3,500 m and 5,000 m (Figure 2). This high species diversity may be due to varied soil, climate and geography of the zone, which gives rise to many micro and macro habitats.[22]

The Northeast region of the Himalayas, particularly Sikkim, contains the greatest number of species of *Saussurea* (32 spp.), which is among the dominant plant genera in the state.[43] In the present study, *Saussurea* was found within 15 habitats: shady/moist, alpine meadows/slopes, shrubberies, open grassy slope, shady rock/boulders, roadside/waste places, cultivated area/agricultural lands, dry places, rocky slopes, snowline/glacier slopes, forest, riverine, alpine screes, flooded areas and saline alkali lands (Table 1). Maximum species diversity was in alpine meadows/slopes (55 spp.), followed by shady/moist places (32 spp.), alpine screes (24 spp.) and forest (23 spp.) habitats. Sixteen species were restricted to one or two habitats only.

Native and endemic species

Of the total *Saussurea* species identified, 37 species were determined to be native to the Himalayan region and the remaining 25 species were non-native (Table 1). Among the native species, 8 species (*S. atkinsoni, S. ceratocarpa, S. clarkei, S. costus, S. laneana, S. obscura, S. pantlingiana* and S. *sudhanshui*) were endemic to the IHR, while 21 other species (*S. abnormis, S. albescens, S. andersonii, S. andryaloides, S. auriculata, S. candolleana, S. conica, S. gilesii, S. graminifolia, S. heteromalla* (*Kaliziri*, Figure 1D), *S. jacea, S. nimborum, S. nishiokae, S. piptathera, S. polystichoides, S. roylei, S. sughoo, S. taraxacifolia, S. thomsonii, S. tridactyla* and *S. yakla*) had extended distribution to neighboring countries like Pakistan, Afghanistan, Bhutan, Tibet and Nepal, and were thus identified as near endemic. Endemic and habitat-specific species are generally considered more prone to extinction than widespread habitat generalists. Among the dominant high altitude genera in the Himalaya, *Saussurea* is the second largest genus with a preponderance of endemic species (35 spp.),[44] suggesting that there is great value in conservation management of the species in this genus.

Figure 1. (A) *Saussurea costus* (photo: Dr. J.S. Butola); (B) *Saussurea gossypiphora* (photo: Dr. R.S. Chauhan); (C) *Saussurea obvallata* (photo: Dr. S.S. Samant) and (D) *Saussurea heteromalla* (photo: Dr. Manohar Lal).

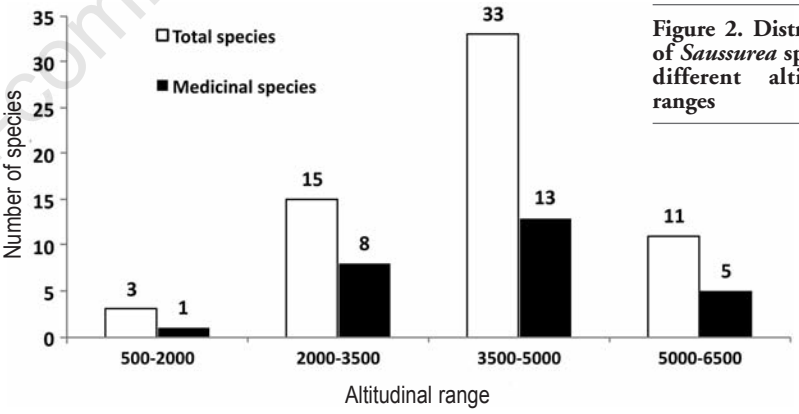

Figure 2. Distribution of *Saussurea* species at different altitudinal ranges

Indigenous uses

Proper documentation and compilation of indigenous knowledge of a species helps to identify the potential and conservation value of the species and the document can be used as a tool to transfer this knowledge from genera-

Table 1. Diversity, distribution, habitat preference, status and indigenous uses of the species of Saussurea in the Indian Himalayan Region.

Taxa	LN/VN	Altitudinal range (m)	Habitat(s)	Nativity	Distribution	Status	Indigenous uses
***Saussurea abnormis Lipsch.*	-	3500-4600	2,13	Ind	Tibet, India (Chamoli Garhwal, Uttar Pradesh), Nepal	Rare	Medicinal
S. affinis Spreng.	Ganga Mula	3300	2,3,6,7,11,12	As Trop	E Himalaya (Assam), E Asia, China, Japan	Occ	Leaves and young shoots are edible. The juice of root is one of the ingredients used in medicines for women's diseases.
***S. albescens* (DC.) Sch.-Bip.	Pirya, Bacha-Shang, Drapada	1500-3000	2,4,6,8,11,	Reg Himal	NE Afghanistan, NW India, (Kashmir, Himachal Pradesh), CW Nepal, N Pakistan	Unco	Heads soaked in water and decant is taken to relieve bronchitis. Leaves for diuretic activities.
***S. andersonii* Cl.	-	3500-4200	1,2	Reg Himal	E Himalaya (Sikkim), S Tibet	Rare	Medicinal
***S. andryaloides* (DC.) Sch.-Bip.	-	4400-4700	9	Reg Himal	W Himalaya (Kashmir), Pakistan	Rare	-
S. aster Hemsl.	-	3900-5400	1,2,13	Tibet	W Himalaya (Ladakh, Himachal Pradesh), China	Rare	-
**S. atkinsoni* Cl.	-	3300-3900	2,10	Reg Himal	W Himalaya (Himachal Pradesh, Ladakh, Uttarakhand)	Rare	Medicinal
***S. auriculata* (Spreng. ex DC.) Schi.-Bip.	Thimra, Nurya, Pachak Kut	3000-3800	1,2,3,5,11	Tibet	Bhutan, India (Uttar Pradesh, Uttar Kashi, Harki Dun, Kashmir, Sikkim, Himachal Pradesh), Nepal, N Pakistan, S Tibet	Rare	Leaves are edible and are considered purgative and antisyphilitic. Leaf paste of the plant and *Betula utilis* used externally in venereal diseases. Roots are a substitute forKuth.
S. bodinieri Lev.	-	3200-4700	2,4,13	Ind Or China	China, Bhutan, N Myanmar, E Nepal, SE Tibet, India (Sikkim)	Occ	-
S. bracteata Decne.	Chhota Doda, Prerak Mul	3500-4800	1,2,5,10,13	Reg Himal	China, India (Uttar Pradesh, Kumaon, Dhauli valley, Kashmir), N Pakistan, W Tibet	Rare	Roots are stimulant and used in boils, headache, cough, cold, fever and lung infection. Also a good soil binder.
***S. candolleana* Wall. ex. DC.	-	2400-4400	1,2,9,11	Reg Himal	Bhutan, India (Uttar Pradesh, Kumaon, Pindari, Himachal Pradesh, Kashmir), Nepal	Rare	-
**S. ceratocarpa* Decne.	Pashka	3500-5000	1,2,11	Reg Himal	Indian Himalaya (Kashmir)	Occ	Whole plant is used in colic, headache, lumbar pain, menorrhea, renel pain.
**S. clarkei* H. f.	-	>2500	1,2,13	Reg Himal	Indian Himalaya (Kashmir)	Rare	Medicinal
***S. conica* Cl.	-	4600-5300	2,4	Reg Himal	Bhutan, India (Sikkim)	Rare	Medicinal
**S. costus* (Falc.) Lipsch.	Kuth, Kut, Kostus, Kstha	3300-4000	1,2,7	Reg Himal	India (Kashmir, Lahaul & Spiti, Uttar Kashi, Barsu)	CR	The root is used in dysentery, rheumatism, skin disorder, stomachache, cough, cold, cholera, bronchitis, fever, edema, gas, jaundice, leprosy, phlegm and skin diseases, toothache, earache, ulcer, bruises and cuts. Also used as a tonic, carminative, stimulant, spasmodic, for dyspepsia and in controlling bronchial asthma. Half teaspoonful powder of the root is given for arthritis for 7-15 days. The aromatic root is sometimes used as a spice. Also used as insecticide to protect shawls and woollen fabrics and an incense. The root oil has a very strong odor and used in high-grade perfume. The oil is also employed in the preparation of hair oil. Apart from medicinal purposes, the upper parts of the plant are used as fodder and fuel.

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Table 1. Continued from previous page.

Taxa	LN/VN	Altitudinal range (m)	Habitat(s)	Nativity	Distribution	Status	Indigenous uses
S. crispa Vaniot.	-	1200-1800	1,2,11	China	India (Himachal Pradesh, Assam), Myanmar, Bhutan, Nepal, Tibet, Burma, SW China, Taiwan Laos, Thailand, Vietnam	Rare	-
S. deltoidea (DC.) Sch. Bip.	-	800-3400	2,3,4,6,11	Reg Himal	Bhutan, India (Sikkim), Laos, Myanmar, Nepal, Pakistan, Thailand, Vietnam, China, Tibet	Co	-
S. depsangensis Pampanini	-	4800-5400	2,13	Mont Kara	Tibet, China, India (Kashmir)	Rare	-
S. donkiah Cl. ex Spring.	-	4000-5000	1,2	Ind Nepal	E Nepal, Bhutan, China, India (Sikkim)	Rare	-
S. fastuosa (Decne.) Sch.-Bip.	Proud Saw-wart	2200-3600	2,3,4,11	Reg Himal	Myanmar, India (Kumaon, Uttar Pradesh, Chamoli Garhwal, Valley of Flower, Himachal Pradesh, Sikkim), Nepal, Tibet, N Burma, SW China	Rare	-
S. forrestii Diels	-	2000-3600	1,2	China	China, India (Sikkim), C Nepal	Rare	Medicinal
***S. gilesii* Hemsley	-	3000-4200	2,4	Reg Afghan	NE Afghanistan, India (Kashmir), N Pakistan	Rare	-
S. glabrata (DC.) C. Shih	-	3500-4000	1	Sibir	NW India, Siberia	Rare	-
S. glacialis Herder.	-	>2500	1,4,13	Turk	Kazakstan, Kyrgyzstan, Mongolia, Russia (Siberia), Tajikistan NE Afghanistan, N Pakistan, India (Jammu & Kashmir, Ladakh, Thang Lang La)	Occ	Amchi use its leaves and flowers in liver, throat and heart troubles. It is also used in mental disorder.
S. glanduligera Schi.-Bip.	-	3000-4500	1,2	Reg Himal	India (Kashmir, Himachal Pradesh, Spiti), N Pakistan, China	Rare	-
S. gnaphalodes (Royle) Sch.-Bip.	Yuliang, Ravi Basin Gugi	4000-4500	1,2,3	Reg Himal	NE Afghanistan, India (Jammu & Kashmir, Ladakh, Thang Lang La, Himachal Pradesh), Tibet, Nepal, W Pakistan, SW China	Occ	Used for kidney problems, cough and cold. Aerial parts dried and pulverized and ½ teaspoonful of powder given 3 times a day for 5-15 days to cure backache, pulmonary affections and also for purification of blood.
S. gossypiphora D. Don	Ghuggi Badshah, Bhutkesh, Kasturi Kamal, Fini Kawal	3500-5700	1,2,9,13	Reg Himal	Bhutan, Nepal, India (Himachal Pradesh, Lahaul & Spiti, Ladakh, Sikkim, Garhwal), S Tibet, SW China	CR	The plant is offered for worship at hill shrines and to guard against evil spirits. It is reputed to possess som medicinal properties, e.g. gynecological disorders, menstrual disorders and hysteria. Roots yield essential oil used in perfumery.
***S. graminifolia* Wall.	Ghoogee	3500-5600	2,7,9,13	Reg Himal	Bhutan, India (Uttar Pradesh, Pindari, Furkia, Kumaon, Kashmir, Sikkim), Nepal, S Tibet	Rare	The entire plant is used in Tibetan medicine. It has a sour and sweet taste with heating potency. Antitussive, aphrodisiac, blood purifier and emmenagogue, it is used in the treatment of coughing due to loss of potency in the spleen, irregular menses, semina/vaginal discharge, excessive bleeding from the womb and pain at the waist due to a loss of renal potency.

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Table 1. Continued from previous page.

Taxa	LN/VN	Altitudinal range (m)	Habitat(s)	Nativity	Distribution	Status	Indigenous uses
****S. heteromalla** (D. Don) Hand.-Mazz.	Batula, Murang, Kaliziri	550-4000	2,6,7,9,11	Reg Himal	NE Afghanistan, Bhutan, India (Uttar Pradesh, Uttar Kashi, Sankari, Kashmir, Himachal Pradesh), Nepal, N Pakistan	Co	Leaf paste with mustard oil massaged on leucoderma and wounds. Root extract taken for fever and colic. The seeds are carminative and used for horse-bites.
S. hieracioides Hk.	-	3700-4950	1,2,13	Reg Himal	Bhutan, Nepal, India (Sikkim), E Tibet, S China	Occ	-
S. hookeri Cl.	-	4350-5100	1,2,11	Reg Himal	Bhutan, India (Kumaon, Kashmir, Sikkim, Lachung), E & S Tibet, SW China	Rare	-
****S. jacea** (Klotz.) Cl.	-	3000-4200	1,2,5	Reg Himal	NE Afghanistan, W Tibet, India (Jammu & Kashmir, Ladakh, Dras, Himachal Pradesh), N Pakistan	Rare	-
S. katochaete Maxim.	-	2200-4700	4,11,14	China	China, Bhutan, Tibet, India (Sikkim)	Rare	-
***S. laneana** W.W. Sm.	-	3300-4200	1,2,11	Ind Or	Indian Himalaya (Sikkim)	Rare	Medicinal
S. leontodontoides (DC.) Sch.-Bip.	-	3500-4500	1,2,13	Reg Himal	India (Uttar Pradesh, Chamoli Garhwal, Amritganga Valley, Kashmir, Himachal Pradesh, Sikkim), Nepal, Tibet, C China	Occ	-
S. medusa Maxim.	Snow Lotus	3000-5600	2,9,13	China Mongolia	China, India (Kashmir), Nepal, E Tibet, N Pakistan,	Rare	The whole herb is used in traditional Chinese and Tibetan medicine for the treatment of headache, high blood pressure and to regulate menstrual cycles and treat menstrual problems. Also used as tonic for weakness and remedy for arthritis.
****S. nimborum** W.W. Sm.	-	4500-5000	2,4,12	Ind Or	Bhutan, India (Sikkim, Kashmir), E Tibet	Occ	-
S. nepalensis Spreng.	Nepal Saw-wort	3200-4900	1,2,3,9,11,13	Nepal	Bhutan, Nepal, India (Sikkim), S Tibet, China	Rare	-
****S. nishiokae** Kitam.	-	4500-4900	1,2,11	Bhutan Nepal	Bhutan, India (Sikkim), Nepal	Rare	-
***S. obscura** Lipsch.	-	3600-4800	1,2,4	Reg Himal	Indian Himalaya (Sikkim)	Rare	-
S. obvallata (DC.) Edgew.	Brahm Kamal, Kanwal, Birm Kanwal	3000-4800	2,3,5,9,10,13	Reg Himal	Myanmar, Bhutan, India (Uttar Pradesh, Chamoli Garhwal, Hemkund, Kashmir, Sikkim), E Tibet, Nepal, Pakistan	EN	The flowers, rhizome and leaves are used for various traditional, religious, medicinal and ornamental purposes. The roots are applied to bruises, boils, wounds and cuts and used as a nerve tonic and powerful antiseptic. It is used in several Tibetan medicines and in the treatment of paralysis of the limbs and cerebral ischemia.
S. pachyneura Franch.	-	3900-5300	1,2,13	China Occi	India (Sikkim), Myanmar, Bhutan, E Nepal, Burma, SW China	Rare	-
***S. pantlingiana** W.W. Sm.	-	upto 3600	1,2,13	Ind Or	Indian Himalaya (Sikkim)	Rare	-
****S. piptathera** Edgew.	Himalayan Saw-wort	3200-4600	2,3	Reg Himal	India (Himachal Pradesh, Lahaul, Koksar, Tehri-Garhwal, Sikkim), Nepal	Co	-
****S. polystichoides** Hk.	-	4200-4800	1,2,11	Reg Himal	C Nepal, India (Sikkim)	Occ	-
S. rufinervis DC.	-	>2500	1,2,11,13	Corea	W Himalaya (Himachal Pradesh)	Rare	-
****S. roylei** (DC.) Sch.-Bip.	-	3000-4200	2,3,4,7,9	Reg Himal	India (Uttar Pradesh, Uttar Kashi, Bhojwasa, Himachal Pradesh, Kashmir), Nepal	Rare	The entire plant is used in Tibetan medicine. It has a bitter taste and a cooling potency. Antidote, anti-inflammatory, emollient, hemostatic and vasoconstrictor, it is used in the treatment of wounds, excessive bleeding and meat poisoning. A paste of the plant is used as poultice to relieve aching joints.

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Table 1. Continued from previous page.

Taxa	LN/VN	Altitudinal range (m)	Habitat(s)	Nativity	Distribution	Status	Indigenous uses
S. schultzii Hk.	-	>3000	5,10	Reg Himal	China, India (Kashmir, Ladakh), N Pakistan	Rare	Medicinal
S. simpsoniana (Field & Gard.) Lipsch.	Jogi Badshah, Ghuggi, Yogeshawar, Fen Kamal	3300-5600	2,8,9,10,13	Reg Himal	China, Tibet, India (Uttar Pradesh, Chamoli Garhwal, Hemkund, Kashmir, Sikkim, Himachal Pradesh), Bhutan, Nepal, Pakistan	EN	The plant is used for all kinds of nervous debility; root extract for snake bite, plague and painful periods; roots and essential oil as insecticides. Also useful for cough, blood purification, leucorrhea and sexual problems.
S. stella Maxim.	-	4500-4800	1,2,11	China	China, India (Sikkim), Bhutan, SE Tibet	Rare	Medicinal
S. stoliczkae Cl.	-	>2500	1,2,11	Reg Himal	India (Kashmir, Himachal Pradesh), Nepal, Tibet, N Pakistan, China	Rare	-
S. stracheyana (Kuntze) Lipsch.	-	2600-3800	1,2,3,4,9	Sibir	India (Uttar Pradesh, Uttar Kashi, Harki Dun, Kashmir), Nepal	Rare	-
S. subulata Cl.	-	4100-5300	2,4,13,15	Reg Himal	Tibet, India (Sikkim), N Pakistan, China	Rare	-
**S. sudhanshui* Hajra	-	2000-3000	8,11	Ind	India (Uttar Pradesh)	Rare	Medicinal
***S. sughoo* Cl.	-	3300-4800	1,2,13	Ind Or	CE Nepal, India (Sikkim)	Rare	Medicinal
***S. taraxacifolia* Wall. ex DC.	-	3000-4500	2,5,9,11,13	Reg Himal	Bhutan, India (Uttar Pradesh, Chamoli Garhwal, Keal Bhairawn, Kashmir, Sikkim), Nepal, Pakistan	Occ	Used for ulcer and cold
***S. thomsonii* Cl.	-	4000-5200	2	Reg Himal	India (Kashmir), N Pakistan, Tibet	Rare	-
S. thoroldii Hemsley	-	3100-5200	14,15	Reg Himal	India (Kashmir), N Pakistan, Tibet, China	Rare	-
***S. tridactyla* Sch.-Bip.	Snow Lotus	upto 5100	2,4,5, 8,9,10,13	Reg Himal	India (Sikkim), Nepal, Bhutan, Tibet	Rare	Ornamental
S. uniflora (DC.) Wall. ex. Sch.-Bip.	-	3300-4200	2,9,11	Reg Himal	India (Sikkim, Lachung), Nepal, Bhutan, SW China	Rare	-
S. wernerioides Sch.-Bip. ex. Hk.	-	4500-4950	2,5,9,11,13	Reg Himal	India (Sikkim), Nepal, Bhutan, SE Tibet, SW China	Rare	-
***S. yakla* Cl.	-	3600-4800	2,9,11,13	Reg Himal	India (Sikkim), Nepal, Bhutan, Tibet (SE Lhasa)	Rare	-

LN=Local Names; VN=Vernacular Names; *=Endemic; **=Near Endemic; 1=Shady moist; 2=Alpine meadow/slopes; 3=Shrubberies; 4=Open grassy slope; 5=Shady rock/boulders; 6=Roadside/waste places; 7=Cultivated area/Agricultural fields; 8=Dry places; 9=Rocky slopes; 10=Snowline/glacier slopes; 11=Forest; 12=Riverine; 13=Alpine screes; 14=Flooded area; 15=Saline alkali lands; Reg Himal=Himalayan Region; CR=Critically endangered; EN=Endangered; Co=Common; Unco=Uncommon; Occ=Occasional; Ind=India; Or=Oriental; Trop=Tropical; As=Asia; Turk=Turkestan; Mont=Mountain; Kara=Karakorum; Sibir=Siberia; Afghan=Afghanistan; Occi=Occidentalis; N=North; S=South; E=East; W=West; C=Central

tion to generation. Therefore, the documentation of indigenous uses is essential for defining priorities for conservation of the species. Recorded information on the economic value of the species of *Saussurea* is very fragmentary.

In the present study, of the total species examined, indigenous uses of 28 species were known, and of these, 27 species had medicinal value or are used for the treatment of various diseases and ailments (Table 1). Six species (*S. affinis, S. auriculata, S. bracteata, S. costus, S. gossypiphora* and *S. obvallata*) are used as medicine, food, fodder, fuel, and for ornamental and religious purposes. Among the various parts, i.e. leaves, stem, flowers, seeds, aerial parts, roots, etc. of the plants used for curing diseases, roots are the most often cited. All parts of the plant of *S. ceratocarpa, S. costus, S. graminifolia, S. medusa, S. obvallata* and *S. roylei* are said to be used for medicinal purposes.

Among the species of *Saussurea*, *S. costus* is the most commercially viable species. Its medicinal properties are well documented in traditional Chinese medicine, the Tibetan system of medicine, and ayurvedic medicine. Out of the 175 formulations reported in *The Handbook of Traditional Tibetan Drugs*, this species is one of the main ingredients in 71 formulations.[45] The roots of *S. costus* have a strong and sweet aromatic odor with a bitter taste, and are used as an antiseptic and in controling bronchial asthma, particularly of the vagotonic type.[8]

Preparations made from this species are also reported to cure various diseases and conditions including dysentery, rheumatism, bronchitis, cholera, jaundice, ulcers, skin diseases, stomachache, gas, toothache, cough, cold, fever, edema, bruises and cuts.[8] The oil extracted from the roots is known as Costus Oil, which is used in high-grade perfumes and in the preparation of hair oil. Costus Oil is also said to be effective in the treatment of leprosy. In the Himalayan states of India, the roots are used as insecticide to protect shawls and woollen fabrics, and as incense. In the Lahaul and Spiti districts of Himachal Pradesh, dried leaves of *Kuth* are smoked as tobacco and

upper parts of its plants are used as fuel and fodder.[8,42] The roots of *S. auriculata* can be substituted for the roots of *S. costus*.[8]

Besides *S. costus, S. obvallata* and *S. gossypiphora* are other high value species used not only for medicine, but also highly valued for religious purposes.[8,46] These species are offered for worship at hill shrines and used to guard against evil spirits. The former, known as '*Brahma Kamal*' has been designated the state flower for Uttarakhand. It is offered to the goddess 'Nanda Devi' and other deities on auspicious days. Some species such as *S. bracteata, S. gnaphaloides, S. costus, S. obvallata* and *S. taraxacifolia* are used as the main ingredients in the '*Amchi*' Medical System, a traditional system of Tibetan medicine.[47] Besides indigenous uses, the roots of *S. costus, S. gossypiphora* and *S. simpsoniana* yield an essential oil which has been sold for a premium in making high-grade perfume, various medicines and insecticides.

IUCN status

Habitat specificity, population size, distribution range and anthropogenic pressure play an important role in identifying the status of the species.[48] Being habitat specific and distributed in a narrow geographical range, most high altitudinal species of *Saussurea* in the Himalayas are in need of some sort of protection (conservation).[49]

Of the total species identified in the present study, 44 were identified as rare, 2 species, *S. costus* and *S. gossypiphora*, as *critically endangered*, and 2 species, *S. obvallata* and *S. simpsoniana*, as *endangered*, due to heavy pressure on these species. Other species were identified as *occasional, uncommon* and *common* in the study region (Figure 3). Population assessment using standard ecological methods is suggested for actual quantification of existing stock of the rare and threatened species in natural habitats.

S. costus has been in high demand in the pharmaceutical industry, but during the last decade the species has been even more popularized due to its threatened status globally. Due to high market demand and uncontrolled exploitation of the species, it was reported to be extinct in many pockets in the wild.[4] To meet the market demand and conserve the species, commercial cultivation of *S. costus* was taken up in the neighboring villages of the habitats in Kashmir, and subsequently it was initiated in high altitude areas of neighboring states such as Himachal Pradesh and Uttarakhand. Being an endemic species to the Himalayas, the distribution of *S. costus* is quite restricted to an extremely narrow geographical range.[50]

Due to great demand for raw material from these plants, most of the natural populations of the species are either under destructive harvesting or have been extirpated. Consequently, this invaluable species has been declared endangered[51,52] and is listed in *Appendix I* of CITES (Convention of International Trade in Endangered Species of Wild Fauna and Flora). The species is also included in the negative list of exports of the Ministry of Commerce, Government of India and in the 'Schedule VI' of the Wildlife Protection Act of India. Also, trade of the species is strictly prohibited under the Foreign Trade Development Act-1992. This species is being cultivated commercially in the cold desert of Lahaul Valley, but owing to the fluctuating and low market prices of raw material, the cultivation is restricted to a few villages.[42]

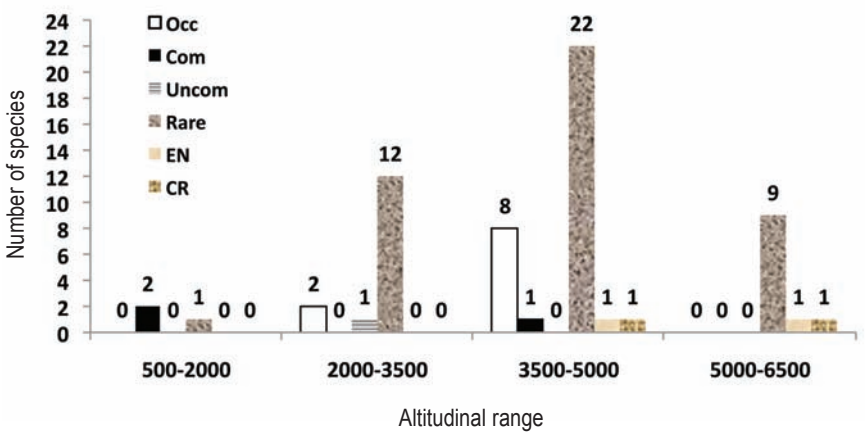

Figure 3. IUCN status of *Saussurea* species distributed in different altitudinal ranges (Abbreviations used: Occ=Occasional; Com=Common; Uncom=Uncommon; EN=Endangered; CR=Critically Endangered)

Besides *S. costus*, many other species of *Saussurea* are categorized under rare and threatened. Apart from the restricted distribution, the harvesting of whole plants of most of the species of *Saussurea* is one of the reasons for their threatened status (harvesting of plant parts which permit regeneration or re-growth is a less damaging mode of use). Incidentally, *S. ceratocarpa, S. graminifolia, S. medusa, S. obvallata* and *S. roylei* are the prominent species whose whole plant is used for medicine and thus, these species are more prone to extinction and need immediate conservation. Law and Salick[53] revealed that the plants of *S. laniceps* (found in the Himalayan region), being larger in size, are easier to find and moreover, the whole plant of this species is harvested just before seed set. Therefore, early or untimely collection of the plants may also be one of the threats to the species.

Review of propagation and cultivation

The review of literature indicates that the propagation (conventional and *in vitro*) and cultivation techniques are lacking for most of the species of *Saussurea* excluding *S. costus*,[28,34] *S. obvallata*[35,36] and *S. medusa*.[37,38] Cultivation of *S. costus* in the Cold Desert of the Lahaul valley was initiated during the 1920s, and at present the species is being cultivated commercially.[8,42] Small scale cultivation of the species by some tribal communities has also been reported from the Nanda Devi Biosphere Reserve (2000-3500 m) of the Uttarakhand.[39] In *S. laniceps*, due to its high medicinal and edible value and rarity, efforts are being made in Tibet towards its conservation and cultivation.[40] Information on the propagation and cultivation of some species of *Saussurea* is available at the Rock Garden Plant Database website.[41]

Conclusions

The present study provides comprehensive information on the diversity, distribution, habitat preference, nativity, endemism and status of 62 species of *Saussurea* in the IHR. Among these, indigenous uses of 28 species are known in the region. The genus *Saussurea* shows high habitat specificity as 16 species were recorded to be restricted to one or two habitats only. A few of the species are known for their economic value and, therefore, other species should also be investigated for their economic importance. *S. affinis, S. auriculata, S. bracteata, S. costus, S. gossypiphora* and *S. obvallata* were recorded as multipurpose species, used as medicine, food, fodder, fuel, and for ornamental and religious purposes. Considering the high industrial demand for raw material and the endangered status of *S. costus, S. gossypiphora, S. obvallata* and *S. simpsoniana*, these 4 species should be priorities for conservation (*in situ* and *ex situ*) throughout the IHR. Population assessment of the native, endemic and rare/endangered species using standard ecological methods has been suggested for the quantification of the

existing stock of these species in their natural habitats. Phytochemical investigations for the identification of active ingredients are urgently required to identify the potential of the species. A review of the literature indicates that propagation and cultivation techniques are available only for a few species of *Saussurea* and, therefore, these techniques need to be developed, particularly for rare/endangered and multipurpose species. Native communities need to be made aware of the sustainable use and conservation value of the species of *Saussurea*.

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