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# Diversity, distribution and traditional uses of medicinal plants in Jammu and Kashmir (J&K) state of Indian Himalayas

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ABSTRACT

The Indian Himalayan state of Jammu and Kashmir (J&K) harbours rich biodiversity, including diverse medicinal flora. The scientific documentation of diversity, distribution and traditional uses of medicinal flora can prove pivotal in the conservation and sustainable use of these precious plant resources in this Himalayan state. The present study, based on extensive ethno-medicinal surveys carried out during the last decade and supplemented with verified records from a systematic literature review, has developed a biodiversity database on medicinal plants of J&K state. The comprehensive database includes a total of 1123 plant species with practised ethno-medicinal uses in the state. The majority of the species (78%) are native to the Himalayan region. In most cases, whole plants are used, followed by leaves and underground parts. In total, these medicinal plant species are traditionally used to alleviate 266 types of disease. The present study has identified 20 important medicinal species, each used to cure more than 25 diseases. Based on the relative frequency citation (RFC) value, *Taraxacum officinale* and *Aconitum heterophyllum* are the most frequently used medicinal plant species in J&K. The present study, by adopting a scientifically sound taxonomic approach, reports one of the most comprehensive and updated syntheses of the medicinal flora of J&K state. This baseline information on the diversity, distribution and traditional uses of medicinal flora has immense applications, as it can provide insightful leads towards the discovery, development and designing of future drugs.

## 1. Introduction

Indigenous knowledge constitutes the basis of traditional healthcare systems and has the potential to contribute significantly to the sustainable development of societies and economies (Bekalo et al., 2009; Patra, 2009; Rana, 2011). It is estimated that 70–95% of people living in developing countries rely on the use of medicinal plants for their primary healthcare needs (WHO (World Health Organization), 2011). However, in recent times, the traditional knowledge of medicinal plants is fast becoming endangered and at risk of being lost forever (Huai, 2000; Ramirez, 2007). Globally, there are many factors that lead to risks to traditional usage, including climate and land use changes (Volpato et al., 2009), urbanization, and economic globalization (Cetinkale and Acıksöz, 2007; Wu and Petriello, 2011). In view of the imminent threat of losing this precious knowledge, recording it and understanding its historical and botanical roots has received increasing global attention (Leonti et al., 2003). In fact, the compilation of authentic and verified traditional knowledge about medicinal plants has gained urgency in recent times because it has wide implications for their conservation and sustainable use. The database thus generated by this study may prove helpful in the implementation of environmental management, policy making, and access-benefit sharing mechanisms relevant to a particular region (Farooquee et al., 2004).

The Himalayan region is well known for its biodiversity, particularly of medicinal plants (Dar et al., 2008; Dar and Khuroo, 2013; Tali et al., 2018). The region is also home to diverse ethnic communities, each with its own culture and traditional knowledge system. In recent times, due to the ever-increasing push for economic development and the resulting socio-cultural transformation, the biodiversity as well as associated Traditional Knowledge (TK) in the Himalayan region is facing a high risk of extinction (Raut et al., 2012). It is in this context that the present study was undertaken, to assess the diversity and

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distribution of medicinal plants and related traditional knowledge in the Indian Himalayan state of Jammu and Kashmir.

The Jammu and Kashmir (hereafter J&K) is well known for its rich floristic diversity, including a diverse medicinal flora (Dar et al., 2008; Dar and Khuroo, 2013). Over the last century, a large body of scientific literature has documented innumerable medicinal uses of plants by ethnic communities in the state (Gupta et al., 1980; Uniyal, 1981; Srivastava and Gupta, 1982; Dar et al., 1984; Bhattacharyya, 1991; Naqshi et al., 1992; Dhar and Siddique, 1993; Singh, 1995; Kaul, 1997; Kirn et al., 1999; Singh, 2002; Beigh et al., 2003; Ganai and Nawchoo, 2003; Khan et al., 2004; Kak, 2007; Ballabh et al., 2008; Ballabh and Chaurasia, 2009; Malik et al., 2011; Bhat et al., 2012; Ganie et al., 2013; Bhatia et al., 2014, 2015), yet scientifically reliable synthesis of this precious ethno-medicinal knowledgebase is still lacking. To fill this knowledge gap, the present study reports one of the most comprehensive and updated syntheses on the diversity and distribution of the ethno-medicinal flora of J&K state. Specifically, the present study aims to: (a) record the taxonomic diversity of medicinal flora, (b) describe their provincial distribution, and (c) document the therapeutic uses of ethno-medicinal flora of the J&K state.

## 2. Materials and methods

### 2.1. Study area

The Indian Himalayan Region (IHR), lying between 21° 57″-37°50″N and 72°40″ - 97°25″E, covers about 16% of India's total geographical area (Nandy and Rao, 2001). Out of the 12 states that fall under the IHR, Jammu and Kashmir (J&K) state is situated on the northwestern boundary of India. Located between 32°11″70′N - 36°15″80′N latitude and 73°12″60′E -80°13 ″00′E longitude (Singh, 1995), the J&K state has an area of 2, 22, 236 $km^2$ (FSI, 2011). The state is mainly mountainous, except for a short belt adjoining the Punjab plains and the main valley of Kashmir. Biogeographically, the state comprises three distinct provinces, viz., Jammu, Kashmir and Ladakh (Fig. 1). The state possesses wide altitudinal gradient, land with diverse geological formations and different climatic zones viz., subtropical, temperate, alpine and cold desert, resulting in the rich diversity of its flora (Dar and Khuroo, 2013).

### 2.2. Ethno-botanical surveys

During the present study, systematic and extensive ethno-botanical surveys were carried out across the state over the last decade (2006–2016). Formal written consent, including consent for publication was received from all the informants. During the present study, 70 villages (25 each in Ladakh and Jammu province and 30 localities in Kashmir province) were surveyed and a total of 650 informants were interviewed, aged between 31–75 years. The informants were specifically asked questions about their traditional knowledge, plant use, part/s used and disease treated. Interviews were generally conducted in local language. All the documented data was then translated into English. Before data collection, a brief group discussion was held with the key informants, in which the objectives of the research were explained to them. This was carried out in order to acknowledge the informants cooperation in preserving the traditional knowledge of the study area and build their confidence for providing reliable information.

### 2.3. Data sources for systematic review

The present investigation started with the development of a database on medicinal plants of J&K, recorded during the field work and then supplemented with a systematic review of previous research studies on ethno-medicinal plants conducted over the last 35 years (1980–2015). A total of ninety six (96) research publications were selected and reviewed (Supplementary Material-I). The previous studies were selected based on the following criteria: (1) the study must have been carried out among the traditional communities within the J&K state (2) the past records of medicinal uses of plant species have been developed from ethno-botanical fieldwork, and those based on bibliographical revision or compilation were excluded, (3) only the vascular plants and pteridophytes were considered, (4) studies reporting on a conference, seminar or symposium summaries/reports/souvenirs were excluded, (5) species lists without information on specific medicinal uses were also excluded.

### 2.4. Compilation of database on medicinal plants

The ethno-medicinal information gathered during the present study through extensive field surveys was supplemented with the data generated from a systematic review of past scientific literature for the compilation of a database on medicinal plants used in curing different ailments by various ethnic communities of J&K state.

### 2.5. Nativity status

During the present study, the medicinal plant species were classified into 5 categories based on the spatial scale: (i) endemic to Western Himalaya (species whose distributional range lies within the biogeographic region of Western Himalaya falling in Pakistan, India, and China); (ii) endemic to Himalaya (species whose distribution range spans across the entire Himalaya falling in Pakistan, India, China, Nepal, and Bhutan); (iii) native (species whose distribution range extends beyond the western and/or eastern limits of the Himalayas; (iv) cultivated (species which are exclusively cultivated in the state) (v) naturalized (species which have been introduced intentionally or accidentally into the state).

To determine the distributional range of species, various specialized online sources such as GRIN taxonomy (www.ars-grin.gov/~sbmljw/johnindex.html) and Catalogue of Life (www.catalogueoflife.org/) were used.

### 2.6. Taxonomic appraisal and scientific nomenclature

The database has been arranged based on the Angiosperm Phylogeny Group-III (APG-III) classification (Haston et al., 2009) as followed by on-line source: The Plant List (www.plantlist.org). In the database, the currently valid scientific name of each taxon with its respective family is supplemented by important information on growth form, provincial distribution (Kashmir, Jammu, Ladakh), part/s used and source(s) of its record in the state. For example, among the dicotyledons, some of the taxa previously recognized under Chenopodiaceae (*Chenopodium*) and Scrophulariaceae (*Lagotis*) have been shifted to Amaranthaceae, and Plantaginaceae respectively and also in some cases generic names of the species (*Cucubalus baccifer* L. instead of *Silene baccifera* (L.) Roth.) have been changed in accordance with The Plant List (see Supplementary Material-I).

### 2.7. Categorization of diseases

The present study has attempted to develop a uniform framework for categorization of different diseases, and the diseases recorded were grouped into 16 categories following the International classification of primary care - 2nd Edition (ICPC-2-English)

### 2.8. Data analysis

#### 2.8.1. Relative frequency of citation

The documented ethno-botanical information was quantitatively analyzed using an index of relative frequency citation (RFC) as;

RFC = FC/N ($0 < RFC > 1$)

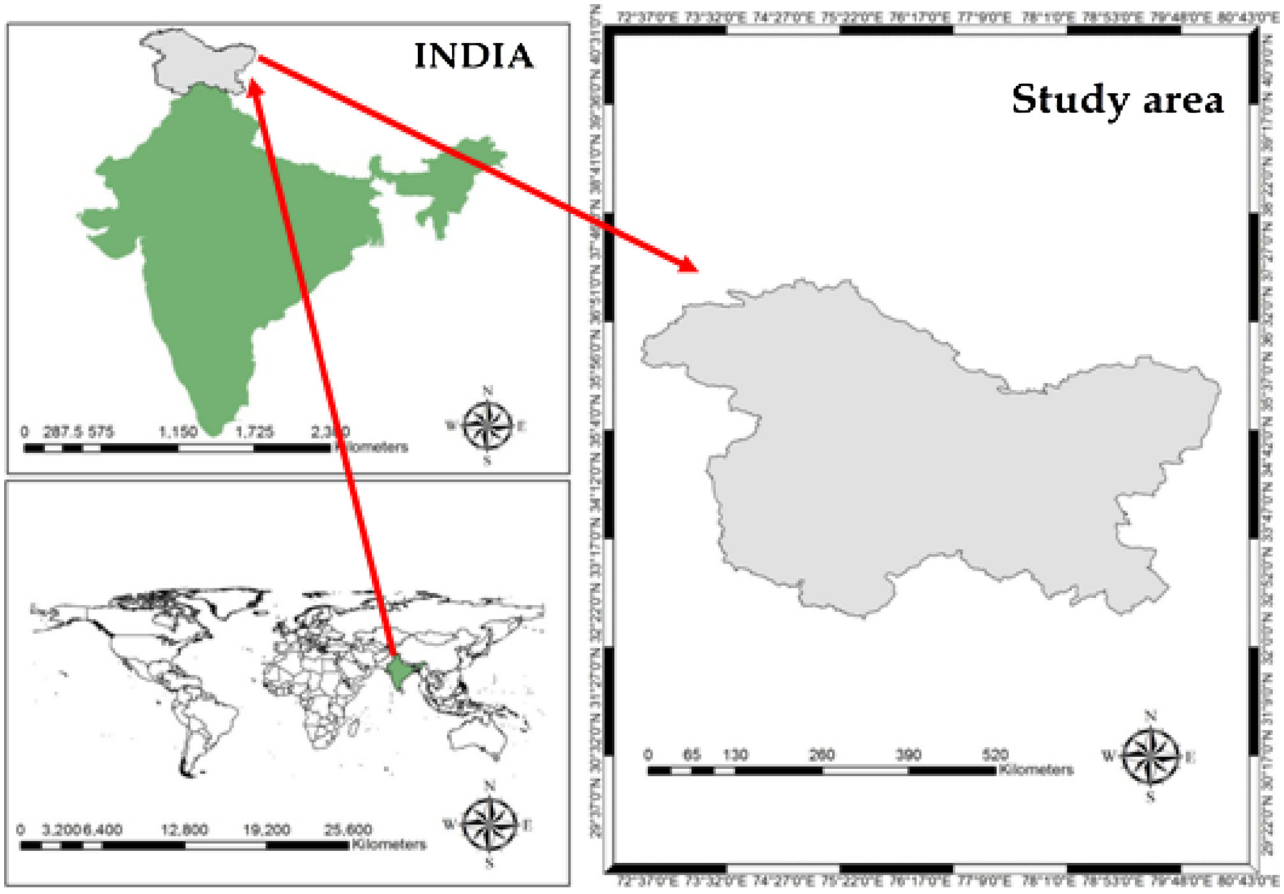


**Fig. 1.** Map showing the study area (Indian Himalayan state of Jammu and Kashmir).

**Table 1**
Dominant families among various taxonomic groups in the ethno-medicinal flora of J&K state.

| Family | No. of species |
|---|---|
| A **Dicotyledons** | |
| Asteraceae | 151 |
| Fabaceae | 69 |
| Lamiaceae | 66 |
| • **Monocotyledons** | |
| Poaceae | 18 |
| Amaryllidaceae | 13 |
| Cyperaceae | 10 |
| Orchidaceae | 10 |
| • **Gymnosperms** | |
| Pinaceae | 7 |
| Cupressaceae | 4 |
| • **Pteridophytes** | |
| Aspleniaceae | 4 |
| Dryopteridaceae | 4 |
| Pteridaceae | 4 |

RFC for a species is calculated by the frequency of citation (FC), (FC is the number of literature sources mentioning the use of the species i.e., number of citations within the perused literature) divided by the total number of literature sources (N) (Zhang et al., 2014) (N = 96 literature sources in the present study).

## 3. Results

### 3.1. Diversity of ethno-medicinal flora

The present study recorded the use of 1123 plant species for various medicinal purposes in the J&K state. The complete database of the ethno-medicinal flora comprising of species name, family, followed by growth form, part(s) used, disease(s) treated and distributional status has been recorded (Supplementary Material-I). These plant species belong to 564 genera distributed in 137 families. Relative contribution to the medicinal flora from major taxonomic groups revealed that dicotyledons are the most dominant followed by monocotyledons, pteridophytes and gymnosperms. The proportional distribution of species in the medicinal flora showed that 87.35% (981 spp.) are dicotyledons, 9.88% (111 spp.) monocotyledons, 1.52% (17 spp.) pteridophytes and 1.25% (14 spp.) gymnosperms.

The ten families namely: Asteraceae, Fabaceae, Lamiaceae, Ranunculaceae, Rosaceae, Apiaceae, Brassicaceae, Polygonaceae, Caryophyllaceae, Gentianaceae contribute about 50% of all the species; and of these 5, families with the highest number of species are Asteraceae (151 species; 13.44% of the total), Fabaceae (69 species; 6.14%), Lamiaceae (66 species; 5.87%), Ranunculaceae (53 species; 4.71%), and Rosaceae (43 species; 3.82%). There were forty six families (43.57% of the total) which were represented by only one medicinal plant species each. The remaining eighty one families contributed between 2–22 species (0.17–1.95% of the total).

The most dominant families with respect to the number of species among different taxonomic groups are depicted in Table 1.

Some of the taxa were obviously dominant at the generic level, 10 genera (1.77% of the total 564) being represented by 10 or more species and contribute about 11.87% of total species. The genus *Artemisia* has the highest number of medicinal plant species (19 species) followed by *Nepeta* (17), *Saussurea* (16), *Astragalus* (15), *Ranunculus* and *Allium* (12 each), *Gentiana* and *Potentilla* (11 each), *Euphorbia* and *Corydalis* (10 each).

These results showed that the medicinal flora of J&K state comprises

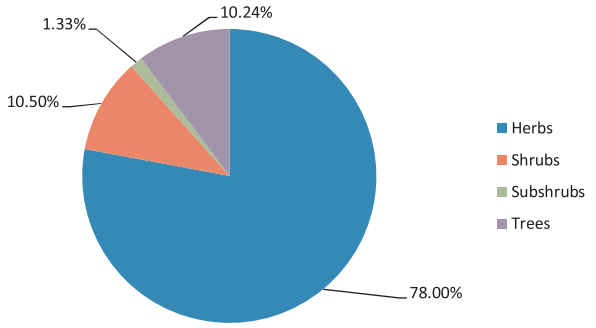


**Fig. 2.** Percentage of different growth forms in the ethno-medicinal flora of J & K state.

of different growth forms. It has been found that among the various growth forms, herbs are dominant followed by shrubs, trees and sub-shrubs (Fig. 2). The distribution of various growth forms among different taxonomic groups is shown in Fig. 3.

### 3.2. Nativity status and provincial distribution of ethno-medicinal flora

During the present investigation, it was revealed that a large proportion of medicinal flora is native to this Himalayan state; and over time, people have gained a rich knowledge of using these natural resources for their health care. Of the total species reported (1123 spp.), 881 (78.45%) are native, 153 (13.36%) naturalized, 69 (6.14%) are cultivated and 20 species (1.78%) are of uncertain origin.

On analyzing the distribution of medicinal flora in the three regions of the state, it was revealed that the Kashmir region harbours the highest diversity of medicinal plants with 560 plant species being used for medicinal purposes, followed by Ladakh and Jammu regions with 495 and 474 species respectively. It was also observed that some of the plants used in one region are also used in the other region/s of the state (e.g. *Valeriana jatamansi* Jones is being used in all the three regions of the state, *Rumex dentatus* L only in Jammu and Ladakh regions, *Astragalus rhizanthus* Benth. only in Kashmir and Ladakh, and *Saussurea heteromalla* (D.Don) Hand.-Mazz used only in Kashmir and Jammu regions) while as some the species are used only in a particular region (e.g. *Epilobium roseum* (Schreb.) Schreb used only in Jammu, *Senecio graciliflorus* (Wall.)DC. in Kashmir region only and *Artemisia dracunculus* L. only in Ladakh region). The nativity assessment across the different life forms and provinces of the state is shown in Tables 2 and 3. It was revealed that at the provincal level, the Ladakh region harbors the highest percentage (86.86%) of native species followed by Kashmir (78.03%) and Jammu (72.15%). Furthermore, the highest percentage of native species by growth form are shrubs (83.19%) followed by herbs (79.42).

**Table 2**
Nativity of medicinal flora across the different provinces of the J&K state.

| Nativity | Number of species | | |
|---|---|---|---|
| | Kashmir | Ladakh | Jammu |
| Native | 274 | 255 | 255 |
| Himalayan endemic | 62 | 73 | 41 |
| North-Western Himalaya endemic | 91 | 102 | 46 |
| Naturalized | 83 | 43 | 82 |
| Cultivated | 42 | 16 | 41 |
| Unknown origin | 8 | 6 | 9 |
| **Total** | **560** | **495** | **474** |

**Table 3**
Nativity of medicinal flora across the different life forms in J&K state.

| Nativity | Number of species | | | |
|---|---|---|---|---|
| | Herbs | Shrubs | Sub-shrubs | Trees |
| Native | 450 | 66 | 9 | 55 |
| Himalayan endemic | 102 | 19 | 1 | 6 |
| North Western Himalaya endemic | 144 | 14 | 1 | 14 |
| Naturalized | 119 | 12 | 3 | 19 |
| Cultivated | 44 | 7 | 0 | 18 |
| Unknown origin | 17 | 1 | 1 | 1 |
| **Total** | **876** | **119** | **15** | **113** |

### 3.3. Ethno-medicinal use

The study revealed that both whole herbs and different plant parts, such as shoots, leaves, flowers, fruits, seeds and rhizomes are used to treat various types of human diseases. Furthermore, different parts of the same species are used to treat different diseases, or the same part is used to cure different diseases, or different plants are used to treat the same disease. In the majority of cases, whole plants (440 spp.) are used for the treatment of various diseases followed by leaves (405 spp.), underground parts (370 spp.), flowers (168 spp.) and seed (158 spp.) (Fig. 4).

The ethno-medicinal flora of J&K state is used to treat 266 types of different human diseases (Supplementary Material-II-). Ten common diseases (fever, cuts and wounds, stomach problems, cough, rheumatism, skin diseases, diuretic, common cold, diarrhea, tonic, and intestinal worms) are treated by more than 100 medicinal plant species. About 250 species are used against fever, stomach problems (159 spp.), cuts and wounds (183 spp.), cough (151 spp.), rheumatism (149 spp.), skin diseases (142 spp.), common cold (123 spp.), intestinal worms (108 spp.), as tonics (114 spp.) and as diuretics (132 spp.). Furthermore, many of the diseases are cured by 50 or more plant species (Table 4). It was also observed that some of the medicinal plants are used to treat more than one disease and likewise, more than one

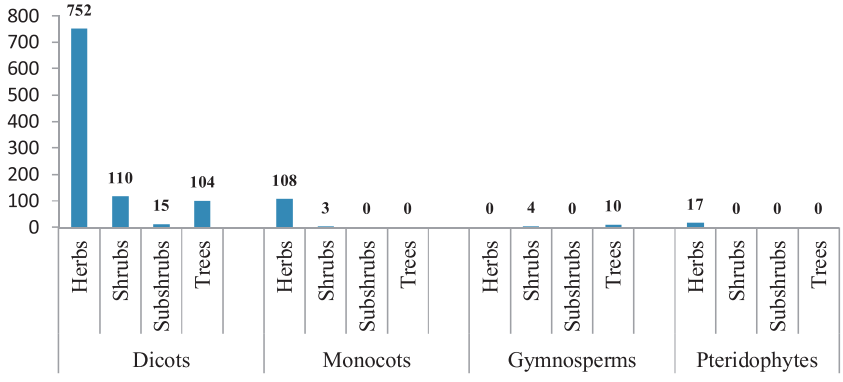


**Fig. 3.** Number of herbs, shrubs, sub-shrubs and trees in different taxonomic groups.

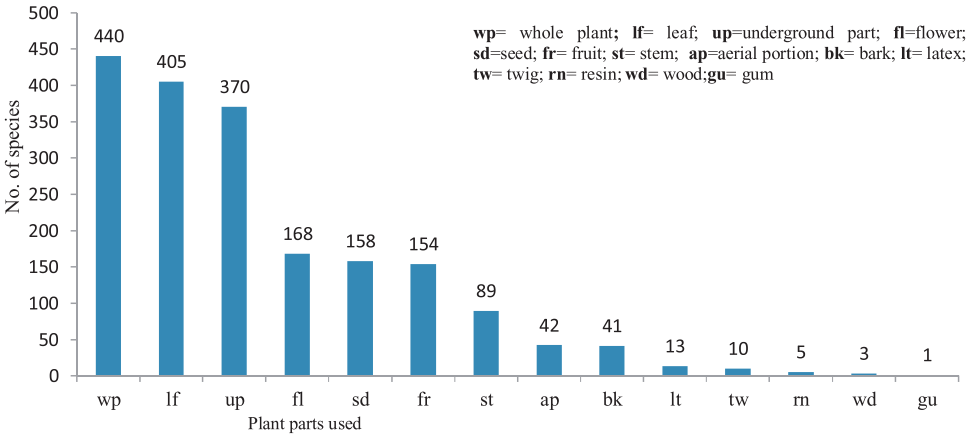


**Fig. 4.** Number of species with reference to the plant part(s) used to treat variousdiseases in the medicinal flora of J & K state.

**Table 4**
Number of different plant species used to treat various diseases in J&K state.

| Disease | No. of plant species used |
|---|---|
| Toothache | 94 |
| Indigestion | 94 |
| Headache | 94 |
| Dysentery | 94 |
| Laxative | 90 |
| Asthma | 87 |
| Boils | 83 |
| Urinary infection | 76 |
| Constipation | 73 |
| Kidney problems | 68 |
| Blood impurities | 68 |
| Abdominal problems | 67 |
| Joint pain | 64 |
| Jaundice | 62 |
| Liver ailment | 61 |
| Eye complaints | 60 |
| Astringent (wounds) | 59 |
| Heart diseases | 55 |
| Bronchitis | 52 |
| Flatulence | 51 |

medicinal plant is used to treat a particular disease.

It was revealed that out of the 16 broad disease categories recognized during the present study, most of the species were used against gastrointestinal disorders. Of the 1123 species, 587 species were used to cure different ailments of the digestive system followed by 435 used for respiratory ailments and 347 for skin problems. The number of plant species used against each category of disease is depicted in Table 5.

Each plant species with ethno-medicinal use recorded during the present study is noteworthy, but some of them hold considerable importance in the traditional medicinal system. The results revealed that there are 20 species which are used to cure more than 25 types of diseases. Based on all the medicinal uses recorded, the present study has prioritized the 20 most important medicinal plants according to the number of diseases cured by these plant species (Supplementary Material-III). On computing the RFC, it was revealed that for 91 species RFC varied from 0.35 to 0.10; for 567 species it ranged from 0.09 to 0.02 and for the rest of the species i.e. 463 species it was 0.01. The top ten species based on the RFC scores are depicted in Table 6.

**Table 5**
Number of plant species used against each disease/condition category proposed by ICPC-2-English in J&K state.

| S. No. | Diseases Category | No. of species |
|---|---|---|
| 1. | General and unspecified | 304 |
| 2. | Blood, Blood forming organs and immune mechanism | 105 |
| 3. | Digestive | 587 |
| 4. | Eye | 47 |
| 5. | Ear | 22 |
| 6. | Cardiovascular | 166 |
| 7. | Musculoskeletal | 273 |
| 8. | Neurological | 154 |
| 9. | Psychology | 92 |
| 10. | Respiratory | 435 |
| 11. | Skin | 347 |
| 12. | Endocrine/ metabolic and nutritional | 22 |
| 13. | Urological | 272 |
| 14. | Pregnancy, childbearing, family planning | 18 |
| 15. | Female genital | 36 |
| 16. | Male genital | 26 |

**Table 6**
Medicinal plant species of J&K state with highest scores of RFC value.

| S. No. | Species | RFC |
|---|---|---|
| 1 | *Taraxacum officinale* | 0.35 |
| 2 | *Aconitum heterophyllum* | 0.33 |
| 3 | *Juglans regia* | 0.31 |
| 4 | *Saussurea costus* | 0.30 |
| 5 | *Achillea millefolium* | 0.30 |
| 6 | *Podophyllum hexandrum* | 0.29 |
| 7 | *Berberis lyceum* | 0.27 |
| 8 | *Datura stramonium* | 0.27 |
| 9 | *Urtica dioica* | 0.25 |
| 10 | *Arnebia benthamii* | 0.23 |

## 4. Demographic data

During the present study, a total of 350 men (53.84%), 300 women (46.15%) were interviewed. The informants were divided into three age groups: (i) 31–45, (ii) 46–60, and (iii) 61–75 years. Most of the informants (i.e. 400) belonged to the age group 61–75 years while for the rest, 150 and 100 informants were between the age of 46–60 and 31–45 years respectively. The study revealed that the people belonging to the age group of 61–75 years possessed richer traditional knowledge about the use of plants than the other two age groups. It was further observed that at the gender level, the women had acquired more knowledge than men.

## 5. Discussion

The present study documented and compiled traditional knowledge of medicinal plants in the J&K state. Documentation of traditional

knowledge is of prime importance because it helps in protecting this unconventional knowledge. Maintaining records of this precious knowledge is equally as important as conservation of the medicinal plants (Raut et al., 2012).

The inhabitants of J&K state embody a rich source of knowledge, learned and transmitted within their culture across space and time. The present study clearly shows the intimate relationship between the provisioning ecosystem services of plants and human well-being in this Himalayan state.

The provincial distribution of the medicinal flora of J&K state indicates that most of these species are used in the main Kashmir valley (temperate region) followed by Ladakh (cold arid zone) and Jammu regions (sub-tropical). Such variations directly reflect the vegetation and floristic diversity of the state (Gairola et al., 2014). The similar composition of these medicinal plant species between the regions indicate that most of the species are shared between the Kashmir and Jammu regions followed by Kashmir and Ladakh whereas only 23 species are shared between Jammu and Ladakh regions. The vegetation of Kashmir region of J&K state shows much resemblance with both Jammu and Ladakh; however, there are few similarities between the flora of Jammu and Ladakh (Gairola et al. (2014).

The present study demonstrates that most of the medicinal plant species belong to Asteraceae (151 species) followed by Fabaceae (69), Lamiaceae (66) and Ranunculaceae (53) while the rest of the families were represented with a variable number of species. The findings regarding the high use of plants belonging to Asteraceae and Lamiaceae in the J&K are in agreement with other studies carried out on ethnomedicinal floras in other parts of the world e.g. Blanco et al., 1999 (El Caurel, Galicia, Northwest Spain); Cornara et al., 2009 (Eastern Riviera, Liguria, Italy); Benı'tez et al., 2010 (Granada province, Southern Spain); Bano et al., 2012 (Deosai Plateau, Himalayan range); Bano et al., 2014 (Skardu valley, Karakoram-Himalayan range, Pakistan). Gazzaneo et al. (2005) observed that there is a tendency for a few plant families to stand out in any pharmacopoeia. Bennett and Prance (2000) reported Lamiaceae and Asteraceae are the leading medicinal plant families whereas Agra et al. (2007) have also reported Fabaceae, Asteraceae, Solanaceae, Amaranthaceae, Convolvulaceae and Lamiaceae as the most represented medicinal plant families. The dominance of medicinal plant species from families such as Asteraceae, Fabaceae, Lamiaceae, Ranunculaceae, Rosaceae, Apiaceae and Brassicaceae could be attributed to their wider distribution and abundance in the region and mostly due to their herbaceous habit (Gazzaneo et al., 2005; Mehraj et al., 2018; Muzafar et al. (2018)). Moreover, the larger number of species from these families might be related to the occurrence of useful bioactive ingredients present in the members of these families which are used against different ailments (Gazzaneo et al., 2005). Asteraceae is reported to possess a huge number of bioactive compounds (Hamill et al., 2000; Leonti et al., 2003) which may support the higher utilization rates of different species of this family for medicinal purposes (Tugume et al., 2016). Stepp and Moerman (2001) suggested that plants of these families concentrate active biological compounds as a function of their habit or of their life strategies.

The present study also listed 20 important plant species, each of which is used to treat 25 or more diseases in J&K (Supplementary Material-III). Not surprisingly, most of these (4) belong to family Asteraceae followed by Solanaceae (3) and the majority of these are native species (18). The higher proportion of native species clearly highlights the importance of historical interrelationship between local communities and plants, allowing more or less experimentation and experience of using them (Molares and Ladio, 2009).

In the present study, the most dominant growth-form reported were herbs followed by shrubs trees and subshrubs (Fig. 2). This seems related to the relative predominance of the herbaceous growth forms in the J&K state. For instance, in a recent study, Malik et al., 2015 showed that herbs are the main components of flora of Wadwan valley of J&K. A similar pattern of growth-forms was also reported in ethno-botanical surveys in other regions (Ayyana and Ignacimuthu, 2005). Not surprisingly, the herbaceous habit being reported as the dominant growth form in our study is a common and widespread ecological phenomenon, particularly in the cold temperate regions of the world (Ibrar et al., 2007; Jan et al., 2011). According to Simbo (2010), the presence of pharmacologic components in higher concentrations in herbs makes them useful for the treatments of different diseases.

In J&K state people mostly use the whole plant for the treatment of various diseases, which is followed by leaf, underground portion, flower and seed. Such a trend is contrary to the previous studies conducted in different parts of the world (Bano et al., 2014; Ahmad et al., 2014), wherein the leaves have been reported to be the commonly used parts of the medicinal plants and in some cases underground parts are shown to be the most utilized parts (Kala et al., 2004).

It was also observed that some of the medicinal plants are used to treat more than one disease and likewise more than one medicinal plant is used to treat a particular disease. The use of single plant species to treat more than one ailment is probably due to the presence of many metabolites in one particular plant and also the fact that the same molecule can be active against different pathogens (Tugume et al., 2016).

These medicinal plant species are used to cure a diverse range of diseases. Of the 1123 plant species, 22.21% of species are used to cure fever, stomach problems (14.43%), cuts and wounds (14.10%), and cough, rheumatism and skin diseases are being treated with 13.39% species each. The higher proportion of medicinal plant species used for the treatment of a particular disease is also recorded by Bano et al. (2014) in Skardu valley, wherein the maximum number of plant species were used against stomach ache, cold, fever followed by rheumatism and wounds. Khan et al. (2014) has reported that in the Naran valley, Western Himalaya, Pakistan, 32.76% of species are used to treat ailments associated with the digestive system followed by the respiratory (13.72%) and urinary (99.13%) systems.

In terms of disease category, most of the plant species are used to cure digestive problems followed by respiratory and dermatological problems (Table 4). According to Bennett and Prance (2000), universally various types of gastrointestinal/digestive problems are predominant, and so a large number of plant species have been discovered by different ethnic communities to cure these diseases. Malla et al. (2015) also observed the predominance of plant species in curing different gastro-intestinal problems in Parbat district of western Nepal. In neighbouring Himalayan state of Uttarakhand, the highest number of species has been reported to cure generalized body aches and colic disorder which was followed by gastrointestinal disorders (Kala et al., 2004).

The RFC value highlights the local importance of the species in the study area. It also reflects the intimate and long term relationship of people with local plants (Ahmad et al., 2014; Bano et al., 2014). The species with high RFC scores were likely to be used in the different areas of the state, while many of those scoring just 0.01 were likely to be used only rarely at some isolated pockets of the state. Medicinal plants including *Taraxacum officinale* (RFC = 0.35), *Aconitum heterophyllum* (RFC = 0.33), *Juglans regia* (RFC = 31), *Saussurea costus* (RFC = 0.30), *Achillea millefolium* (RFC = 0.30) and *Podophyllum hexandrum* (RFC = 0.29) were found to be the most effective indigenous remedies against different diseases and seem to be well-known to the locals which is substantiated with their high frequency of citation. However, in neighboring countries as well as in the other parts of the world different plant species were reported with respect to their preference use (Mitherman et al., 2005; Abbasi et al., 2010; Cornara et al., 2009). Ahmad et al. (2014) reported that in Chail valley, *Origanum vulgare* L, *Geranium wallichianum* D. Don and *Skimmia laureola* (DC.) Sieb were the most familiar to the locals as reflected by their high RFC values. The RFC values were found to be higher for some species, which could be ascribed to the increasing trend of exploitation of these species in the study area (Bano et al., 2014).

The diversity of medicinal plants as well as related traditional knowledge is rapidly declining globally, and among the other recommendations suggested for their conservation and sustainable use, is the establishment of species and traditional knowledge inventories which would to a large extent help in reducing the loss of this precious knowledge (Chen et al., 2016). The significance of medicinal plant inventories can be huge as they are vital for conservation and sustainable use which may in turn lay strong scientific foundations for the conservation of natural habitats and ecological services (Hamilton, 2004).

## 6. Conclusions

The present study is the first work of its kind in the J&K state, using scientifically sound taxonomic appraisal to document the diversity, distribution and therapeutic uses of local ethno-medicinal flora. The study has recorded 1123 plant species which are being used in ethnomedicine in this part of the world. The authentic taxonomic inventory of these medicinal plants and documentation of their traditional use can provide baseline information for sustainable utilization of this plant wealth, which can play a pivotal role in bio-resource-based regional sustainable development. The knowledge of use of these resources for primary health care can prove helpful in creating awareness regarding the conservation and sustainable utilization of these prized plant resources. Furthermore, this baseline information is also crucial as it can provide important leads towards the discovery, development and designing of future remedies. Thus, the present study has, to a large extent, filled the knowledge gap by documenting this valuable information of ethno-medicinal botany from this Himalayan region.

## Conflicts of interest

None

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## Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.hermed.2019.100280.

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