Ethnobotanical investigations on plants used in folk medicine by native people of Kumaun Himalayan Region of India

Devesh Tewari, Archana N. Sah, Sweta Bawari and Rainer W. Bussmann

Databased and Inventories

Abstract

*Background :*A large population in the rural area of Uttarakhand is still dependent upon traditional plant-based knowledge to combat various disease conditions. This study aimed to explore the ethnopharmacological information and document traditional uses of plants in the Kumaun Himalayan region. Here we show the study of nine villages of three districts of the Uttarakhand state in India, located in the western Himalayan region.

Methods: A total of 26 traditional healers and experienced inhabitants between 30-85 years of age were interviewed by a semi-structured questionnaire. The data obtained was quantitatively evaluated using use value (UV). Further, the informant consensus factor (ICF) and fidelity level (FL) were also calculated for species having UV higher than 0.15.

Results: A total of 56 plant species were reported from 34 families. The highest number of plant species were collected from Asteraceae and Lamiaceae families followed by Rosaceae. Primary uses of plants were categorized into 29 disease categories. The highest number of species was reported to be used for gastrointestinal disorders (11.21%) followed by immuno-modulation, anti-stress, as adaptogens (10.2%), analgesics (7.47%), for nervous system related disorders (6.54%) and as antimicrobials (6.54%).

Conclusions: Local traditional knowledge and practice of plant-based medicine is quite widespread in the rural areas of Uttarakhand and is an indispensable part of the healthcare system. It plays a vital role in the absence of basic medical facilities and tremendous paucity of trained medical personnel.

Keywords: Ethnobotany, Himalaya, Cordyceps, Uttarakhand

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Background

Ethnopharmacology is a multidisciplinary science which deals with underlying anthropological principles and pharmacological basis of various natural products. These natural entities include plants, animals, minerals, microbes, fungi, and herbo-minerals which are utilized in different human cultures (Rivier, Bruhn 1979). Hundreds of years of beliefs and observations are the basis of various traditional medicine systems, which predate the expansion and spread of modern medicine. Such

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systems were developed by our ancestors who learned very comprehensively from nature initially by tasting of what was available in their surrounding areas (Aburjai *et al*. 2007). This knowledge regarding traditionally used medicines is rapidly vanishing and it is believed that the rate of disappearance of traditional medicinal knowledge is even faster than that of plant species biodiversity and a large amount of priceless information is at the verge of irrevocable depletion (Appendino *et al*. 2010).

In the 1990s ethnopharmacological based screening of bioactive natural products gained tremendous importance, due to information on therapeutic indications which serves as a lead in the ethnopharmacological approach (e.g. Artemisinin:(Klayman 1985); Cyclotides:(Koehbach, Gruber 2013)), however, this approach subsequently declined. The popularity of complementary medicine is, however, increasing rapidly since past few decades. Traditional systems of medicine, for instance Ayurveda, traditional Chinese medicine system and other indigenous systems of medicine are widely used worldwide, and the traditional preparations are marketed in many developed countries as dietary supplements. It was reported in a survey that approximately 48.5% respondents from Australia and 34% respondents from the USA had used at least one form of alternative therapy including herbal medicine (Eisenberg *et al*. 1998, Grover *et al.* 2001, MacLennan *et al*. 1996). The World Health Organization (1980) have recommended that the proper evaluation of the effectiveness of plants should be done for conditions that lack safe modern drugs for therapeutic interventions (Grover *et al.* 2001, MacLennan *et al*. 1996, Upadhyay, Pandey 1984).

Ethnopharmacological studies are gaining tremendous importance these days. There are several such studies that are being conducted in recent times (Barkaoui *et al*. 2017, Davids *et al*. 2016, Eddouks *et al*. 2016, Kose *et al*. 2015, Moteetee, Kose 2016, Rahman *et al.* 2016, Shawahna, Jaradat *et al*. 2017, Zhao *et al*. 2017). Significance of ethnopharmacological studies could be well understood by its importance in the drug discovery process. A search in the PubMed database showed 194 items by searching the keywords “ethnopharmacology and drug discovery” and 1810 items with the word “ethnopharmacology”. Same keywords were searched in Google Scholar database and a total 33300 web hits were found with the keywords “ethnopharmacology and drug discovery” and 136000 web hits were found with the keywords “ethnopharmacology” alone (as accessed on 05.08.2017).

Several of medicinal plants are used by the natives of the Kumaun Himalayan region for numerous disorders. Although studies have been conducted to explore the Uttarakhand region (Farooquee *et al*. 2004, Kala *et al*. 2005, Negi *et al*. 2011, Phondani *et al*. 2010, Sharma *et al*. 2011, Kumari *et al*. 2012) still there is a vast potential in the Himalayan region concerning the ethnomedicinal wealth.

Uttarakhand (formerly known as Uttaranchal) is the newest state among the Himalayan provinces of India and came in existence as the 27th state of the Republic of India. The state comprises 13 districts and is divided into two divisions, namely Kumaun and Garhwal. A large population of the state is dependent on the surrounding natural environment, and a large population is dependent on agriculture for livelihood. However, agriculture is difficult in this mountainous region due to geographical and climatic factors. The state is gifted with large forest cover and water resources providing for the origins of several important rivers as well. Although, studies have been conducted in the Kumaun Himalayan region to explore medicinal plant diversity and in some places the use of medicinal plants in the different ailments by the inhabitants (Bhatt *et al*. 2012, Gangwar, Gangwar 2010, Kapkoti *et al*. 2011, Mathur, Joshi 2013, Shah, Joshi 1971, Upreti *et al*. 2009). However, most of the area covered in this study is still unexplored and to the best of our knowledge no study is available with the quantitative analysis of the ethnopharmacological information from this area so far. Therefore, the study was conducted to collect and evaluate data from traditional healers and experienced inhabitants on medicinal plant-based remedies from the middle and high-altitude region of western Himalaya.

Materials and Methods

Study area

Uttarakhand state is a part of the North-Western Himalayas and is located between 28° 43' - 31° 27'N latitudes and 77°34' - 81°02' E longitudes. The state is affluent in culture, religious attributes and the beautiful natural sights. The state is full of biodiversity and natural resources in context to flora, fauna or people. It is different from other states due to its mountainous geography. The state is mainly a mountainous state and most of the people of Uttarakhand are known as “*Paharis*” which means 'people of the hills', and similar “*Pahari*” people with different cultural and linguistic characters are found in the neighboring state in west Himachal Pradesh and east Nepal (Mawdsley, 1997, Joshi, Negi 1994). Uttarakhand is the place of origin of the holy river ‘Ganga’ and it is also important due to the presence of the Himalayan ranges that form the border of the neighboring countries. The state is separated by the

river Tons from Himachal Pradesh in the north-west and the river Kali separates it from Nepal in the east.

An explorative study was conducted in the Kumuan Himalayan region (Figure 1). Different villages namely:Jauljibi, Mostamanu, Ucheti, Fafa, Askot (Pithoragarh district), Binsar (Almora district), Ratighat, Bohrakun, Ghinghrani, Gagar, Betalghat (Nainital district) were surveyed. The main focus area during the survey was Pithoragarh district in general and Jauljibi and adjoining villages in particular, which are situated at Indo-Nepal border and lies at the confluence of Gori and Mahakali rivers. The major town of Dharchula is around 30 Km away from the main study area. Jauljibi is well known for the trade. Several migrants and workers from Nepal come and do their business in this small town. The region is mainly famous for the small markets of both India and Nepal and an old famous festival locally known as “Jaljibi Mela” is celebrated here every year to celebrate the trade relations of India and Nepal and thousands of people from many villages from both the sides participate in this fair. Most of the respondents belonged to the Bhotia tribes who are resident of the upper Himalayan regions in summer, and due to extreme weather conditions move to the lower parts of the region during September-October to Jauljibi to spend the winter season. The area is also famous for about a century-old trade fare popularly known as “Jualjibi Mela” which is a symbol of trade between India and Nepal. The details of the study area are provided in Figure 2.

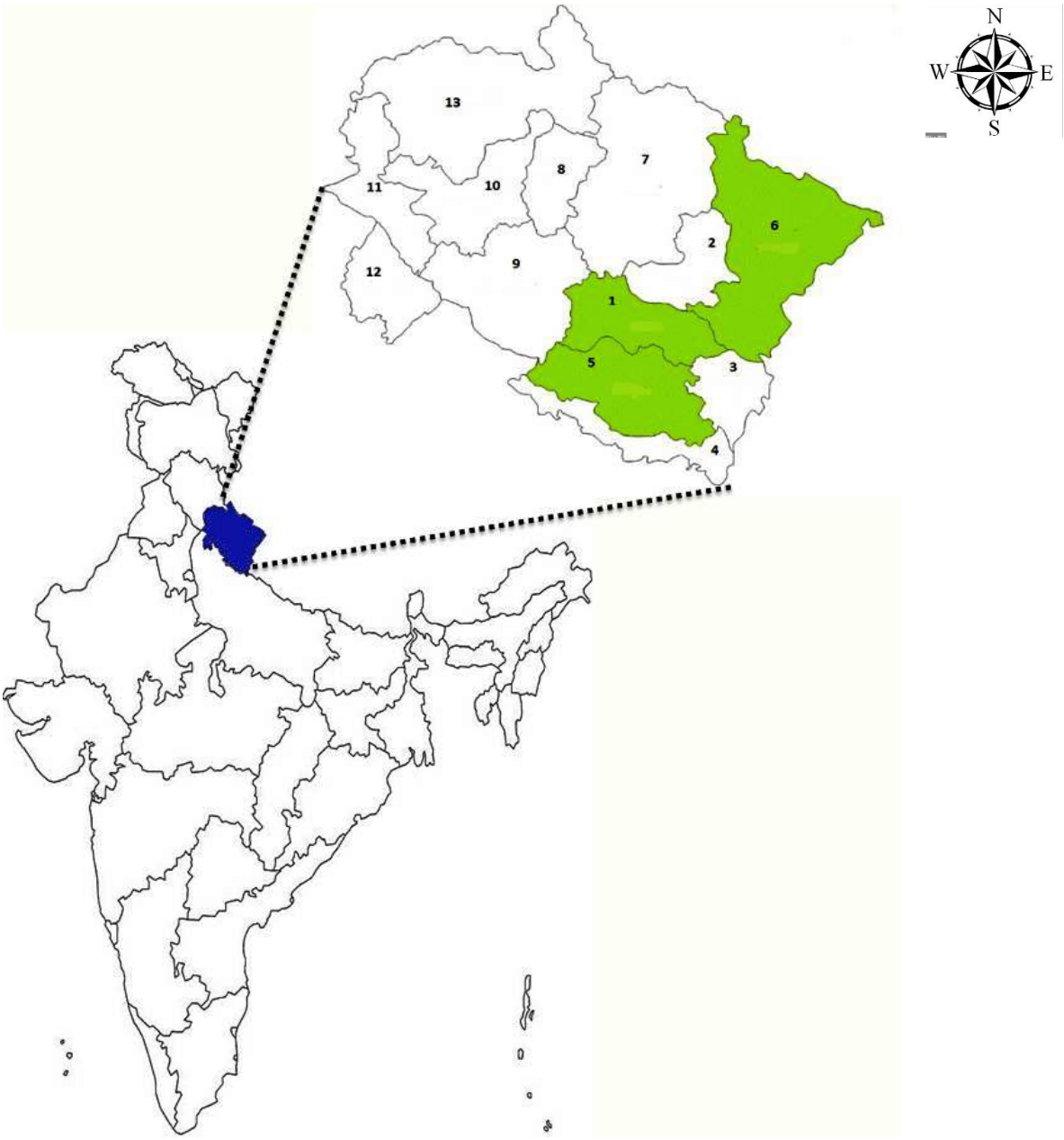

Figure 1. Map showing India, map of Uttarakhand state (blue) and districts covered in study (green)

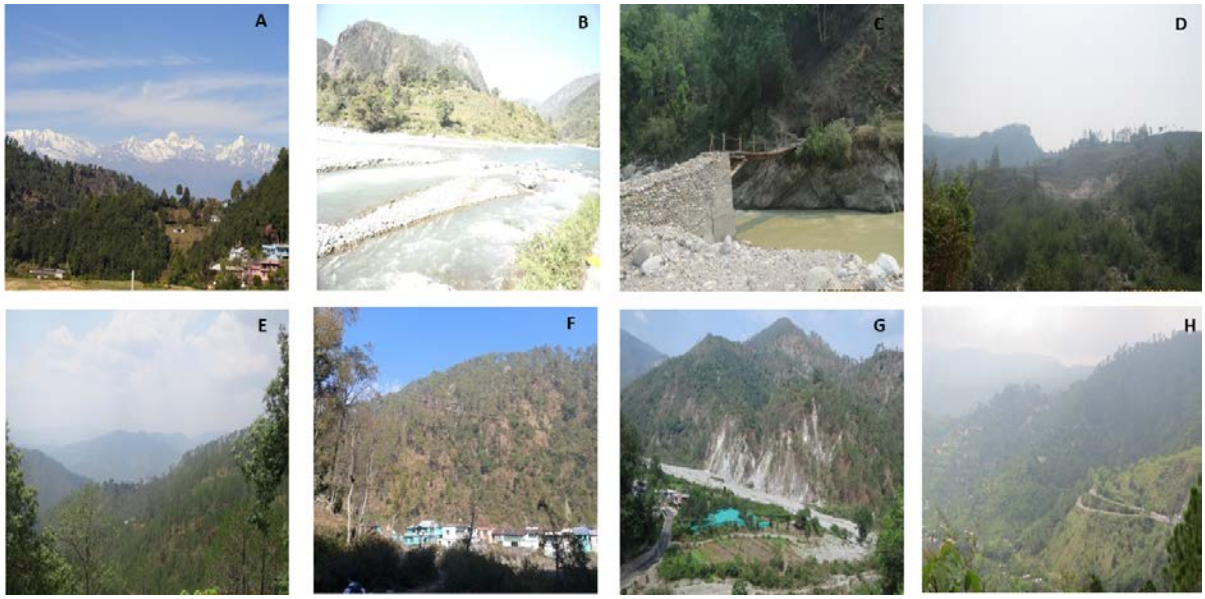

Figure 2. Images of study area (A: Mostamanu; B: Jauljibi (Confluence of river Gori and kali Ganga), C: Way towards Phapha village; D: Ucheti; E: view from Kapadkhan; F: Bohrakun; G: Betalghat; H: Jeolikot)

Data collection

The study was based on field surveys conducted from the years 2014-2016. The surveys were done throughout the day in different seasons including the last part of the summer season and the onset of monsoon. Verbal prior informed consent was taken from all the participants after telling them the purpose of the study. Data about the therapeutically important medicinal plants were gathered with the help of open ended semi-structured interviews. Interviews were conducted in Hindi and local language Kumauni depending upon the social and educational status of the respondents. Most of the people were interviewed at their homes but some of them were also interviewed in the forest areas and in groups as per the suitability for drawing maximum information. Field surveys were conducted with traditional healers and experienced natives of the villages, and plants were collected accordingly. Stays were also made in different villages with the help of the villagers. An extensive literature review was also done to verify the pharmacological relevance of collected information.

Collection, identification and authentication of the plants

Medicinal plants were collected in different seasons throughout the year from the fields and forest areas. Most of the plants were collected from areas at the altitudes of 970-3000 m above sea level. Collected medicinal plants were dried, mounted on herbarium sheets and identified in government identification centers, including the Botanical Survey of India, Dehradun, Regional Ayurveda Research Institute (RARI), Jhansi, RARI Tarikhet, Systemic Botany Division, Forest Research Institute (FRI), Dehradun and Botany Department, Kumaun University, Nainital. The plant specimens were identified by expert taxonomists and deposited in the respective herbaria. One set of vouchers was kept at the herbarium of Department of Pharmaceutical Sciences, Bhimtal for future reference.

Data analysis

Use value

Obtained informant data were analyzed by quantitative index: use value (UV). The use value (Phillips, Gentry, 1993, Ngarivhume *et al*. 2015) is a quantitative method that is used to demonstrate the relative importance of a species known locally. UV was calculated using the formula:

$$UV=U/N$$

Where, UV denotes the use value of a species; U is number of citations per species; and N refers to the number of informants. Range of UV is 0 to 1. UV is high when several use reports exist for a plant, which means that the plant is imperative. UV drops to 0 when only few use related reports of a plant are found. However, UV does not differentiate if a plant is used for one or more purposes (Khattak *et al*. 2015).

Informant consensus factor (ICF)

After calculation of the UV of all reported species, only plants having higher UV (>0.15) were selected for the calculation of ICF. ICF value was calculated using the formula (Heinrich *et al*. 1998; Trotter and Logan, 1986).

$$ICF = (Nur-Nt)/(Nur-1)$$

Where, Nur is the total number of use reports for each ailment category and Nt is number of taxa used in that category.
ICF is the indicative of the extent of homogeneity within the information between the informants.

Fidelity level (FL)
Similarly to ICF, plants with higher UV (>0.15) were selected for the calculation of FL. FL index was calculated using following formula (Friedman *et al*. 1986):

$$FI\ (\%) = (Np/N \times 100)$$

Where Np is the number of informants citing the use of the plant for a particular disease category and N is the whole number of informants citing the plant for any disease category.
Higher FL is an indicative of frequent use of a particular plant species for the treatment of a disease or ailment of specific category by the informants of the studied area (Musa *et al*. 2011).

Photography
Photographs of the plants used as traditional medicines were captured in the study area. In most of the cases, habitat was also taken into account along with the study area. Images of the plants were captured along with flowers, fruits and inflorescence for identification as and when available (Plate 2-8).

Results and Discussion

Respondent biographic details
The data were collected by open informal and sometimes group interviews. The samples were selected on the basis of stratified sampling procedure and mainly two methods were used to select the respondents. Firstly, the information was collected from the district level officers about their known folklore practitioners and secondly the information about the respondents were collected from the local villagers or sometimes from the respondents themselves. Twenty-six traditional medicine practitioners and experienced local inhabitants were interviewed, out of which 84.61% were male and 15.38% were female. This is an important information which represent that the substantially higher male population is aware about the folklore medicine practices. All the informants were native to the area and their families were residing in the region from generations. In some of the studies female informants were reported in higher numbers like the study of Cornara and colleagues reported that out of 52 informant 37 women and 15 men were interviewed (Cornara *et al.* 2009). However, in similar line to our study, Agyare and co-workers reported around two thirds of the men, one third women traditional healers from Ghana (Agyare *et al.* 2009). Average age of the respondents was 57 years, ranging from 30-85 years. Most of the respondents had attained either a primary level of formal education or no formal education and gained the knowledge about medicinal plants from their parents or grandparents. Most of these folk healers do not charge any fee for giving their treatment, even though their economic conditions were poor. The details of the respondents are presented in Table 1 and Figure 3.

Table 1. Demographic characteristics of informants (n=26)

Characteristic	Frequency
Gender	
Male	22
Female	04
Education	
No formal education	10
Primary education	08
Secondary education	07
Special education	01
Religion	
Hindu	26
Other	Nil
Ethnicity	
Bhotia Tribe	07
Non tribe	19
Year of experience of the healer	
Less than 5 year	Nil
Between 1-10 years	05
Between 11-20 years	08
Between 21-30 years	05
Between 31-40 years	01
Between 41-50 years	02
51> years	05

Social life and challenges
Different sections of the study area had almost similar socioeconomic conditions. One of the major problems observed in the remote mountainous regions like Ucheti, Phapha and Jauljibi was that of the migration of the local inhabitants from the hilly areas to the nearby plain areas for better economic conditions and in search of job opportunities. The problem of migration was not a big concern in villages neighboring to comparatively bigger towns, such as Jeolikot, Bohrakoon and Ghinghrani villages, but in the remote areas like Ucheti, Phapha and Jauljibi migration is a common problem and a great matter of concern. Most inhabitants of these villages are either dependent on agriculture, or dependent on their livestock for their daily needs. Several geriatric people were found living alone or as couple, while their children were living in the cities for earning livelihood. Sometimes elderly people didn't desire to leave their villages either. The life in these

areas is very challenging. Some of the major challenges are poor connectivity of roads, lack of basic facilities such as schools, hospitals etc. The area is prone to the natural disasters such as earthquakes, landslides, and cloudburst. Although, in some areas schools and hospitals are present, but teachers and medical practitioners are unwilling to work in these remote areas, and the children of these villages remain deprived of the fundamental rights of education and healthcare. People used to travel from one side of the river to the other by using a typical rope way as seen in Plate 1. Often people have to walk for miles in the rocky terrains to access even the most basic needs. Socioeconomic conditions of the study area are presented in Plate 1. Still, it cannot be said that all the villagers are poor, but the majority certainly are in a difficult economic situation. It was also found during the study that the basic facilities and economic conditions were better in the villages that are in close vicinity of the towns and/or plain areas.

Species distribution

A total of 56 plants were reported, belonging to 34 families. The highest numbers of plant species were collected from Asteraceae and Lamiaceae families, followed by Rosaceae. Other important families were Acoraceae, Ranunculaceae, Araceae, Berberidaceae, Rutaceae, Zingiberaceae, Scrophulariaceae, Euphorbiaceae, Bignoniaceae, Oxalidaceae, Amarylliaceae, and Rubiaceae. The caterpillar fungus *Ophiocordyceps sinensis* and one herbo-mineral drug "Shilajeet" was also recorded from the study area. The details of species distribution are presented in Figure 4.

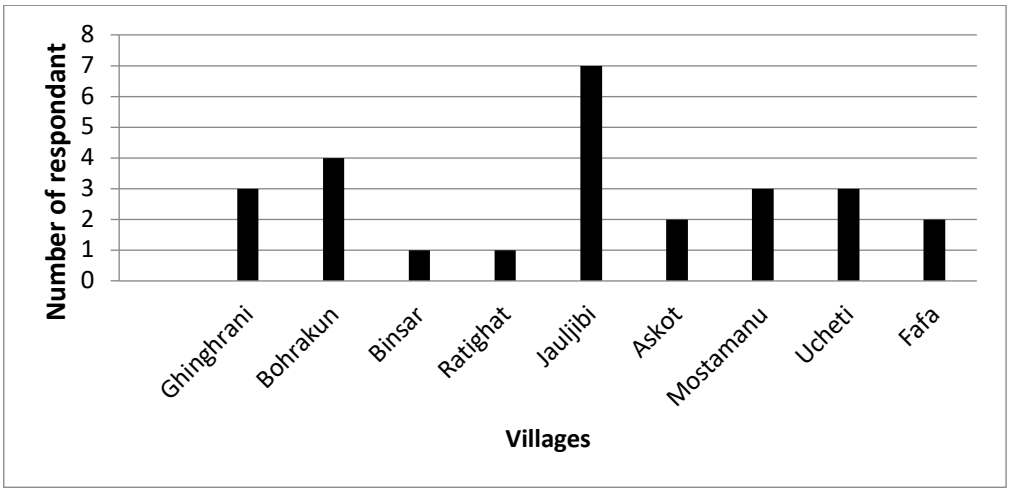

Figure 3. Graph showing the number of traditional medicinal practitioners from different villages

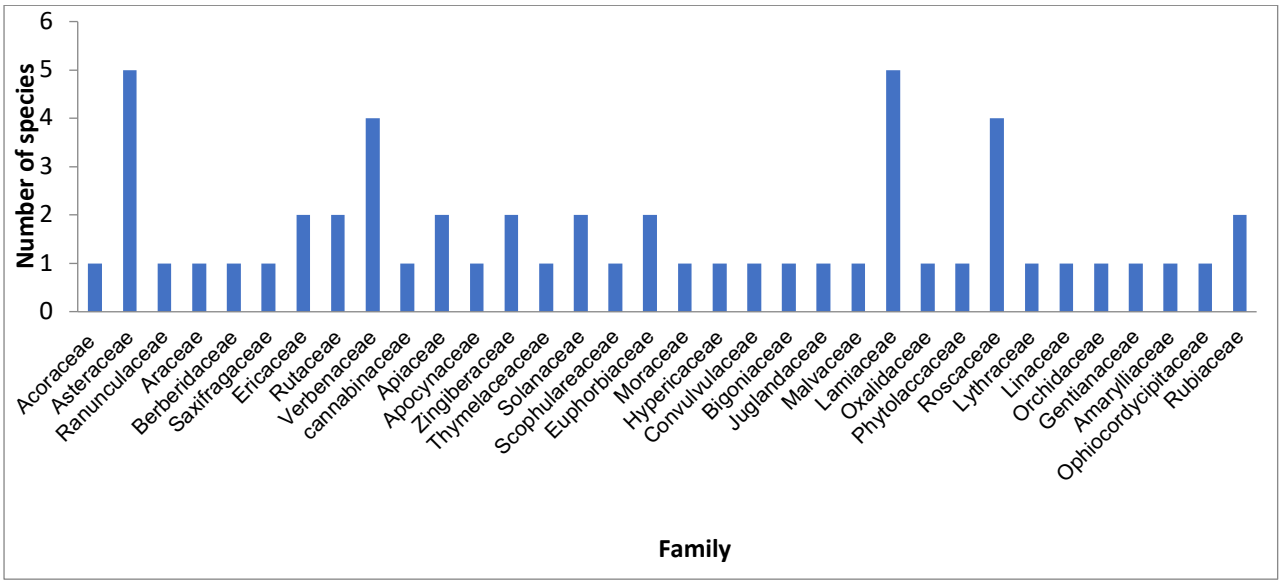

Figure 4. Graphical representation of the family and number of species

Quantitative data analysis of plants used in various disease conditions

Primary uses of plants were organized in 29 disease categories. The highest number of plants were used for gastrointestinal disorders (11.21%), followed by immunomodulation, anti-stress, adaptogens (10.2%), analgesic (7.47%), for nervous system related disorders (6.54%), and as antimicrobials (6.54%). The explanatory details of primary uses of plants are presented in Figure 5. The use values of the plant species fell between 0.01-0.5. Most of the plants fell below an UV of 0.15, and 11 species, *Acorus calamus* L., *Berberis aristata* DC., *Bergenia ciliata* (Haw.) Sternb, *Carum carvi* L., *Euphorbia pilosa* L., *Ficus palmata* Forssk., *Ocimum tenuiflorum* L., *Ocimum basilicum* L., *Pyracantha crenulata* (Roxb. ex. D Don), *Rhododendron arboreum* Sm. and *Swertia chirata* Buch.-Ham. ex Wall. were found with UV higher than 0.15, and further considered for calculation of ICF and FL %. The details of the documented plant species along with their traditional uses and UV are presented in Table 2.

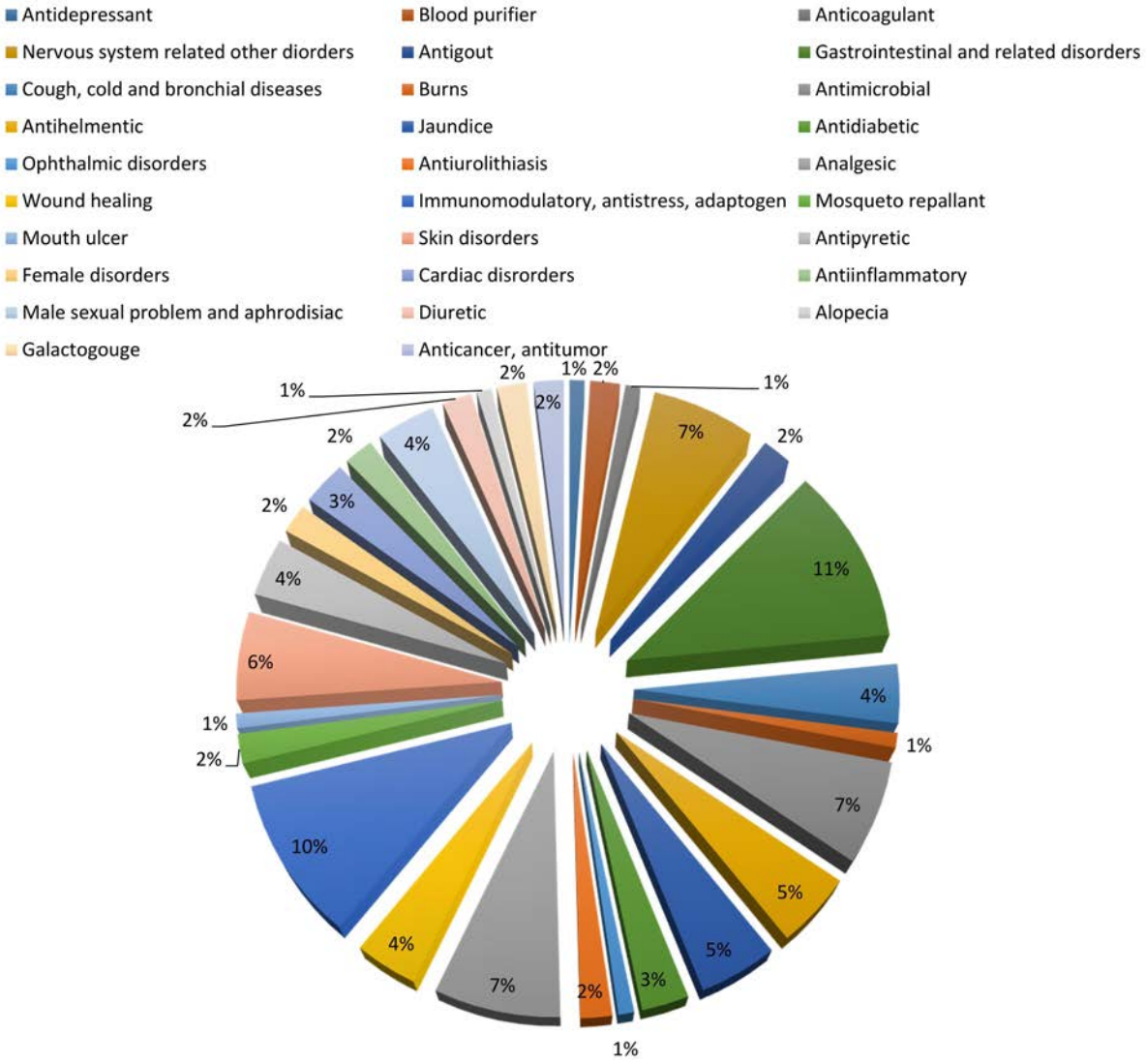

Fig. 5. Pie chart showing the main uses of medicinal plants encountered.

Table 2. Ethnopharmacological and medicinal uses of plants in the Kumaun Himalayan region

Botanical Name and accession number	**Family**	**Part used**	**Therapeutic use**	**Local / Common Name#**	**UV**	**Use described earlier**
Acorus calamus L. 115195	Acoraceae	Rhizomes	Aromatic, tonic, antigout, dyspepsia, to reduce cough	Vacha	0.19	Emetic (Srivastava *et al*. 1986), to kill lice (Rao 1983), nervous system, throat related disorders, diarrheal, antitumor (Jha & Varma 1996, Viswanathan, 1995), used for protection against smallpox (Jain 1989), ringworm (Bajpai *et al*. 1995), for respiratory and gastrointestinal tract diseases and snakebite (Bist & Badoni 1990, Mohanty *et al*. 1996, Singh, 1995), for gout and rheumatism (Jain & Puri 1994), and for dysmenorrhea (Borthakur & Goswami 1995, Mukherjee *et al*. 2007).
Zephyranthes minuta (Kunth) D.Dietr. (Syn. *Zaphyranthes grandiflora* Lindle) RKT 947	Amarylliaceae	Bulbs	Antimicrobial, antitumor	Gulabi lily	0.07	Details not found in our search
Carum carvi L. JHS 25275	Apaiaceae	Fruit, seed	Stomach pain, itching, fever, dyspepsia, menstrual pain and morning sickness, spice, condiment and preparation of expensive oil	Kala jeera, Dhave	0.23	Aphrodisiac, lactiferous diuretic, menstrual disorders (Sadeghi & Mahmood, 2014).
Hydrocotyle javanica Thunb. (*Hydrocotyle nepalensis* Hook. f) 115209	Apiaceae	Leaf	Memory enhancer, relieve constipation in children	Brahmibheda also known as Brahmi in some area	0.07	Jaundice, diarrhea, dysentery, peptic ulcer (Borah *et al*. 2006), typhoid fever (Choudhury *et al*. 2010).
Cascabella thevatia (L.) Lippold. 115194	Apocynaceae	Flowers	Toxic	Peela Kaner	0.01	Leaf paste with castor oil used for external injuries as a pain alleviator (Nayak *et al*. 2004) toxicity from leaves (Koch *et al*. 2015).
Arisaema tortuosum (Wallich) Schott RKT 8486, 115181	Araceae	Whole plant	Gastrointestinal disorders, jaundice and other liver ailments believed in snake bite	Bagh Jandhra, Snake plant Sarapabheda	0.11	Snake bite (Kumar 2017), anthelmintic (Verma *et al*. 2012).

Anaphalis margaritacea (L.) Benth. & Hook. f. RKT 19962	Asteraceae	Flower, whole plant	Poultice is used for burns, anti-inflammatory, joint pain	Western pearly everlasting	0.11	Root liquid used for diarrhea (Balami, 2004) and in veterinary diseases (Lans *et al*. 2007).
Bidens pilosa L. 115510	Asteraceae	Root, Whole plant	Constipation in children	Kuri, kumar, Eir	0.03	Stomachache (Ayyanar & Ignacimuthu 2005), constipation and malaria, (Geissberger & Sequin 1991) and dysmenorrhea (Bartolome *et al*. 2013; Noumi *et al*. 1999).
Erigeron karvinskianus DC. 115511	Asteraceae	Leaves	Wound healing, analgesic, anti-inflammatory	NA	0.11	Skin diseases (Sharmila *et al*. 2014).
Inula cuspidata (Wall ex.DC) CB Clarke 115516	Asteraceae	Root	Anthelminthic	Pokara	0.07	Decoction of fresh roots in empty stomach used to expel worms (Rana *et al*. 2014, Sharma & Sood 2013)
Taraxacum officinale G.E. Hugland 115512	Asteraceae	Whole plant	Jaundice, anti-inflammatory, anti-urolithiasis	Kanphool, Dugdhfeni	0.11	Used for bile and vesicular disorders, kidney and liver pain, stomach ulcer, antitussive, diabetes, rheumatism, anemia and irregular menstruation and as appetizer (Martinez *et al*. 2015, Mustafa et al. 2012, Šarić-Kundalić et al. 2011).
Berberis aristata DC. JHS 25270	Berberidaceae	Root, root bark, stem	Jaundice, antidiabetic, eye diseases	Kilmoda	0.38	Jaundice, fever, weakness (Kumar 2017), ulcer and malaria fever (Bhushan & Kumar 2013).
Jacaranda mimosifolia D. Don 115184	Bigoniaceae	Flower, leaves, bark	Wound healing, sexually transmitted diseases and as dye,	Neela Gulmohar, Jacaranda	0.11	Wound healing and skin infections also used as a substitute for the Unani herb in Pakistan (Khare, 2008), bark used for treating wounds and dermatitis, astringent and diuretic (Roth & Lindorf, 2002), blood purifier (Babu *et al*. 2015; Yu *et al*. 2006).
Cannabis sativa L. JHS 25269	Cannabinaceae	Seeds, leaf, resin	Analgesic, dietetic preparation, narcotic	Bhang	0.02	Used for urinary tract diseases, asthma, depression, insomnia and depression due to its sedative and analgesic effects (Aziz *et al.* 2016), analgesic, antispasmodic , diuretic and astringent and narcotic (Aziz et al. 2017).
Ipomoea purpurea (L) Roth. 115508	Convolvulaceae	Seed	Anthelminthic, diuretic	Kakatiya	0.06	Anti-syphilitic and emetic (Parihaar *et al*. 2014), bronchitis (Amjad 2015).
Lyonia ovalifolia (Wall) RKT 25902	Ericaceae	Bark	Scar, burning scar, anti-herpes, eczema itching, skin diseases	Ayar,Agnyo, Agyun	0.11	Leaf paste for pain and for ring worm infection (Joshi *et al*. 2011), treatment eczema and boils (Dangwal *et al*. 2010).
Rhododendron arboreum Sm. JHS 25277	Ericaceae	Flower juice, wood	Cardiac disorders, antihypertensive, anti-	Burans	0.5	Dysentery, diarrhea, throat clearance when fish bones get stuck in the gullet, remove stuck thorn of fish (Namsa et al. 2011, Paudyal &

			depressant, anti-asthmatic, leucorrhea			Singh, 2015). Also used for headache, fever, dysentery, wounds and nose bleeding (Sharma et al. 2013), for splenomegaly (Dangwal & Sharma 2011), digestive and respiratory disorder (Chauhan et al. 2017). Flowers useful as bee forage; plant used in religious ceremonies (Tiwari *et al*. 2010). Flower is used in diarrhea and throat pain. Young leaf is chewed to get relief from headache (Kunwar & Adhikari 2005).
Euphorbia pilosa L. JHS 25268	Euphorbiaceae	Latex	Purgative, emetic, antiseptic, antimicrobial	Sataala	0.15	Cuts, wounds and sores in livestock (Pande *et al*. 2007).
Euphorbia obvata Decne (*Euphorbia prolifera* Buch. (Ham) ex) RKT 2111	Euphorbiaceae	Latex	Antimicrobial	NA	0.01	For constipation, emetic (Prajapati 2003), food poisoning (Farooquee *et al*. 2004).
Swertia chirata 10429A	Gentianaceae	Whole plant	Fever, veterinary disorders , blood purifier, diuretic, gastric disorders	Chirayta	0.19	For headaches, blood pressure (de Rus Jacquet *et al*. 2014, Malla *et al*. 2015), for tremor fever (de Rus Jacquet *et al*. 2014), to cure malaria (Chakraborty *et al*. 2017, Shah *et al*. 2014), and also used as a purgative and laxative (Chakraborty *et al*. 2017).
Hypericum oblongifolium Choist 115193	Hypericaceae	Leaf	Mental disorders	Pendant St. John's Wort	0.01	Leaves and fruits used as antihypertensive, in gastric ulcer and removing prolepsis in cattle (Amjad *et al*. 2017), powder of flowers given in jaundice (Kapkoti *et al*. 2014).
Juglans regia L. JHS 25272	Juglandaceae	Bark, fruit	Toothache, memory enhancer, alopecia	Akhrot	0.03	Leaf decoction for diabetes (Barkaoui 2017), aromatize cheese and for protection of it from dust and parasites (Guarrera et al. 2005), jaundice (Jaradat *et al*. 2017).
Mentha longifolia L. JHS 25271	Lamiaceae	Leaf	Aromatic, spice, food, condiment, gastritis, liver disorders, itching, anti-acne	Pudina	0.03	Carminative, for rheumatic pain, nausea, sickness and vomiting, diarrhea, dysentery, stomach pain and cooling effect (Aziz *et al*. 2016, Tariq *et al*. 2015).
Nepeta hindostana (Roth) Haiens. RKT 4082	Lamiaceae	Leaf	Ornamental, antimicrobial	Billilotan	0.01	It has anti-asthmatic, anti-catarrhal, sedative properties (Awan 1960), also used for fever, body ache, diarrhea, dysentery, carminative, antispasmodic (Quattrocchi 2012), as a gargle for sore throat and bad breath, gonorrhea (Nadkarni 1996), hypo-cholesterolemic and central nervous system (CNS) depressant effects (Khare 2008, Mahmood *et al.* 2017).

Ocimum tenuiflorum L. 113663	Lamiaceae	Whole plant	Cough, fever, antioxidant, spider bite	Ram tulasi		Flue, cough, ring warm infection (Uddin *et al*. 2012).
Ocimum basilicum L. 113664	Lamiaceae	Whole plant	Cold, fever, cough, spider bite	Kali tulasi		For headache, bad breath, cold, skin diseases, cancer, quit smoking (Ahmed 2016).
Salvia leucantha Cav. 115506	Lamiaceae	Inflorescence	Essential oil used as antimicrobial, memory enhancer	White Mischief	0.04	Stomachache, weakness, mal aire (Juarez-Vazquez *et al*. 2013).
Rienwarditia indica Dumortier 115206	Linaceae	Flower	Dye	Basanti	0.01	Tongue wash (Bhat *et al*. 2013), used for wounds infected with maggots in cattle. Leaves are used in the treatment of paralysis (Verma & Chauhan 2007).
Punica granatum L. JHS 25267	Lythraceae	Fruit peels	Antitussive	Dadim	0.07	Fruit, fruit rind for jaundice, stem bark is used as anthelmintic, antispasmodic, nasal congestion (Bhatia *et al*. 2014), recover from iron deficiency, given to cattle for treating diarrhea (Aziz *et al*. 2016), anti-diarrhea and ulcer protective (Tahvilian *et al*. 2014).
Malva verticillata L. 115513	Malvaceae	Leaf	Antidiabetic, galactagogue, stomach disorders immunomodulator, antistress	Suverchala	0.02	Anthrax (livestock) crush by mixing with leaves of *Solanum mariginatum* and Datura applied paste on affected part (Teklay *et al*. 2013), Root Grinded and mixed with one glass of beer (Getnet *et al*. 2016)
Ficus palmata Forssk. JHS 25273	Moraceae	Fruits, leaves, latex	Bachache, analgesic, adaptogen, male sexual disorders, anti-helentic (Ascaris in stomach), jaundice	Bedu	0.19	Use as wild edible fruit and vegetable (Abbasi *et al*. 2013), fodder and fuelwood (Panthi & Chaudhary 2002). Fruit paste is used in ringworm and skin diseases (Thapa 2001). Ripe fruits are used in dysentery and vomiting (Devkota & Karmacharya 2003, Pant & Panta, 2004). Stem latex is applied to extract spines deeply lodged in the flesh (Kunwar & Bussmann 2006, Manandhar 1995), wounds, increase lactation (in ethnoveterinary) (Pande *et al*. 2007).
Ophiocordyceps sinensis	Ophiocordycipitaceae	Whole parts	Aphrodisiac, adaptogen, immunomodulator	Yar-tsa-gambo, Yarsa gumba, Keeda jadi		Increase longevity, for erectile dysfunction, female aphrodisiac, jaundice, arthritis (Panda & Swain 2011).
Satyrium nepalensis Summerh. RKT 2817	Orchidaceae	Root	Memory enhancer, immunomodulator, antipyretic	Mushri, Mishri	0.02	Root powder is given with cow-milk as tonic (Tiwari *et al*. 2010).

Oxalis intermedia A Rich 115196	Oxalidaceae	Leaf	Wound healing, antioxidant	Changeri, khatti meethi	0.02	Dysentery, stomach disorders, rheumatism, toothache (Arbiastutie *et al*. 2017; Sen *et al*. 2011).
Phytolacca acinosa Roxb. JHS 25274	Phytolaccaceae	Leaf, root	Anticancer, vegetable, immunomodulator	-	0.11	Veterinary diseases (Khateeb *et al*. 2015), wild editable (Lata *et al*. 2013).
Anemone vitifolia Buch.-Ham ex DC. RKT 14831	Ranunculaceae	Roots	Antimicrobial, anthelminthic	Agali	0.07	Ringworm, eczema (Kumar 2017, Pande *et al*. 2007), for anti-leech (Balami 2004).
Prinsepia utilis Royle. 115509	Rosaceae	Fruits and seeds	Analgesic, immunomodulator	Jhitalu	0.02	Fruit used for body pain, joint pain, rheumatism, wound healing (Balami 2004, Uniyal *et al*. 2006), root extract is taken orally as an antidote to neutralize the effect of poison intake (Uniyal *et al*. 2006).
Prunus persica (L.) Batsch. JHS 25266	Rosaceae	Fruits	Antioxidant, immunomodulator	Aadu	0.07	Leaf extract used in diarrhea (Maroyi 2013), leaf paste is applied on animal' s body to remove external parasites (Bhatia *et al*. 2014).
Pyracantha crenulata (Roxb. ex. D Don) 115515	Rosaceae	Fruits, leaf and roots	Analgesic, adaptogen, coagulant	Ghingharu	0.30	Edible fruit (Wr *et al*. 2013), constipation, in burns in livestock (Pande *et al*. 2007).
Rubus elipticus Sm. JHS 25265	Rosaceae	Root	Analgesic, stomach disorders, antiulcer, anthelminthic	Hisalu	0.11	Plant is used in diarrhea, cough, fever and dysentery (Haq 2012, Parihaar *et al*. 2014), wound healing, fruit juice is used in the treatment of fever, colic, cough and sore throat (Haq 2012). Fruit is edible and is useful for removal of kidney stone (Ahmad *et al*. 2011).
Rubia cordifolia RKT 27417	Rubiaceae	Leaves, root	Blood purifier, skin diseases, leukoderma	Manjishtha	0.11	Used for diabetes in combination of other drugs (Kumar & Janardhana 2012).
Wendlandia heynei (Schult) Santapau & Merchant 115207	Rubiaceae	Leaves	Antihypertensive	Tillak	0.02	Furuncle (Tayade & Patil 2006), and as a toothbrush (Rawat *et al*. 2009).
Boenninghausenia albiflora (Hook) Rchb. ex. Meisn RKT 26684	Rutaceae	Whole plant	Mosquito repellant	Pissumar, upaniyajhar	0.02	Used for wound healing and to relieve headache and for scabies (Thakur and Sarika, 2016).
Murraya koengii L. Sprendle RKT 26776	Rutaceae	Leaf	Food, condiment	Curry patta	0.01	Leaves smell to patients with epilepsy, used for malaria, diarrhea, dysentery, and fever (Bajpai *et al*. 2016, Silja *et al*. 2008).
Bergenia ciliata (Haw.) Sternb JHS 25276	Saxifragaceae	Root	Lithotriptic, stomachache, wound healing (dry powder of root),	Pattharchatta, Pashanbhed, Silfoda	0.61	Kidney stone, sores, swelling (Kumar, 2017), veterinary diseases (Pande *et al*. 2007), gastrointestinal disorders and diabetes (Begum *et al*. 2014).

			Antidiabetic, adaptogen, gastritis constipation			
Digitalis purpurea L. RKT 25577	Scrophulariaceae	Leaf	Cardiac disorders	Hritpayyi, Tilpushpi	0.02	Used in cardiac disorders, coughs, skin diseases, wounds, sprains, inflammation, tuberculosis, old ulcers, burns, festering of stone-bruises, and as a repellent (Allen & Hatfield 2004).
Datura innoxia Mill 115505	Solanaceae	Fruit	Toxic and spiritual purpose	Dhatura	0.03	Leaf powder orally taken with honey, to cure asthma, smoke as narcotic and skin diseases (Patil 2015).
Solanum nigrum L. 115191	Solanaceae	Leaf	Anticoagulant in veterinary preparation	Makoi, Ninoni, Gaiwai	0.03	Leaves are crushed and mixed in water and applied topically, used for washing painful eyes (Abbasi *et al*. 2013), pain in body (Mahmood *et al*. 2011)
Daphne papyracea Wall. Ex. G. Don 115504	Thymelaeaceae	Leaf, seed	Leucoderma, constipation	Satpura /skin diseases	0.07	In preparation of hand-made paper for painting and writing religious scripts in Buddhist monasteries (Namsa et al., 2011).
Callicarpa macrophylla Vohl 115507	Verbenaceae	Fruits	Mouth ulcer, gout	Priyangu, betmaalu	0.03	Dry fruit powder blend with honey too treat acne, pimples, blemishes, and allergic skin patches (Bhatt *et al*. 2012), in traditional agroforestry (Deb *et al*. 2009).
Duranta plumieri Jacq. RKT 1755	Verbenaceae	Flower	Mosquito repellant	Duranta	0.01	The fruits are used for intoxicating and catching fishes (Kalita *et al*. 2010).
Verbena bonariensis L. 115208	Verbenaceae	Leaves	Antimicrobial, galactagogue	NA	0.01	Mouth infection in babies (Ngari 2010).
Viburnum cylindricum Buch-Ham ex. D. Don 115514	Verbenaceae	Seeds	Laxative	NA	0.01	Edible (Geng *et al*. 2016; Zhang *et al*. 2016), to control the sweatiness and heat from body especially from hands and feet after washing (Dangwal & Singh 2013).
Cautleya spicata (JE Smith) Baker RKT 25842	Zingiberaceae	Root	Skin diseases	Ban Haldi, Jaharu Haldi	0.02	In veterinary practices for internal wounds (Tiwari & Pande 2004), and for gastritis (Acharya & Rokaya, 2005).
Roscoea purpurea Sm. (Syn. *Roscoea procera* Wall) RKT 15325	Zingiberaceae	Root, rhizomes	Immunomodulator, wound healing	Kakoli	0.07	Rhizome juice is used in cleaning wounds (Kunwar & Adhikari 2005).

We also correlated the plant families with the number of diseases for which they were being indicated. It was found that the representatives of Asteraceae followed by Lamiaceae, Rosaceae and Verbenaceae were being employed as remedies for the majority of diseases. These results are also justified as the species which were recorded at large are being used in the treatment of a large number of disorders. The details are illustrated in Figure 6.

Leaves were found to be the highest used part of the plants (27.14%). Next to leaves, roots (18.57%), fruits, flowers and whole plants (9.99%) were used, followed by seeds (7.14%), stem bark (4.28%) and rhizomes (2.85%). Some other parts like stem, fruit peel and wood (1.42%) were also used for different disease conditions. These findings resonate with the observations of Bekalo *et al*. (2009), Ogbe *et al*. (2009), and Rahmatullah *et al*. (2012) who also reported that leaves were the most used parts. Sometimes leaves, bark and roots of the same plants were used interchangeably by various healers.

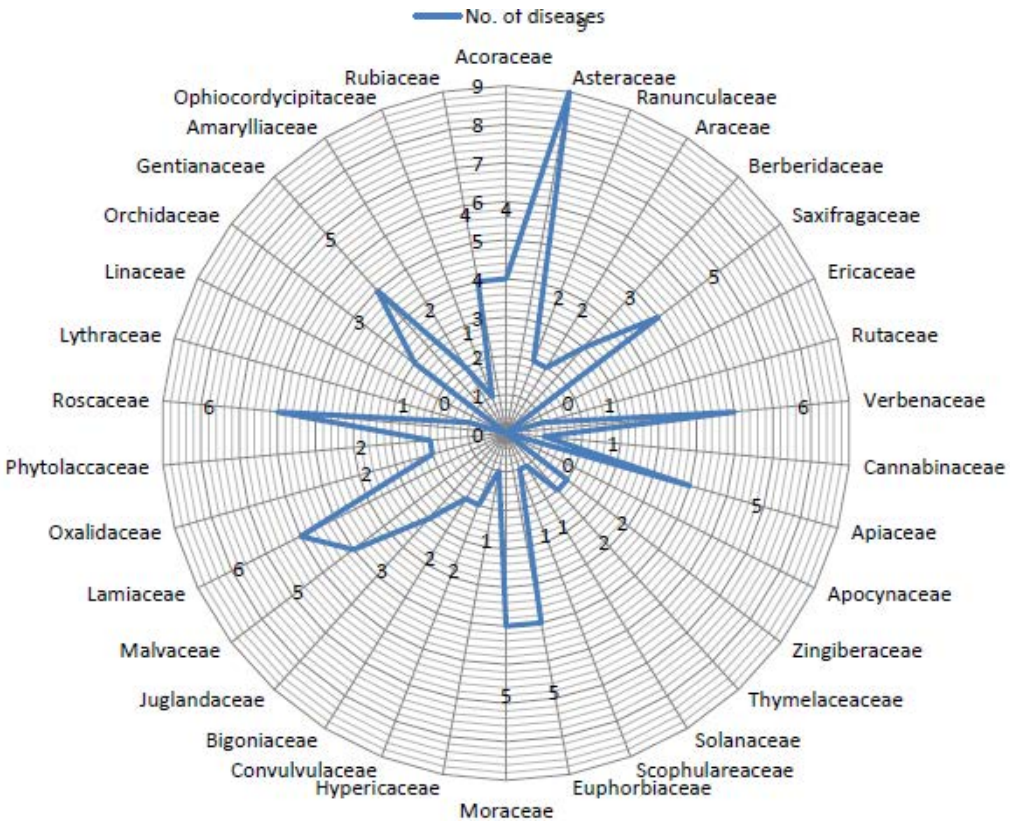

Figure 6. Spider chart (irregular polygon) showing the correlation between plant families and number of diseases cured

Our findings deviate from the work of Bussmann (2006), Musa *et al*. (2011), Cheikhyoussef *et al*. (2011), Maroyi (2013) and Ngarivhume *et al*. (2015) who reported roots as the highest used parts for treatment of diseases and ailments (Ngarivhume *et al*. 2015, Friedman *et al*. 1986, Bussmann 2006, Cheikhyoussef *et al*, 2011, Maroyi 2013) (Details are presented in Figure 7). Moreover, among all plants, herbs (56.14%) had the highest prevalence in being used among all plants followed by shrubs (24.56%) and trees (15.78%) (Figure 8).

The consensus analysis and FL revealed that *Bergenia ciliata* had highest FL and ICF value as an anti-urolithiatic. *B. ciliata* is a well-known and well-established plant for the treatment of kidney stones (Bashir, Gilani 2009, Byahatti *et al*. 2010). Some plants with high FL and ICF were *Pyracantha crenulata* for analgesic activity with 100% FL and 0.5 ICF, *Rhododendron arboreum* with 85.71% FL and 0.4 ICF, *Ocimum basilicum* and *O. tenuiflorum* with (100%) FL but comparatively lower ICF (0.33%). Similar results were obtained for *Swertia chirayita*. Additionally, *Berberis aristata,* as an antidiabetic, showed high (71.42%) FL and even higher (0.75) ICF, and for jaundice, the plant showed 42.85% FL and 0.5 ICF. *Ficus palmata* exhibited an FL of (66.66%) and ICF (0.25). The details of FL and ICF are presented in Table 3.

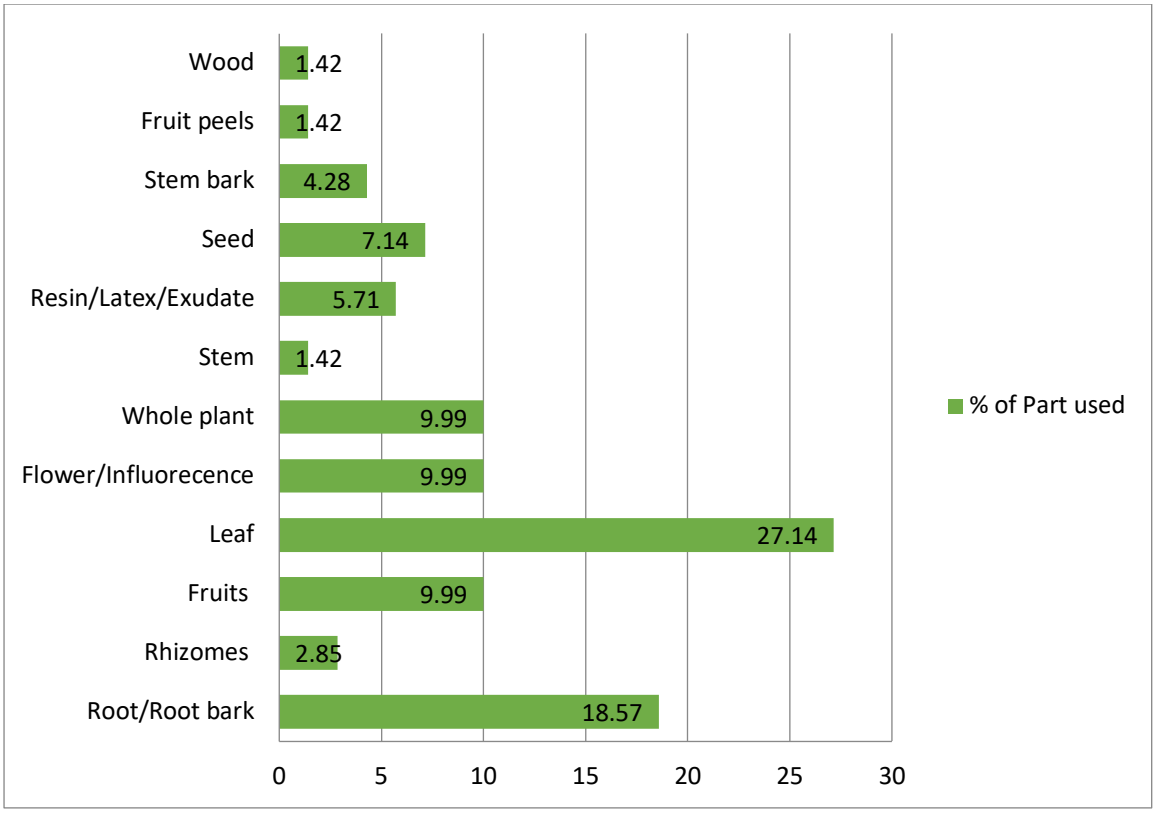

Figure 7. Schematic representation of % of plant parts used

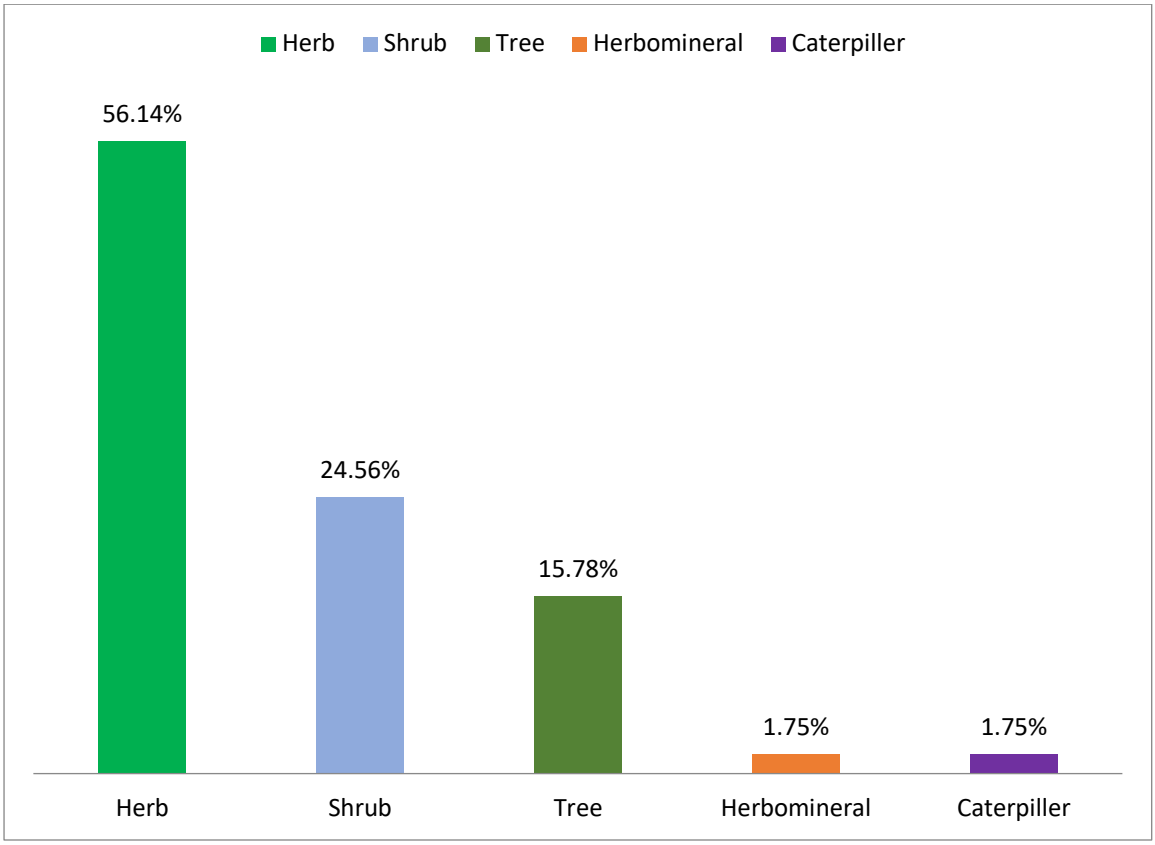

Figure 8. Distribution of plant habits and other products used

Table 3. Plants used in different therapeutic conditions with FL and ICF

Species	Therapeutic indication	FL (%)	ICF
Acorus calamus L.	Nervous system related disorders	50	0.25
Berberis aristata DC.	Antidiabetic	71.42	0.75
	Jaundice	42.85	0.50
Bergenia ciliata (Haw.) Sternb	Lithotriptic	100	1.00
Carum carvi L.	GIT disorders	33.33	0.25
Euphorbia pilosa L.	Antimicrobial	100	0.03
Ficus palmata Forssk.	Analgesic	66.66	0.25
Ocimum tenuiflorum L.	Cough, fever, cough	100	0.33
Ocimum basilicum L.	Cold, fever, cough	100	0.33
Pyracantha crenulata (Roxb. ex. D Don)	Analgesic	100	0.5
Rhododendron arboreum Sm.	Antidepressant	85.71	0.4
Swertia chirata	Fever	100	0.33

Comparative analysis of documented data with previous literature

A literature survey on ethno-medicinal uses was carried out to verify whether the plants utilized by people of Kumaun Himalayan region were previously known for their therapeutic uses against similar or other disease conditions or not. The detailed comparative results are enlisted in Table 2. Some of the plants were found to be used for similar indications as recorded in the survey.

Acorus calamus L. is reported to be used in throat related disorders and for the treatment of gout; *Artisaema tortuosum* (Wallich) Schott is reported to be used for snake bite; *Anemone vitifolia* Buch. as an anthelmintic, *Berberis aristata* DC. was used for jaundice, *B. ciliata* (Haw.) Sternb for the treatment of kidney stones, *Digitalis purpurea* L. in cardiac disorders, *Hydrocotyle javanica* Thunb. in gastrointestinal disorders, *Inula cuspidata* (Wall ex. DC) CB Clarke as anthelmintic, *Jacaranda mimosifolia* D. Don for wound healing effect, *Lyonia ovalifolia* (Wall) for skin related disorders and antipruritic effect, *Mentha longifolia* L. for carminative effect and in gastrointestinal disorders, *Prinsepia utilis* Roxb. for analgesic effect, *Swertia chirayita* (Roxb.) Buch.-Ham. ex C.B. Clarke for antipyretic effect, *Roscoea purpurea* Sm. for wound healing effect, *Rubus elipticus* Sm. for gastro-intestinal disorders, *Taraxacum officinale* G.E. Hugland for jaundice and biliary diffusion, and *Verbena bonariensis* L. for microbial infections and related diseases.

Several other important therapeutic claims were also documented from different medicinal plants apart from already reported claims such as cure of alopecia by bark and fruits of *Juglans regia* L., antidepressant effect of *Rhododendron arboreum* flower juice, anti-herpes effect of *Lyonia ovalifolia* Wall., beneficial effect of the fruits of *Callicarpa macrophylla* Vohl against mouth ulcers, *Boenninghausenia albiflora* (Hook) Rchb. ex. Meisn as mosquito repellant, seeds of *Carum carvi* L. in dysmenorrhea, *Rubia cordifolia* in vitiligo, *Jacaranda mimosifolia* D. Don in sexually transmitted diseases and others. The lists of these plants are presented in Table 4.

Table 4. List of medicinal plants reported during the study along with their therapeutic effects

Botanical Name	Family	Part use	Common name	Therapeutic effect
Allium stracheyi	Alliaceae	Root/stem	Sekua, chota jambu	Stomachache, gastritis, jaundice
Achyranthes aspera	Amaranthaceae	Root, stem	Latjeera, Apamarg	Asthma, cough
Angelica archangelica L.	Apiaceae	Root	Gandarain	Gastritis & stomachache
Cetella aciatica	Apiaceae	Leaf	Mandukparni	Memory enhancer, constipation in child
Eryngium foetidum L.	Apiaceae		Jangli gajar	Leukoderma
Saussurea obvallata wall.eEx. C. B. Clarke	Asteraceae	flower	Brahmakamal Kwanl ka phool	
Podophyllum emodi	Berberidaceae	Rhizomes, fruit	Bankakadi	Gastritis
Arnebia euchroma (Royle) Johnston	Boraginaceae	Root	Baljhadi	Hair loss/hair dye
Raphnus sativus L.	Brassicaceae	Leaf	Mooli	Scorpion bite
Valleriana hardwickii	Caprifoliaceae	Root	Tag , samewa	Stomachache

Terminalia chebula	Combretaceae	Fruit	Harad	Cough & fever, stomachache
Dioscorea bulbiflora	Dioscoraceae	Tubor	Gethi	To prevent cold
Embellica officinale	Euphorbiaceae	Fruit	Aonla	Food muraba, cold
Accacia catechu (L.F.) Willd.	Fabaceae	Stem	Khair	Analgesic
Bauhinia vahlii W & A.	Fabaceae	Leaf	Maluka	Food
Beutea utilis D. Don.	Fabaceae	Leaf	Bojptra	Wound healing
Millettia racemosa	Fabaceae	Root	Junga	In the removal of umbilical cord
Ougeinia dalbergioides Benth.	Fabaceae		Sanan	Wound healing, coagulant
Coleus parviflorus Benth.	Lamiaceae	Root	Colis	Fever in cow,
Colebrookea oppositifolia J. E. Smith	Lamiaceae	Fruit, root	Bhekmalu	Oral ulcer, Gout
Thymus vulgaris L.	Lamiaceae	Seed	Vanajwoin	Expectorant
Cinnamomum tamala (Buch-Ham.) T.Nees & Eberm	Lauraceae	Leaf	Tej patta	Food preparations as condiment and flavoring agent
Cinnamomum zeylanicum Blume	Lauraceae	Bark	Dalchini	Condiment and gastritis
Paris polyphylla Sm.	Melanthiaceae	Root	Satua	Stomachache
Azardirachita indica Juss.	Meliaceae	Leaf	Neem	Fever
Tinospora cordifolia	Menispermaceae	Stem		Galactagogue cow, arthritis, bp
Ficus ariculata Lour.	Moraceae	Fruit	Timil	Heat in stomach
Musks muskone	Moschidae		Kasryri mrig	Aromatic
Myrica nagi Hook f. non Thunb	Myricaceae	Seed	Kafal	Blood purifier, kidney stone, immunomodulatory Relieve constipation
Syzygium caryophyllum (L.) Alston	Myrtaceae	Fruit	Jamun	Antiemetic, diarrhea
Orchis latifolia L./ *Cissus quadranguleris L*	Orchidaceae.	Root	Salampanja Hathajadi	Wound healing, coagulant
Pinus roxburghii	Pinaceae	Wood	Chir	Building
Cynodon dactylon Pers.	Poaceae		Doob	Piles
Rgeum emodii	Polygonaceae	Root	Dolu, arch	Bone disorders, wound healing, eye pain, fracture
Aconitum heterophyllum Wall ex. Royle	Ranunculaceae	Root	Atees	Fever, wound healing, stomachache
Coptis tecta Wall	Ranunculaceae	Leaf juice	Mamera	Eye diseases
Delphinium denudatum Wall	Ranunculaceae	Root	Nirvishi	Antitoxin, aromatic,
Potentilla arbuscula D. Don.	Rosaceae	Whole plant	Bajradanti	Toothache
Cinchona spp.	Rubiaceae	Bark	Dabada	Wound healing, adhesive
Citrus limon	Rutaceae	Root	Nimbu	Antiemetic in children
Xanthozylum armatum	Rutaceae	Fruit	Timur /inna	Cold, fever, in spice, toothache, anthelmintic
Aesculus indica (Wall. ex Cambess.) Hook.	Sapindaceae	Fruit	Pangar	poisonous, veterinary disease in cow fever, galactagogue in veterinary
Bacopa monnieri (L.) Wettst.	Scrophulariaceae	Leaf	Brahmi	Memory enhancer
Picorrhiza curoroa	Scrophulariaceae	Root	Kutaki	Fever, stomachache and analgesic/diabetes/hypertension, fever, bone fracture
Solanum xanthocarpum	Solanaceae	Root	Kantakari	Jaundice
Urtica dioca/ Gerardiana diversifolia Eriss.	Urticaceae		Bichhu	Galactagogue for cow, food and tea
Fagonia cretica	Zygophyllaceae	Whole plant	Dhamaku	Fever

Occurrence of a unique plant and mushroom

Apart from the above-mentioned species, *Strobilanthes wallichii* Nees. was also recorded during the survey as a special ceremonial plant (Figure 9). The purple blooms of the plant are believed to appear only once in every twelve years, when the festival of "Kangdali" is celebrated in the Pithoragarh district. The festival is celebrated by the Rung tribe of the district who are closely related to the Bhotia tribes of the studied area, and. Festival is held in "Chaundas" valley between the months of August and October. The festival is celebrated to rejoice and commemorate the defeat of Zorawar Singh's army (from Ladakh), who attacked in 1841 from Ladakh. Several tales are associated with the blooming of the flower of the plant. One of these tales is of "a boy who died after applying the paste of the root from a shrub known as Kang-Dali on his wound. His enraged mother cursed the shrub and ordered the "Shauka" women uproot the "Kang-Dali" plant off its ground upon reaching its full bloom, which happens once in twelve years"(Negi, 2003).

Figure 9. *Strobilanthes wallichii* Nees.

Another important occurrence was the caterpillar fungus *Ophiocordyceps sinensis*. It is also very popular in the entire region due to its very high cost and demand. Most of the people from the Jualjibi valley go back to the high-altitude Himalayan areas in the month of March-April with their kids when the snow melts in search of the so-called magic remedy Yar-tsa-gumbo. *O. sinensis* is an annual Ascomycete, widely used in traditional Tibetan and Chinese medicine and also reported from Sikkim. The people of the study area were very much engaged in the collection of *O. sinensis* due to its high cost. At the same time local people of the area were not much satisfied with the government policy for the exploitation of this traditionally used drug and they believed that the government should increase the trade rate for this mushroom. Even a single piece of *O. sinensis* costs about Rs. 500 and people were very much aware about its sale. A favorable policy for its exploitation at a mutual consent with the government and local people is required for sustainable development.

The significant plant wealth in the Himlayan region can be potential source for the development of the socioeconomic conditions of the populations residing in the study area. As mentioned earlier that there are several socio-economic challenges are present in front of the rural people of the study area. The gathered plants can substantially improve the economic conditions of the native people of the study area. For instance, cultivation of different important plants like *Berberis*, and *Bergenia* could provide high economic outcomes in terms as these plants are endangered and possess a huge market value due to their potential uses in the Ayurvedic and other traditional medicine formulations. Moreover, value addition in the form of product development from various Himalayan medicinal plants like *Rhododendron*, *Ficus palmata*, *Carum carvi*, *Ophiocordyceps* and many others have the potential to generate great market values.

Due to changing lifestyles, great secrecy of traditional healers and disinterest of youngsters, the practice of, and dependence of ethnic societies on folk medicines is in rapid decline globally. Therefore, ethnobotanical exploitation and documentation of indigenous knowledge about the usefulness of such a vast pool of genetic resources is deliberately needed (Behera, Misra 2005, Bussmann, Sharon 2006, Kunwar *et al*. 2006, Longuefosse, Nossin 1996, Saikia *et al*. 2006, Singh *et al*. 2012). It was already mentioned by "*Charak*" and "*Sushrut*" (ancient scholars of Ayurveda) that "knowledge of medicinal plants and their identification should be gained with the help of cowherds, hermits, hunters, forest-dwellers and those who gather plants of the forest for food" (https://www.ncbs.res.in/HistoryScienceSociety/content/overview-indian-healing-traditions, accessed on 3.8.2017). The original *shloka* is mentioned in Figure 10.

Although, the healers were much sentient of the occurrence of inequitable bioprospecting practices from different pharmaceutical companies and other institutions, however, they were not much aware about the legal protection of their intellectual properties. Similar information about the legal protection of plant was also also described by others as well (Ngarivhume *et al*. 2015, Uprety *et al*. 2012). It was very surprising to see the behavior and awareness of the healers as well as old informants

about their willingness of sharing their information. They also knew that their knowledge on traditional practices for healing is very precious and needs to be conserved. Moreover, the informants were also disappointed to see the negligence of youngsters towards the extinction of traditional knowledge. Another reason for this is the death of many healers and traditional medicine practitioners without documenting or communicating their invaluable knowledge, which have lead to the irrevocable loss of lots of the precious data.

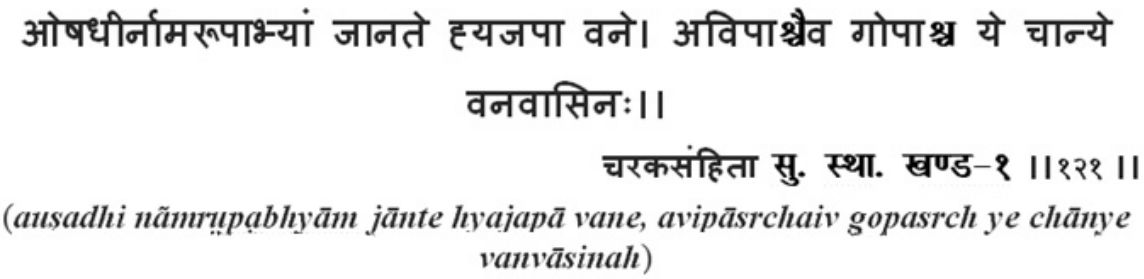

Figure 10. Shloka given in "*Charaksamhita*" mentioning about the importance of various forest people in the identification of the plants

The average age of the respondents for the present study was 57 years which is approximately the similar to the average age of informants reported in another studies from Egypt and Morocco (50 and 55 years, respectively) (Gonzalez-Tejero *et al*. 2008). Asteraceae, Lamiaceae and Rosaceae were found to be the majorly used families for different therapeutic purposes. This may be due to the presence of higher quantities of phytoconstituents such as terpenoids, phenolic and flavonoid compounds in Lamiaceae and lactones in Asteraceae which are responsible for the antioxidant and other therapeutic activities (Brahmi *et al*. 2016, Candan *et al*. 2003, Khaled-Khodja *et al*. 2014, Miliauskas *et al*. 2004, Ouelbani *et al*. 2013). The healers also believed that in most cases cultivated plants were less potent than wild plants, similar to what has been reported from Zimbabwe (Ngarivhume *et al*. 2015). Such findings agree with the findings of Okello and Ssegawa (2007) in Uganda (Okello, Ssegawa 2007), Bussmann (2006) in South Turkana, Kenya, and Babungo (Camroon) (Bussmann, 2006), Moosa et al. (2011) in Sudan (Musa *et al*. 2011) and Ngarivhume *et al*. (2015) in Chipinge, Zimbabwe (Ngarivhume *et al*. 2015). During the survey it was observed that the number of practitioners were declining rapidly. Several inhabitants of the surrounding areas and different villages told that most of the practitioners were either already dead or migrated to other areas, and therefore, a comprehensive anthropological study would be required to quantify such data. One of the most common problems mentioned by most of the respondents was that their children were not interested to acquire the knowledge related to medicinal plants and local treatments due to poor economic conditions and general lack of interest. This kind of situation is really very threatening for the traditional knowledge in the whole Himalayan region.

The villagers were also concerned about their forest wealth. Due to exploitation of vegetation from forest areas as fodder for cattle, and unwanted human interruption, which also sometimes leads to forest fires, another prime concern in the entire region. In some communities the inhabitants mutually surrendered the whole forests of some regions as "forest of the village god". After such surrender no one is allowed to exploit these forests. Based on the conversations with the villagers, it was found that this practice of forest surrender has dramatically reduced forest use and squatting in such forests.

Conclusions

In the rural areas of Uttarakhand, practice of plant-based medicine and local traditional knowledge plays a vital role in people´s lives, and such knowledge is widespread. This knowledge is becoming even more important in the primary healthcare system of the rural mountainous areas where there is a huge scarcity of registered medical practitioners. This explorative survey accentuated the importance of preservation and documentation of traditional knowledge for various disease conditions and for additional elaborative scientific research on these as well as other plants for the evaluation of their therapeutic efficacy and safety. Proper scientific validation is an important step for the standardization and optimum utilization of the therapeutic claims in the field of drug discovery from natural products. We are also working on the validation of some of the reported traditional applications and claims such as antidepressant potential of *R. arboreum* and analgesic potential of *F. palmata* and *P. crenulata*.

Declarations:

List of abbreviations: Not applicable

Ethics approval and consent to participate: The study was approved by University Research Degree Committee of Kumaun University Nainital. All participants provided oral prior informed consent and signed in the questionnaire as their consent.

Consent for publication: Not applicable

Availability of data and materials: Not applicable

Competing interests: The authors declare no competing interest.

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Authors' contributions: DT conceived the study, participated in conceptualization, implementation, data and plant collection, interpretation, drafting of manuscript, ANS participated in study design and overall guidance, SW participated in data interpretation and RWB critically revised and edited the manuscript. All the authors participated in writing and giving feedback on the manuscript and approved the final version of the manuscript.

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Plate 1. Social life & Challenges (A: Poor economic condition of villagers living in hut with their Cattle's; B: Poor situation of road towards the main block; C: People use old traditional "Chulha" for cooking in their business; D: Poor connectivity of transport; E: Agriculture in terrain system; F: Typical device to cross the river in the rainy season)

Plate 2. Plants collected during study (A: *Berberis aristata* DC. (Flowering); B: *Berberis aristata* DC. (Fruiting); C: *Rhododendron arboreum* Sm. (Tree); D: *Rhododendron arboreum* Sm. (Flower); E: *Punica granatum* L. (Fruit budding); F: *Punica granatum* L. (Flowering))

Plate 3. Plants collected during study (A: *Roscoea procera* Wall.; B: *Hedychium spicatum* Sm.; C: *Nepeta hindostana* (Roth) Haiens.; D: *Geranium wallichianum* D. Don ex Sweet.; E: *Digitalis purpurea* L.; F: *Zaphyranthes grandiflora* Lindle.)

Plate 4. Plants collected during study (A: *Solanum nigrum* L.; B: *Juglans regia* L.; C: *Pyracantha crenulata* (Roxb. ex D. Don) M. Roem.; D: *Rubus elipticus* Sm..; E: *Urtica dioca* L..; F: *Cannabis sativa* L.)

Plate 5. Plants collected during study (A: *Euphorbia prolifera* Buch.-Ham in D. Don.; B: *Phytolacca acinosa* Roxb.; C: *Carum carvi* L.; D: *Pinus roxhburghii* Sarg.; E: *Allium stracheyi* Baker.; F: *Taraxacum officinale* G.E. Hugland)

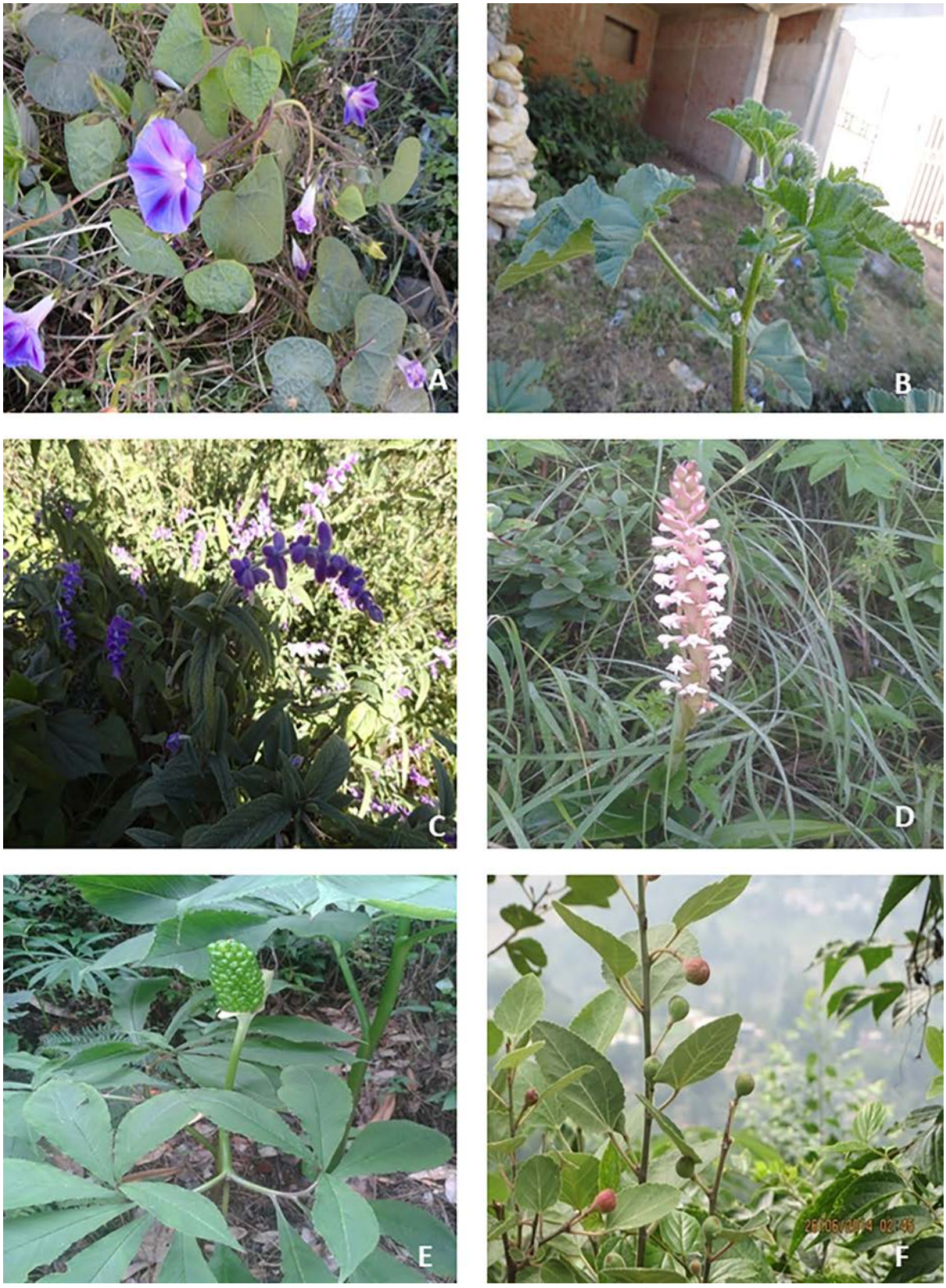

Plate 6. Plants collected during study (A: *Ipomoea purpurea* Roth; B: *Malva verticillata* L.; C: *Salvia leucantha* Cav.; D: *Satyrium nepalensis* DC.; E: *Areseamone tortuosum* (Wallich) Schott; F: *Ficus palmata* L.

Plate 7. Plants collected during study (A: *Datura innoxia* Mill.; B: *Boenninghausenia albiflora* (Hook) Meisn; C: *Murraya koenigi* (L.) Spreng.; D: *Callicarpa macrophylla* Vohl..; E: *Cautlaya spicata* (J.E. Smith) Baker; F: *Daphne papyracea* Wall. ex Don.

Plate 8. Plants collected during study (A: *Lyonia ovalifolia* (Wall.) Drude.; B: *Polygonum hydropiper* L.; C: *Bidens pilosa* L.; D: *Rubia cordifolia* L..; E: *Inula cuspidata* (Wall. ex DC.) C.B. Clarke; F: *Bergenia ciliata* (Haw.) Sternb