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Original Article

Quantitative ethnomedicinal study and conservation status of medicinal flora used by the indigenous peoples of Sultan Khail valley, Dir Upper, Pakistan

Estudo etnomedicinal quantitativo e estado de conservação da flora medicinal utilizada pelos povos indígenas do vale Sultan Khail, Dir Upper, Paquistão

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Abstract

The present study was conducted to explore the ethnomedicinal uses, quantitative analysis and conservation status of medicinal flora of Sultan Khail valley, Dir Upper, Pakistan. The data was collected during 2017-2019 using a semi-structured questionnaire. Ethnomedicinal uses of plant species were determined and the plant species were classified based on habits, parts used, and method of preparation of remedies. Frequency of citation (FC), relative frequency of citation (RFC) and family importance values (FIV) were calculated. The plant species were assessed for their conservation status as per IUCN standard criteria. The inhabitants of the Sultan Khail valley use 88 plant species belonging to 57 families for the treatment of different human diseases. Lamiaceae was the dominant family represented with 8 medicinal species (9%) followed by Rosaceae (5 species, 6%). The most commonly used plant parts were leaves (33.1%) followed by fruits (16.1%), while the main method of remedy preparation was decoctions (33.3%). The highest RFC value was recorded for *Geranium wallichianum* (0.47), followed by *Berberis lycium* (0.44). Lamiaceae was the most cited family (FIV, 231), followed by Polygonaceae (73). Five plant species were found to be endangered, 39 species were vulnerable, 32 species were rare, and 12 species were found to be infrequent. The medicinal flora of the area is under severe biotic pressure and needs proper conservation; otherwise, they will be lost in the near future.

Keywords: ethnomedicinal flora, Frequency of citation, relative frequency of citation, family importance value, conservation status, Sultan Khail valley, Dir Upper, Pakistan.

Resumo

O presente estudo foi realizado para explorar os usos etnomedicinais, análise quantitativa e estado de conservação da flora medicinal do vale do Sultão Khail, Dir Upper, Paquistão. Os dados foram coletados durante 2017-2019 por meio de um questionário semiestruturado. Os usos etnomedicinais das espécies vegetais foram determinados e as espécies vegetais foram classificadas com base nos hábitos, partes utilizadas e modo de preparo dos remédios. Frequência de citação (FC), frequência relativa de citação (RFC) e valores de importância familiar (FIV) foram calculados. As plantas foram avaliadas quanto ao seu estado de conservação de acordo com os critérios padrão da IUCN. Os habitantes do vale do Sultão Khail usam 88 espécies de plantas pertencentes a 57 famílias para o tratamento de diferentes doenças humanas. Lamiaceae foi a família dominante representada com 8 espécies medicinais (9%) seguida por Rosaceae (5 espécies, 6%). As partes das plantas mais utilizadas foram as folhas (33,1%) seguidas dos frutos (16,1%), enquanto o principal método de preparo do remédio foi a decocção (33,3%). O maior valor de RFC foi registrado para *Geranium wallichianum* (0,47), seguido por *Berberis lycium* (0,44). Lamiaceae foi a família mais citada (FIV, 231), seguida por Polygonaceae (73). Cinco espécies de plantas estavam ameaçadas de extinção, 39 espécies eram vulneráveis, 32 espécies eram raras e 12 espécies eram infrequentes. A flora medicinal da área está sob forte pressão biótica e necessita de conservação adequada; caso contrário, eles serão perdidos em um futuro próximo.

Palavras-chave: flora etnomedicinal, frequência de citação, frequência relativa de citação, valor de importância familiar, estado de conservação, vale do Sultão Khail, Dir Upper, Paquistão.

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1. Introduction

Ethnobotany is an interdisciplinary branch of science that concerns all aspects of human and plant interactions. Because of the rising cost of synthetic drugs, people who cannot afford them are being encouraged to use medicinally important plant species for the treatment of various diseases (Mohamad et al., 2011). The northern localities of Pakistan, especially Hindu Kush range, of Pakistan is faced with significant anthropogenic stress. The local community is unaware of the endangered species, over-grazing of the animals, timber wood smuggling, etc. It is critical to identify where and how ethno-medicinal plants can be found. This knowledge is essential to classifying susceptible plants to collect them or change their habitats to other distant regions of the country. Ethnobotanical research can help bio-conservationists and foresters plan for the future (Hassan et al., 2017). Various Researchers have made substantial contributions to explore the medicinal uses of plants species and their conservation status in different parts of the world and in Pakistan (Musa et al., 2011; Faruque et al., 2018; Bano et al., 2013; Hussain et al., 2010; Barkatullah and Ibrar, 2011; Jan et al., 2014; Khan et al., 2014; Shinwari et al., 2017; Hassan et al., 2019; Sulaiman et al., 2020). However, there is no information on the ethno medicinal flora and their conservation status in the Sultan Khail valley, Dir Upper, Pakistan. Therefore, the present study aimed; (i) to gather indigenous knowledge on the healing benefits of plant species. (ii) To identify new medicinal plant species in the study area that may be a source for the discovery of novel drugs. (iii) To assess the conservation status of the medicinal flora in the area

2. Materials and Methods

2.1. Study area

The beautiful Sultan Khail valley is situated in Dir Upper, Khyber Pakhtunkhwa, Pakistan (Figure 1). Although the valley is located in Pakistan's subtropical dry temperate zone, while some parts of the study area lies in the country's moist temperate zone (Khan, 2011). The name Sultan Khail is given to the valley due to the majority of the inhabitants of Sultan Khail tribe living in the area. It lies between 34° 59' 20", 35° 59' 52" North latitude and 71° 00' 11", 72° 00' 2" East longitude. The valley is bordered by river Panjkora and Nehag Dara in the East, Dir Lower (Maidan) in the West, Jelar valley in the South and Kair Dara in the North.

Climate of the study area is continental type and is influenced by various topographic and ecological factors. Spring, summer, autumn, and winter are the four distinct seasons in the area. Winter season is very cold and severe and start from the mid of November in which the temperature fall abruptly. Summer season in the valley is typically moderate, with June and July being the hottest months of the year. The average maximum temperature reaches 35.5 °C to 35.9 °C in the months of June and July while in January the mean minimum temperature falls below zero (-1.3 °C). The area receives maximum rainfall in the months of February, March and August. The total population of Sultan Khail valley is 40117 including 18939 male and 21178 female (DCR Dir Upper; PBS, 2017). The majorities of the peoples in the area are illiterate, and travel to the province or country's main cities, or even abroad, in search of work to earn money.

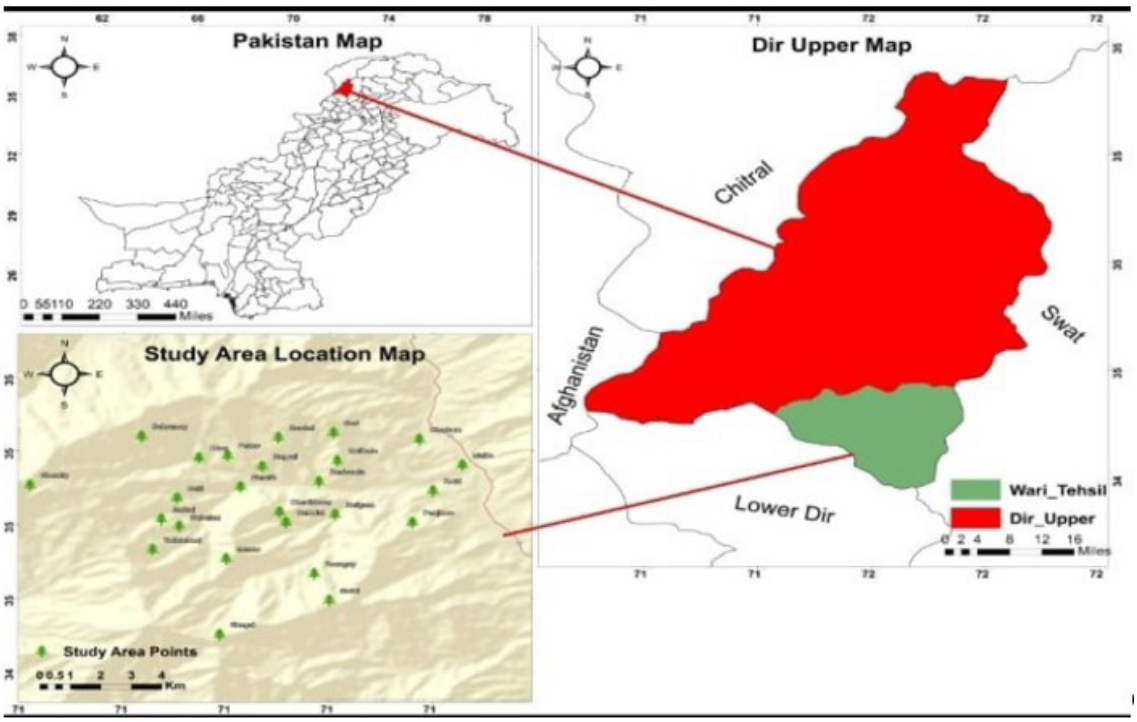

Figure 1. Location map of the Sultan Khail valley, Dir Upper, Pakistan.

Other sources of revenue include agriculture, the sale of fuel wood, timber wood, medicinal plants collection, daily wage work, and livestock production. Agriculture land is too less in the area and the agriculture practice mostly occurs at the mountain slopes. The vegetation of the valley is subjected to extensive anthropogenic pressure in the form of grazing, medicinal plants collection, timber wood collection and smuggling to other areas.

2.2. Data collection

The present study was conducted during 2017-2019 in Sultan Khail valley, Dir Upper, Pakistan using a semi-structured questionnaire. 140 respondents were interviewed following Ali et al. (2018). The collected specimens were identified with the help of flora of Pakistan (Ali and Qaiser, 2015) arranged in alphabetical order. Voucher numbers were given and deposited at the Herbarium Department of Botany, Islamia College, Peshawar.

2.3. Data analysis

The medicinal flora was divided into different groups based on habit, part use, and method of remedy preparation. Frequency of citation (FC), relative frequency of citation (RFC), and family importance values (FIV) were calculated following Ullah et al. (2020). Frequency of citation was recorded as: FC = No. of informants who reported the medicinal uses. The following Formula 1 was used for the calculation of relative frequency of citation.

$$RFC = \frac{\ddot{u}}{N}\left(0 < RFC < 1\right) \quad (1)$$

where FC = Number of informants who mentioned the uses of plant species; N = Total number of informants. RFC value must be less than one and greater than zero.

Family importance value was calculated as Formula 2:

$$FIV = \frac{FC\left(Family\right)}{N} \times 100 \quad (2)$$

where FC = frequency of citation of the family; and N = Total number of informants.

The plant species were assisted for their conservation status as per IUCN standard criteria. The conservation status of medicinal plants was enumerated according to their parts used, their life cycles, and their demand in the local and international market.

3. Results and Discussion

3.1. Taxonomic diversity of medicinal flora

The traditional uses of plant species for medicinal purposes are often a gender-based profession performed by both men and women and passed from generation to generation with time. However, the knowledge of parts used and the preparation of recopies depend upon the long-term experience of the expert people. Illiterate and old age persons are more knowledgeable about the use of medicinal plants as compared to male, literate and young persons. The indigenous people of Sultan Khail valley use 88 plant species includes pteridophytes (02 species), gymnosperms (5) and angiosperms (81) belonging to 57 families and 77 genera for the treatment of different human diseases. Lamiaceae was the dominant family followed by Rosaceae and Polygonaceae, while the remaining families contributed a lower number of species (Figure 2; Table 1). The dominance of these families may be due to their wide range of distribution (Hussain et al., 2018), large number of species (Gras et al., 2020), and high traditional values (Gonfa et al., 2020).

3.2. Growth form of medicinal flora used to treat human ailments

The inhabitants of the valley mostly used herbs (56%) followed by trees (24%) and shrubs (20%) to treat different human diseases (Figure 3). The reason for the wide usage percentage of herbs for medicinal purposes is their high level of abundance; easy to access, collect, and prepare easily for herbal medicine; and the existence of maximum pharmacologically active constituents. The present findings are in line with Akhtar (2015), who reported similar results from Miandam (Swat), Gonfa et al. (2020) Ethiopia, Shinwari et al. (2017), and Hazrat et al. (2011) from Kohistan valley (Dir).

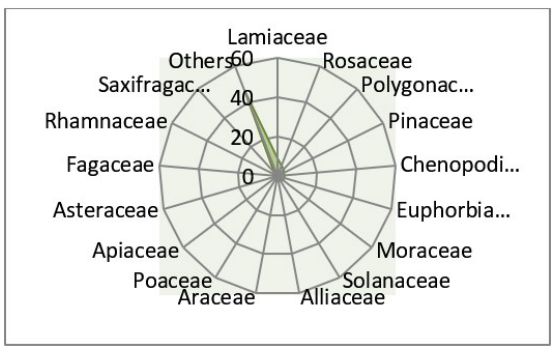

Figure 2. Taxonomic diversity of medicinal flora.

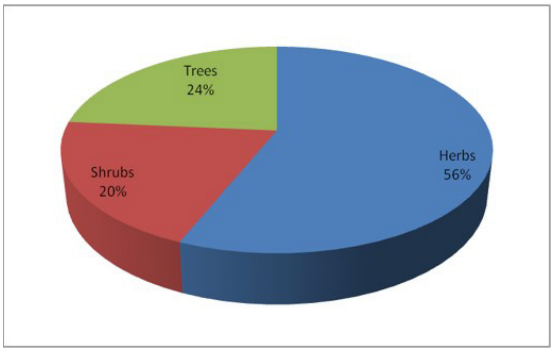

Figure 3. Growth form of medicinal plants.

Table 1. Medicinal plants species, local names, uses, FC, RFC and FIV and Conservation status of Sultan Khail valley, Dir Upper, Pakistan.

S. no	Taxon	Local name	Habit	Part use	Mode of remedies preparation	FC	RFC	FIV	Uses	Conservation status
					I. Pteriddophytes					
1				Adiantaceae				7.9		
	Adiantum capillus-veneris L.	Sumbal	H	Whole plant	Juice	11	0.08		Juice is use for constipation, pneumonia, and scorpion bites.	R
2				Equisetaceae				24.3		
	Equisetum arvense L.	Bndaky	H	Whole plant	Juice	34	0.24		Juice extract is used to treat kidney stones.	V
					II. Gymnosperm					
3				Cupressaceous				6.4		
	Cupressus sempervirens L.	Sarwa	T	Cone	Powder	9	0.06		The fruit is powdered, soaked in water and used as an anthelmintic and astringent.	V
4				Pinaceae				55		
	Pinus wallichiana A.B. Jackson.	Ghwargi	T	Resin	Crude form	29	0.21		The resin is mixed with butter and eaten before meals and is used in the treatment of facial acne, warts, and the expulsion of worms.	V
	Abies pindrow Royle.	Achar	T	Resin	Crude form	22	0.16		The resin is mixed with butter to treat warts and facial acne.	R
	Cedrus deodara (Roxb. Ex. D. Don) G. Don	deyar	T	Resin, oils	Crude form	26	0.19		Resin is mixed with yoghurt and used as an anthelmentic. Oil in a small amount is taken in water and used as a refrigerant, antiseptic, and antipyretic.	V
5	Taxaceae							13.6		
	Taxus wallichiana Zucc.	Belanzai	T	leaves	Decoction	19	0.14		Leaves are boiled in water and used in hysteria and epilepsy.	V
					III. Angiosperm					
					i. Monocotyledonae					
6				Alliaceae				55.7		
	Allium cepa L.	Piyaz	H	leaves, bulb	Juice, Crude form	35	0.25		The bulb is used as an antiseptic. The leaves are diuretic and anthelmintic.	V
	Allium sativum L.	Oga	H	Leaves, bulb	Crude form, decoction	43	0.31		The bulb is eaten with bread to treat high blood pressure, heart diseases, and cough. The juice from the leaves and the bulb are also used as an approdiasic.	V
7				Amaryllidacae				11.4		
	Narcissus tazetta L.	Gulingas	H	Flowers	Juice	16	0.11		The juice of the flowers is antiallergic, purgative, and emetic.	R

Note: H = Herb; S = Shrub; T = Tree; C = Climber; V = Vulnerable; I = Infrequent; R = Rare; E = Endangered.

Table 1. Continued...

S. no	Taxon	Local name	Habit	Part use	Mode of remedies preparation	FC	RFC	FIV	Uses	Conservation status
8	Araceae							25		
	Arisaema flavum (Forssk.) Schott	Marjarai	H	Rhizome, fruit	Juice	18	0.13		The juice of fresh rhizome is used against snake bite.	R
	Sauromatum venosum (Dryand. ex Aiton) Kunth	Marjaraibraga	H	Rhizome	Juice	17	0.12		The juice of fresh rhizome is used against snake bite.	V
9	Asparagaceae							15		
	Asparagus gracilis Royle	Halon	S	Whole plant	Decoction	21	0.15		Boiled in water and used as a diuretic and an aphrodisiac agent.	V
10	Liliaceae							20.7		
	Polygonatum verticillatum All.	Wormal	H	Rhizome	Crude form	29	0.21		The fresh rhizome is used to treat rheumatism and as an aphrodisiac.	V
11	Poaceae							15.7		
	Avena fatua L.	Jawdar	H	Seeds	Decoction	8	0.06		Boiled in water and used as an emollient, refrigerant, and diuretic.	R
	Cynodon dactylon (L.) Pers.	Kabal	H	Whole plant	Decoction, poultice	14	0.1		Boiled along with rose flowers and used in the treatment of jaundice and dysentery. A poultice is used to treat piles.	R
	ii. **Dicotyledonae**									
12	Anacardiaceae							20.7		
	Pistacia chinensis Bunge.	Sharna	T	Bark	Decoction	29	0.21		Bark is boiled in water and used for curing wounds, hepatitis, and loss of appetite.	V
13	Apiaceae							64.3		
	Coriandrum sativum L.	Dhanya	H	Leaves, fruits	Crude form, powder, decoction	46	0.33		Leaf decoction is used in colic, as well as used as a carminative, diuretic, tonic, stomachic, and as a digestive stimulant.	R
	Foeniculum vulgare Mill.	Kaga	H	Leaves, fruits	Crude form, powdere, juice	44	0.31		Leaves and fruits are boiled in water or powder is mixed with little sugar and used in gastrointestinal disorders, abdominal pain, as wormicides and as digestive stimulants.	R
14	Apocynacae							9.3		
	Nerium oleander L.	Ganderay	S	Roots, leaves, flower	Poultice	13	0.09		Boiled in water and used externally for skin diseases.	V
15	Asclepiadaceae							15		
	Calotropis procera (Willd.) R. Brown	Spalmy	S	Leaves, latex	Powder	21	0.15		Powder is mixed with butter and used to treat nausea, flu, and colds.	R

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Table 1. Continued...

S. no	Taxon	Local name	Habit	Part use	Mode of remedies preparation	FC	RFC	FIV	Uses	Conservation status
16	Asteraceae							32.1		
	Artemisia santolinifolia Turez ex Krasch	Tarkha	H	leaves	Juice	26	0.19		Used as a cooling agent and in worm expulsion in children.	R
	Calendula arvensis L.	Ziargulay	H	Leaves, flowers	Powder	19	0.14		The powder of flowers and leaves is used for the treatment of scrofula. It is also used as an anthelmintic and tonic.	I
17	Berberidaceae							44.3		
	Berberis lycium Royle	Kwaray	S	Root bark, leaves, fruits	Powder	62	0.44		Drank after being soaked in water to treat diabetes, wound healing, bone fracture, pain, and diarrhea	V
18	Brassicaceae							11.4		
	Nasturtium officinale R. Br.	Talmera	H	Whole plant	Decoction	16	0.11		Leaves are boiled in water and used as blood purifiers, diuretics, antiscorbics, and expectorants.	R
19	Buxaceae							33.6		
	Sarcococca saligna (Don) Muell.	Shenolay	S	leaves	Juice	47	0.34		Fresh juice is used to treat hepatitis and diabetes. Also lower cholesterol level.	R
20	Cannabaceae							18.6		
	Cannabis sativa L.	Bhang	H	leaves	Juice	26	0.19		The juice extract of the leaves is mixed with sugar and used as a refrigerant, sedative, pain reliever, and ulcer treatment.	I
21	Chenopodiaceae							63.6		
	Chenopodium album L.	Sarmai	H	Shoots	Decoction	17	0.12		The leaves are cooked and used for constipation and hepatitis.	I
	Chenopodium ambrosioides L.	Skhabotay	H	leaves	Decoction, juice	33	0.24		Decoction of leaves is used for the treatment of fever and germs.	I
	Chenopodium botrys L.	Kharawa	H	leaves	Juice, powder	39	0.28		Mixed with the mother's milk to control children's constipation. It is also used as an anthelmintic. The dried form of leaves is used to cure dysentery, odema, diarrhea, and hepatitis.	I
22	Euphorbiaceae							35		
	Euphorbia helioscopia L.	Mandano	H	Latex, leaves	Powder	19	0.14		The powder is taken with water to treat intestinal problems and constipation. Milky latex is roasted with an additive and applied to the skin to treat skin eruptions.	I
	Andrachne cordifolia (Wall.exDcne.) Muell. Avg.	Klachay	S	Leaves	Decoction	12	0.09		Boiled in water and used to treat diabetes.	I
	Ricinus communis L.	Arhanda	S	Roots, leaves, seed	Decoction, poultice	18	0.13		The decoction of leaves is poisonous, emetic, and purgative. The poultice leaves are applied to swellings. The seeds are sedative. Roots are useful for constipation and rheumatism.	V

Note: H = Herb; S = Shrub; T = Tree; C = Climber; V = Vulnerable; I = Infrequent; R = Rare; E = Endangered.

Table 1. Continued...

S. no	Taxon	Local name	Habit	Part use	Mode of remedies preparation	FC	RFC	FIV	Uses	Conservation status
23			Fagaceae					50		
	Quercus baloot Griffth.	Seri	T	Fruits	Powder	39	0.28		When combined with honey, the powder is used to treat joint pain and urinary tract infections.	V
	Quercus incana Roxb.	Banj	T	Bark	Powder	31	0.22		Powder is mixed with honey and used for bone fractures and urinary disorders.	V
24			Fumaraceae					22.9		
	Fumaria indica (Hausskn.) H.N.	Papra	H	Whole plant	Decoction, juice	32	0.23		The juice or decoction has antipyretic, blood purifying, diaphoretic, and refrigerant properties. Also used to treat whooping cough, sore throat, and malaria.	V
25			Geraniaceae					47.1		
	Geranium wallichianum D. Don. Ex Sweet	Sra Zeela	H	Rhizome	Powder	66	0.47		Rhizome's powder is mixed with wheat flour, sugar, and desi ghee and cooked to make halwa. It is an efficient astringent, used for chronic dysentery, diarrhea, passive hemorrhages, backaches, and leucorrhoea.	V
26			Hypericaceae					35		
	Hypericum perforatum L.	Shin Chai	H	Whole plant	Decoction	49	0.35		Decoction is used for diarrhea, gastric disorders, and irregular menstruation.	R
27			Juglandaceae					12.9		
	Juglans regia L.	Ghuz	T	Bark	Decoction	18	0.13		Decoction is used for wound healing.	V
28			Lamiaceae					231.4		
	Ajuga bracteosa Wall. Ex Benth.	Gooti	H	Whole plant	Juice	54	0.39		Fresh plant juice is used to treat jaundice, hypertension, and sore throat.	R
	Mentha arvensis L.	Podina	H	Whole plant	Juice, powder	44	0.31		Powder or juice of the whole plant is mixed with curd and used to treat indigestion, vomiting, and abdominal pain.	R
	Mentha longifolia (L.) Huds.	welanay	H	leaves	Powder, juice	52	0.37		Powder is soaked in water or mixed with sugar and used as a carminative. It is also used to treat indigestion, vomiting and cholera.	R
	Micromeria biflora Benth.	Naraybotay	H	Whole plant	Juice	29	0.21		Juice from fresh plants is used to treat stomach disorders.	R
	Origanum vulgare L.	Da Ghar Zankai	H	Whole plant	Decoction, crude form	17	0.12		Decoction is diuretic and is also used to treat toothaches and earaches.	R
	Salvia moorcroftiana Wall. ex Bth.	Kharghoag	H	leaves	Poultice	37	0.26		Leaf poultice is used for wound healing.	I
	Teucrium stocksianum Boiss.	Sperbotay	H	Whole plant	Juice	45	0.32		Juice from fresh plants is taken before meals for weight loss. It is also used to treat diabetes and stomach disorders.	V
	Thymus linearis Bth. Ssp. Linearis Jalas	Da ghar sperkai	H	whole plant	Decoction	46	0.33		The decoction is used to treat hepatitis, diabetes, colds, coughs, bronchial troubles, and to lower cholesterol.	V

Note: H = Herb; S = Shrub; T = Tree; C = Climber; V = Vulnerable; I = Infrequent; R = Rare; E = Endangered.

Table 1. Continued...

S. no	Taxon	Local name	Habit	Part use	Mode of remedies preparation	FC	RFC	FIV	Uses	Conservation status
29	Malvaceae							5.7		
	Abelmoschus esculentus (L.) Moench.	Bendi	H	Fruite, mucilage	Juice	8	0.06		The juice of fruit and mucilage is used to treat joint pains.	R
30	Meliaceae							30		
	Melia azedarach L.	Watani Shandai	T	Leaves	Decoction	42	0.3		The leaves' decoction is antidiabetic, a blood purifier and a wormifuge.	R
31	Moraceae							45		
	Ficus palmata Forssk.	Inzar	T	Fruits	Crude form	24	0.17		Fruit is mixed with milk and used for the removal of wort. It is also used to treat stomach disorders and constipation.	V
	Morus alba L.	Spin toot	T	Fruits	Crude form	17	0.12		Fresh fruit is used to treat constipation and improve digestion.	V
	Morus nigra L.	Toor toot	T	Fruit	Crude form	22	0.16		Fresh fruit is used as laxative, cooling agent and also used to treat cough.	V
32	Myrsinaceae							37.1		
	Myrsine africana L.	Manogaya	S	Leaves, fruits	Juice, powder	52	0.37		Fresh leaves and fruit juice or powder are soaked in water and used as an anthelmintic.	R
33	Myrtaceae							30.7		
	Myrtus communis L.	Manno	S	Leaves, seeds	Decoction	43	0.31		The leaves are boiled in water along with ghur and used to treat diarrhoea and stomach pain.	V
34	Nyctaginaceae							7.1		
	Mirabilis jalapa L	Mazigargulay	H	Roots	Decoction, juice, powder	10	0.07		The decoction, juice, and powder are used as purgatives, emetic, and cathartics.	V
35	Oleaceae							37.9		
	Olea ferruginea Royle.	Khona	T	Leaves, fruits	Juice	53	0.38		Fruit juice is used in diabetes. The leaves are used to treat sore throats and toothaches.	V
36	Oxalidaceae							20		
	Oxalis corniculata L.	Garday Taruky	H	Whole plant	Juice	28	0.2		Juice from fresh plants is used to treat stomach disorders and skin inflammation.	R
37	Fabaceae							20.7		
	Indigofera heterantha Wall. ex Brand.	Ghoraja	S	Roots bark, leaves, flowers	Decoction, powder, juice	29	0.21		Decoction, powder, or juice are used to treat abdominal pain.	V
38	Platanaceae							9.3		
	Platanus orientalis L.	Chinar	T	Bark	Decoction	13	0.09		Decoction of bark is mixed with vinegar and used to treat diarrhea, dysentery, rheumatism, and toothaches.	E

Note: H = Herb; S = Shrub; T = Tree; C = Climber; V = Vulnerable; I = Infrequent; R = Rare; E = Endangered.

Table 1. Continued...

S. no	Taxon	Local name	Habit	Part use	Mode of remedies preparation	FC	RFC	FIV	Uses	Conservation status
39	Polygonaceae							72.9		
	Rumex dentatus L.	Shalkhay	H	Leaves	Decoction	41	0.29		Leaves are boiled in water and used for skin rashes and wound healing.	I
	Rumex hastatus D.Don	Tarokai	H	Leaves	Juice	26	0.19		Juice from fresh plants is used as a purgative. It is also used to treat skin diseases and arthritis.	I
	Bistorta amplexicaulis (D. Don) Green	Spenshalkhay	H	Leaves, shoots	Decoction	22	0.16		The decoction of leaves and shoots is used to treat ulcers. It is also used as a carminative and tonic.	I
	Polygonum barbatum L.	Palpoluk.	H	Leaves	Decoction	13	0.09		Leaves are boiled in water and used for skin diseases.	R
40	Primulaceae							8.6		
	Primula denticulata Wight.	Chautargulay	H	Leaves, Rhizome	Decoction, powder	12	0.09		Rhizome powder is mixed with honey and vinegar and is applied for leucoderma, bacterial and ophthalmic diseases.	V
41	Punicaceae							27.1		
	Punica grantaum L.	Anunghoray	T	Leaves, bark, fruits	Powder, crude form	38	0.27		Fresh leaves are crushed and the extract is used for dysentery and checking for bleeding from the nose. Fruit is an astringent, laxative, cooling agent, and blood purifier. The bark of stems and roots is anthelmintic and antipyretic.	E
42	Ranunculaceae							40.7		
	Aconitum heterophyllum Wall. Ex Royle	Sarbawali	H	Rhizome, flower	Decoction, powder	57	0.41		Decoction or powder of rhizome along with mutton is given to weak children to enhance their growth and physique.	E
43	Rhamnaceae							35.7		
	Ziziphus nummularia (Burm. f.) Wight &Arn.	Badra	S	Leaves, fruit	Decoction, juice, poultice	25	0.18		Leaves and fruits are boiled in water and used to treat ulcers and skin infections; the fruit is edible, astringent, and a cooling agent.	V
	Ziziphus mauritiana Lam.	Markha	T	Leaves, fruits	Decoction, juice	25	0.18		Fruits are boiled in water and used as a blood purifier and a carminative. Leaves' juice is used to make a plaster in strangury.	V

Note: H = Herb; S = Shrub; T = Tree; C = Climber; V = Vulnerable; I = Infrequent; R = Rare; E = Endangered.

Table 1. Continued...

S. no	Taxon	Local name	Habit	Part use	Mode of remedies preparation	FC	RFC	FIV	Uses	Conservation status
44	Rosaceae							70.7		
	Duchesnea indica (Andr.) Focke	Gongrus	H	Leaves, fruit	Crude form, juice	24	0.17		Leaves and fruits are diuretic, astringent, and refrigerant. The leaves' extracts are used to treat coughs and sore throats.	R
	Rosa webbiana Wall. ex Royle	Zangaligulab	S	Leaves, flowers	Decoction	16	0.11		Leaves are boiled in water and used as memory stimulants, antispasmodics, and to improve digestion. Flowers are boiled and applied to treat foul ulcers and wounds.	R
	Rubusfruticosus L.	Karwara	S	Fruits	Crude form	21	0.15		Fresh fruits are used as a cooling agent.	R
	Rubus ulmifolius Schott	Karwara	S	Leaves, fruits	Powder, decoction	14	0.1		Fresh leaves are boiled and used as blood purifiers and refrigerants. It is also used to treat dysentery and diarrhea.	R
	Prunus persica L. Batsch.	Shaltalo	T	Leaves, fruits	Powder, juice	24	0.17		The powder is mixed with honey and used to treat stomach and liver disorders. Fresh fruits and a decoction of leaves are used to treat diabetes.	V
45	Rutaceae							33.6		
	Zanthoxylum armatum DC.	Dambara	T	Fruits, seeds	Crude form, powder	47	0.34		Fruits and seeds are powdered and used as cooling agents, as carminatives, stimulants, and antidiuretics.	V
46	Salicaceae							9.3		
	Salix denticulata var. hazarica (R. Parker) Ali	Betawla	S	Bark	Decoction	13	0.09		Decoction of bark is used as a febrifuge, astringent, and anthelmintic. Also used to treat fever.	E
47	Sapindaceae							7.9		
	Dodonaea viscosa (L.) Jacq.	Ghuraski	S	Leaves	Poultice	11	0.08		Warm leaves are kept on the wound to relive pain.	R
48	Saxifragaceae							28.6		
	Bergenia ciliata (Haw.) Sternb.	Kakolpanra	H	Rhizome	Decoction	23	0.16		Rhizome is boiled in water and used to treat urinary disorders, stopping bleeding from wounds and dissolving kidney stones.	R
	Bergenia stracheyi (H. & T.) Engl.	Kakolpanra	H	Rhizome	Powder	17	0.12		Rhizome is powdered, mixed with milk and used for the treatment of kidney stones and diabetes. It is also a refrigerant.	R
49	Simaroubaceae							12.9		
	Ailanthus altissima (Mill.) Swingle	Shandai	T	Leaves, flower	Juice	18	0.13		Bark juice is mixed with milk to treat dysentery and diarrhea.	V

Note: H = Herb; S = Shrub; T = Tree; C = Climber; V = Vulnerable; I = Infrequent; R = Rare; E = Endangered.

Table 1. Continued...

S. no	Taxon	Local name	Habit	Part use	Mode of remedies preparation	FC	RFC	FIV	Uses	Conservation status
50	Solanaceae							38.6		
	Solanum nigrum L.	Kachmachu	H	Leaves, fruits	Juice, poultice	21	0.15		Used to treat diarrhea, eye-troubles, and fever. The ripe fruits are used in piles.	R
	Solanum surattense Burm. f.	Maraghonay	H	Whole plant	Decoction, powder	33	0.24		Dried fruit powder is taken with water to treat diabetes. Leaves are boiled in water and taken before meals to treat kidney stones. Decoction of the whole plant is used as an expectorant, diuretic, anti-asthmatic, and carminative.	V
51	Thymelaeaceae							12.9		
	Daphne mucronata Royle	Leghunai	S	Whole plant	Decoction	18	0.13		Roots are crushed, boiled and used to treat abdominal pain, swellings, wounds, and gastrointestinal irritation.	V
52	Trilliaceae							38.6		
	Trillium govanianum Wall. ex Royle.	Matarjarai	H	Rhizome	Powder	54	0.39		The powder is mixed with wheat flour, sugar, and cooked in desi ghee to make halwa and is used to treat menstrual disorders, infertility, and improve aphrodisiac properties.	E
53	Ulmaceae							9.3		
	Celtis caucasica Willd.	Taghaga	T	Bark	Decoction	13	0.09		Boiled in water and used as a cooling agent.	V
54	Valerianaceae							35		
	Valeriana jatamansi Jones.	Mashkibhala	H	Rhizome	Powder, decoction	49	0.35		The powder of rhizome is mixed with a little sugar and used as a carminative and antispasmodic, while the decoction is used to treat dysentery and cholera.	V
55	Verbenaceae							7.1		
	Verbena officinalis L.	Shomakai	H	Whole plant	Decoction	10	0.07		Boiled in water with sugar and used before meals to treat fever.	R
56	Violaceae							42.9		
	Viola canescens Wall. Ex Roxber	Toorapanra	H	Whole plant	Decoction	60	0.43		Boiled in water or taken with tea to treat fever, cough, asthma and coolness of the body.	I
57	Vitaceae							26.4		
	Vitis vinifera L.	Kwar	C	Whole plant	Poultice, decoction	37	0.26		The leaves are used to treat mouth sores. Roots are boiled in water and used to induce milk secretion in nursing mothers. The fruits are diuretic, tonic. Also used to treat smallpox.	V

Note: H = Herb; S = Shrub; T = Tree; C = Climber; V = Vulnerable; I = Infrequent; R = Rare; E = Endangered.

3.3. Plant parts used in the preparation of ethnomedicine

Inhabitants of the valley mostly used leaves (33.1%) for the preparation of ethno medicine, followed by fruits (16.1%) and whole plants (15.3%) (Figure 4). The reason may be easy collection, and the presence of a maximum quantity of bioactive secondary metabolites. They are the primary organs for photosynthetic activities and act as fluid storage sites, which not only protect plants from hazards but also provide therapeutic benefits for people. Different researchers worked on the ethnomedicinal flora and reported the use of leaves (Hazrat et al., 2011; Hussain et al., 2019; Sulaiman et al., 2020), fruits (Hussain et al., 2018) and whole plants (Hazrat et al., 2015) as a major and commonly used plant part for the preparation of ethnomedicine.

3.4. Preparation of ethnomedicine

The main method of preparation of remedies was decoction followed by juice, powder, crude form, and poultice (Figure 5). The use of decoction as a common mode for the preparation of ethnomedicine might be due to the ability to obtain more chemical constituents for fruitful results. Our findings are in line with Hussain et al. (2018, 2019), Sulaiman et al. (2020) and Akhtar (2015).

3.5. Relative frequency of citation (RFC)

Relative frequency of citation represents the rank and local importance of each species based on informants who mentioned the uses of these plant species. The highest RFC value was recorded for *Geranium wallichianum*, *Berberis lycium*, *Viola canescens*, *Aconitum heterophyllum*, *Ajuga bracteosa*, *Trillium govanianum*, and *Olea ferruginea* (Table 1). Shinwari et al. (2017) conducted a similar study in the northern areas of Pakistan and observed a high RFC value for *Berberis lycium*, while Hussain et al. (2019) reported the highest RFC value for *Valeriana jatamansi* and *Ajuga bracteosa* in the Bahrain valley. Rhizome of *Geranium wallichianum* is used to treat rheumatism and as an aphrodisiac. The decoction of *Berberis lycium* is used in diabetes, diarrhea, pain, wound healing, and bone fracture; *Viola canescens* (whole plant) is boiled in water or taken with tea to treat cough, fever, and asthma. The decoction of *Viola canescens* is also used as a refrigerant. *Aconitum heterophyllum* is given to weak children to enhance their growth and physique. *Ajuga bracteosa* is used to treat sore throats, jaundice, and hypertension. *Trillium govanianum* is used for the treatment of menstrual disorders, infertility, dysentery, and wound healing. *Myrsine africana* is anthelmintic, while *Olea ferruginea* is used for diabetes, toothaches, and sore throats. *Mentha longifolia* is used to treat indigestion, vomiting, cholera, carminatives, and anticolic. The current findings are consistent with previous national (Bano et al., 2013; Kayani et al., 2015; Ali et al., 2018; Hussain et al., 2019; Sulaiman et al., 2020) and international (Faruque et al., 2018; Islam et al., 2020) research. The plants with the highest RFC could indicate that they have good healing potential for specific diseases and help to identify species for which appropriate conservation and sustainable utilization strategies should be formulated to ensure a regular supply of raw materials for the future. The present findings are in line with the studies conducted by Sulaiman et al. (2020), Hassan et al. (2017) and Hussain et al. (2018), with some differences in RFC and ethnomedicinal importance, which may be due to the distance among the areas, environmental factors, method used, loss of ethnobotanical knowledge, and minimal cultural exchange among the areas and countries.

3.6. Family importance value

Family importance value (FIV) determines the ethnomedicinal significance of medicinally important plant families. Based on FIV, Lamiaceae was observed to be the richest family, followed by Polygonaceae (Figure 6). Sulaiman et al. (2020) also observed the highest FIV for the family Lamiaceae in Gokand. However, the present findings are strongly supported by Ahmad et al. (2014), who reported Lamiaceae and Polygonaceae as the best represented families in terms of FIV from the Chail valley (Swat).

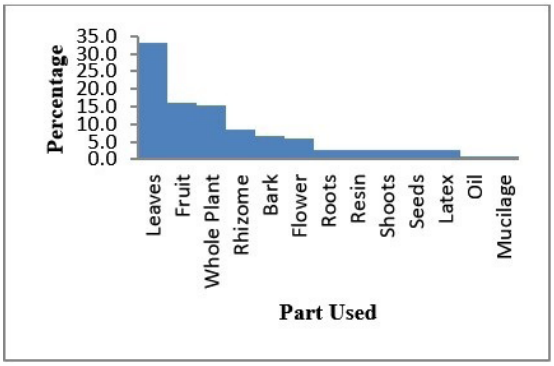

Figure 4. Classification of species by parts used.

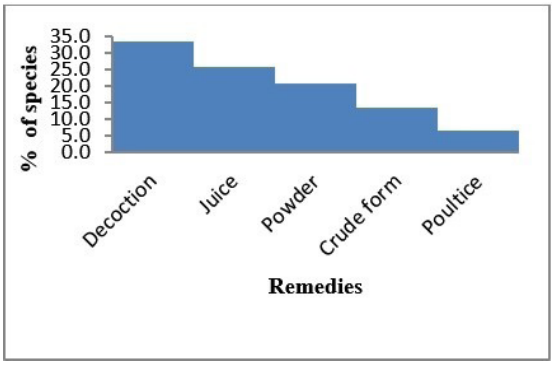

Figure 5. Different methods of remedies formulation.

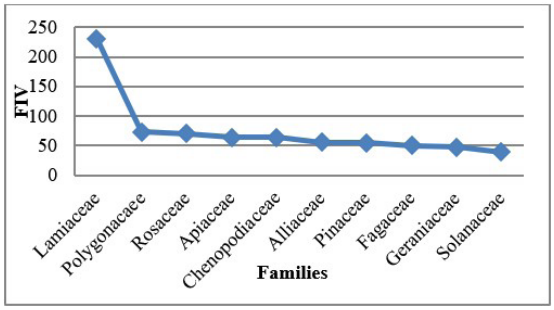

Figure 6. FIV of top ten medicinal plants families.

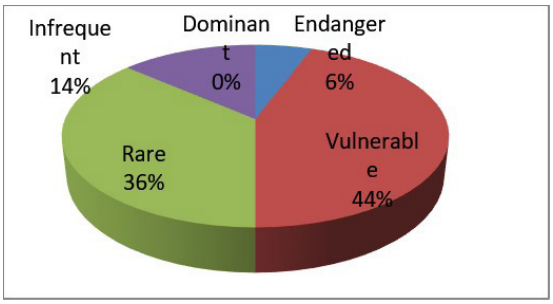

Figure 7. Conservation status of medicinal plants of Sultan Khail valley.

3.7. Conservation status of medicinal flora

Medicinal plants are in grave danger of extinction in those areas of the world where people rely on them for health treatment and revenue from wild collection (Ture and Bocuk, 2010). In the present study, the conservation status of 88 medicinal species growing in Sultan Khail valley, Dir Upper, Pakistan was determined following IUCN criteria for conservation (IUCN, 2001). The medicinal flora was comprised of five endangered (*Platanus orientalis*, *Punica grantaum*, *Aconitum heterophyllum*, *Salix denticulata var. hazarica,* and *Trillium govanianum*), 39 vulnerable, 32 rare, and 12 infrequent species, while no species fulfilled the IUCN criteria of dominant species (Table 1;Figure 7). The present finding reveals that the overall medicinal flora of Sultan Khail valley is threatened due to various factors and needs proper conservation. The major threats to the medicinal flora of the Sultan Khail valley are over collection, trade and high market prices, fuels, and timber wood demands. The inhabitants of the area not only use the medicinal flora for their own medicinal needs but also sell it in the local market to earn money. The poor villagers of the area collect the rhizomes of *Aconitum heterophyllum*, *Trillium govanianum*, *Geranium wallichianum*, *Valeriana jatamansi*, *Polygonatum verticillatum*, etc. on a daily basis from spring to autumn and sell them in the local market. Besides their medicinal needs, the inhabitants also cut the trees and shrubby plant species mostly for timber wood and fuel purposes, due to which the population of these medicinal plant species decreases day by day. Besides the above threats, deforestation (Ahmed et al., 2011), severe grazing pressure (Haq, 2011), habitat fragmentation (Corlett, 2016), high market prices (Jan et al., 2014) and unscientific methods of collection are the major causes for the extinction of these valuable plant species. The present findings are in line with Akhtar (2015), and Sultan-Ud-Din et al. (2016), who reported similar threats.

4. Conclusion and Recommendations

Medicinal flora of the area is under severing biotic pressure and need proper conservation otherwise they will be loss in the near future. There is a need to adopt both ex situ and in situ conservation methods for already endangered and threatened flora of the area. Both the government and non-government organizations should provide relief to the local inhabitants to cultivate and conserve the medicinal flora. Awareness should be created among the local people about the importance of vegetations and medicinal plants species to reduce the pressure of grazing animals, cutting of plants species and unsustainable collection of medicinal plants. Detailed socioeconomic data on local people should be collected, and actions should be taken to improve their living conditions to utilize plants sensibly. Long-term planning is required to ensure and increase the area's overall sustainable biological production, including the restoration of damaged habitats by the introduction of fast-growing plants species.

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