A review of current trends and future directions in the medical ethnobotany of Gilgit-Baltistan (Northern Pakistan)

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Ethnobotany Research and Applications 24:18 (2022)

Review

Abstract

Background: Ethnobotanical studies play an important role in understanding the plant diversity, bio-cultural variability, utilization of plant-based resources, drug discovery and conservation efforts. The current paper reviews and assesses the ethnobotanical literature and documented medicinal plants of the region of Gilgit-Baltistan, Northern Pakistan.

Methods: Relevant literature was searched using electronic scholarly databases Google Scholar, Google, Scopus, Sciences Direct, PubMed, Medline and Web of Science internet websites were extensively browsed using different 24 terms as key words. A total of twenty-four (24) academic journal articles published from 2002 – 2020 were reviewed.

Results: Geographically, 54% articles were from Karakorum Range, 75% form Gilgit sub region and 25% Gilgit district. Ethnic-wise 58% of the studies were conducted on Shinas, 25% on Baltis and 12.5% on Brushiski while Wakhi and Khwar were least explored. For data collection interview methods were solely used. A total of 413 plant species were used for 3160 remedies in 224 genera and 79 families from both wild (83%) and cultivated sources (16%). Asteraceae, Rosaceae and Fabaceae were the most used plant families with 58, 36 and 32 species respectively. *Artemisia* was the leading genus with 11 species followed by *Prunus* (9 species). *Salix*, *Saussurea*, *Potentilla*, *Astragalus* and *Allium* contributed seven (7) species each. Regarding habit herbaceous species were most commonly used (310 species, 75%) and shrubs and trees showed comparatively less contribution with 53 (12%) and 49 (11%) species. Article quotation of the recorded species indicated that, *Hippophae rhamnoides* and *Thymus linearis* were the most important medicinal species with highest AQ values (number of reports)17 i.e. reported by 70% of the articles. These recorded species were used to treat 353 disease types for different human body systems.

Conclusion: The region of GB is still poorly investigated ethnobotanically, and limited literature found on this subject. However, the diverse medicinal flora of Gilgit-Baltistan validated the regional potential of phytomedicines despite scarce research efforts. GB territory possesses three national parks and current study may be fruitful to develop strategies for regional biodiversity conservation and natural resource management.

Keywords: Indigenous knowledge, medicinal plants, mountain ecosystem, natural resources

Manuscript received: 22/06/2022 – Revised manuscript received: 01/10/2022 - Published: 12/10/2022
http://dx.doi.org/10.32859/era.24.18.1-16

Background

Rapid unsustainable utilization of natural resources is deteriorating the ecosystem integrity and depleting direct and indirect services (Gandhi, 2015; Sandifer *et al.*, 2015; Worm *et al.*, 2006). The global burgeoning human population, climate change, and rampant development have imperiled much of the world's biodiversity and related services (Díaz *et al.*, 2006; Luck *et al.*, 2003). Plant-based medicine has long been one of the most used, and focused natural resources (Jain, 1968; Lambert *et al.*, 1997; Máthé, 2015). Traditional medicine (TM) obtained from biological diversity (plants, animals, fungi, algae and lichens) is used by 80% of the population of countries with limited health facilities (WHO, 2003). To date, it is estimated that the global flora contains 350000 – 400000 plant species (Joppa *et al.*, 2011; Paton *et al.*, 2008), and 10% (35000 species) of those possess medicinal properties (Prance *et al.*, 1987; Sher *et al.*, 2016). Pakistan harbors a multicultural society using a great number of medicinal plants (Athar and Bokhari, 2006). The Flora of Pakistan includes 6000 plant species so far (Ali, 2008), more than 10% (>600 species) of them possess therapeutic potential and are generally confined to the country's northern mountainous terrains (Shinwari, 2010b). The region of Gilgit-Baltistan (GB) is recognized as a virtual sanctuary of medicinal plants (Abbas *et al.*, 2016) and is also an intriguing place because of its incredible topography, ancient history, multicultural society, and ethnology (Aziz *et al.*, 2020). The term 'medicinal plant' refers to a plant with healing properties, and the field of ethnobotany deals the study of plant-people interactions including medicinal plants. The ethnobotanical literature has reached a tremendous scientific rigor in the past two decades (Hoffman and Gallaher, 2007). The annual worldwide ample literature, including books, research articles, conference papers, and reports mirrors the growing interest in medicinal plant research. In Pakistan, the subject of ethnobotany gained attention quite recently and is still in its exploratory phase, and even the floristic diversity of some areas has yet to be documented (Ali, 2008, Abbas *et al.*, 2021). There are various areas yet to be surveyed particularly the mountain communities of the Himalayas, the Karakorum and the Hindu Kush. In GB, substantial ethnobotanical studies exist in wide-ranging geographic locations, ethnicity, languages, methodology, and medicinal flora. However, a review of the existing scattered literature is missing. The academic literature associated with regional ethnobotany of Gilgit-Baltistan may be analyzed for who conducted the research, research locality, publishing source, targeted ethnic groups/languages, methods used for data collection (interview, group discussion, free listing), ethnobotanical research approaches (descriptive, quantitative or comparative), aspects focused (medicine, fodder, timber, handicraft, wild edible food, ethno-veterinary, etc.), what has found (outcomes), and the research gaps. The paper offers a quantitative review of ethnobotanical literature focusing medicinal plants (used for human health disorders) conducted in the region of Gilgit-Baltistan.

This paper articulates the review of the current available ethnobotanical literature and the reported medicinal plants of the Gilgit-Baltistan region, Northern Pakistan. It attempts to address seven research questions: (1) how many ethnobotanical studies have been conducted so far reporting medicinal plants? (2) Journal in which they have been published. (3) what is the ethnobotanical research type and where the research has been carried out? (4) what methods have been used and which ethnic group/language has been targeted? ? (5) how many species have been recorded? (6) what is the plants' habit, diseases (s) treated, quoted times (documented in paper)? (7) what are important research gaps?

Materials and Methods

Study site

Gilgit-Baltistan (GB) is a sparsely populated area in the far North of Pakistan and borders with Azad Kashmir to the south, the province of Khyber Pakhtunkhwa to the west, the Wakhan Corridor of Afghanistan to the north, the Xinjiang region of the Republic of China to the east and northeast, and the Indian-administered state of Jammu and Kashmir to the southeast covering an area of 72496 km² (Khan *et al.*, 2013a) (Fig. 1). Administratively, it is the union of two sub-regions, Gilgit and Baltistan, with the capital cities Gilgit and Skardu respectively. It is further divided into ten districts i.e. Astore, Diamer, Ghanche, Ghizar, Gilgit, Hunza, Kharmang, Nagar, Shigar and Skardu. Gilgit city is the regional capital while Skardu is known as the largest city of the region. GB territories unevenly distributed in the lap of three giant mountain ranges of the Himalaya, the Karakorum and the Hindu Kush (Hunzai, 2013; Khan, 2012a).

Gilgit Baltistan is a diverse landmass in the context of geology, topography, climate, anthropology, history, ecology, archaeology and biological diversity. Regarding tectonics the Kohistan - Ladakh island arc and Karakoram plate are exposed in the region, with precious and base metals deposits (Ahmad *et al.*, 2016; Kreutzmann, 2006). GB includes the Deosai Plains (altitudinal range 3960-4420 m), Khunjerab Pass (4876 -5182 m) and Nanga Parbat Area (6096-8126m) and Rakaposhi peak (altitudinal range 7010-7121 m). It displays a plethora of landscapes such as glaciers, peaks, rivers, alluvial fans, sandy plains, undulating foothills, and rugged cold deserts sharing a considerable income

in country assets by its potential tourism. The region is the most glaciated tract outside the polar including famous Baltoro glacier (>63 km), Biafo glacier (67 km), Batura glacier (59 Km) Hispar Glacier (49 km), and Siachen glaciers (70km) (Kuhle, 2004; Seong *et al.*, 2007).

Figure 1. Map of the study area (Gilgit-Baltistan)

K2 (8611m), Nanga Parbat (8126), Gashebrum I (8080), Broad Peak (8047), Gashebrum II (8035), Skil Brum (7360), and Angel Peak (6858) are well-known peaks. The main water course of the country's extensive irrigation system, the river Indus flows from the alpine glaciers of Baltistan and collects ample water from various tributaries for instance Shyok, Shigar and Gilgit rivers. Among lakes, Attabad, Khalti, Phander, Rush, Nultar, Shangrilla, Foroq Xo, Sheosar, Sadpara, and Rama are well known. Climate is mainly dry and highly continental (Kreutzmann, 2005; Kuhle, 1990). The monsoon cloud does not reach the area and receives considerable rain in early spring and late summer (Abbas *et al.*, 2017b; Klimes, 2003). The region is home for about 1.8 million people distributed in main five linguistic groups of Balti, Brushishki, Khawar, Shina, Wakhi. They may further be divided in different ethnic pedigrees. The region is considered as reserve of fresh water, biological diversity, gemstones, and other mineral resources. The complex mountain system provides various goods, including water, aesthetic views, timber, medicine, fuel wood and tourism opportunities.

Flora

The region encompasses mainly a dry and rugged topography with wide-ranging altitudinal amplitudes. In the forest types of Pakistan the area is generally regarded as dry temperate zone (Champion *et al.*, 1965). The major forest trees are *Juniperus excelsa, Pinus Wallichiana, Pinus gerardiana* and *Betula utilis* accompanied by few shrubs like *Juniperus communis*, *Salix karnelii, Berberis* spp. *Ribes* spp. *Cotoneaster* spp. etc. The vegetation is sparse but diverse, and greatly changes along elevational gradients. However, it can be recognized in distinct altitudinal belts i.e. colline, sub montane, montane, sub alpine, alpine, sub nival and nival (Abbas *et al.*, 2017b; Dickoré and Nüsser, 2000). In the floristic regions of the world the territory is included in the eastern part of Irano-Turanian region (Ali and Qaiser, 1986; Takhtajan, 1986). The geographical distribution of the species shows close relationship with Central Asiatic and Western Himalayan elements (Abbas *et al.*, 2019a). Eco-physiologically, a large part of the flora shows xerophytic traits and is distributed throughout the region. Family Asteraceae is the largest family and the *Seriphidium brevifolium* is the most prevailed regional species. *Saussurea*, *Astragalus*, *Nepeta* and *Pedicularis* are some prominent genera of the region. Due to frequent droughts and the rocky physiography the area is mainly populated by herbaceous plants Abbas, 2018.

Data collection

A systematic quantitative literature review was performed employing a quantitative review technique (Petticrew, 2001; Roy *et al.*, 2012; Tariq *et al.*, 2018; Uttra *et al.*, 2018) (Table 1). Relevant literature was searched using electronic scholarly databases Google Scholar, Google, Scopus, Sciences Direct, PubMed, Medline and Web of Science internet websites were extensively browsed. The research papers investigating medicinal plants were searched by using 24 terms as key words i.e. *ethnobotany, traditional knowledge, traditional therapies, ethnobotanical surveys, medical anthropology, phytomedicines, phytoculture, biocultural diversity, folk medicine, ethnomedicinal studies, medicinal plants, medicinal trees, medicinal shrubs, and medicinal herbs*. All these terms were used individually as well as together with the name of all cities, town, valleys, sub-valleys and linguistic groups of Gilgit-Baltistan. The cited literature of gathered research papers was also looked up to find additional articles. A Microsoft Excel database of collected literature was generated based on 10 pieces of information from each research article; they were (1) author(s) (2) year of publication, (3) journal, (4) study area (city, town, valley, sub valley), (5) ethnic language/group (Balti, Brushishki, Khwar, Shina and Wakhi), (6) sub-region (Gilgit, Baltistan), (7) mountain ranges (the Himalaya, the Karakorum and the Hindu Kush), (8) methods have been used (9) ethnobotanical research approaches (10) number of plants documented, and (11) voucher specimens storage/deposit (12) comments; were used to develop inclusion criteria.

Similarly, another data base (inventory) of all documented medicinal plants in the research articles was developed on Microsoft Excel sheet by 11 items of information: (1) family (2) scientific name (3) vernacular name (4) habit (5) used part (s) (6) treated disease(s) and (7) total citation as AQ (article quotation=number of article in which the species 'X' is reported).

Keeping the limited ethnobotanical work in the region in mind, we conceived easy inclusion criteria in order to include more papers, to give a more holistic picture of ethnomedicinal study. However, only papers presenting the result of original research on medicinal plants used for human ailments in English language and published in peer reviewed journals were included. The name of specific study area within the region of Gilgit-Baltistan along with ethnic group/language were made mandatory for inclusion. The studies addressing natural resources including medicinal plants were also included. Articles dealing with medicinal plants used for veterinary therapies, wild edibles and non-medicinal ethnobotany were excluded. Reports, short communication, booklets and conference papers were also excluded. To generate a medicinal plant inventory, only those papers based on vouchers, or papers where the identification of the plant material was confirmed, and with complete information such as family name, scientific name, vernacular name, plant used part(s), and ailments(s) cured were included. The vernacular/folk name of medicinal taxa was given special weightage for inclusion in the list as the folk name of course is the first validation of medicinal plants of any ethnic group or community (Cotton, 1996; Singh, 2008).

The papers were filtered to discover the ethnobotanical uses for human health issues and again plants with worth as edible, veterinary, cultural, ritual and handicraft were not incorporated in the inventory. In order to evaluate the diseases treated, first of all reported remedies (described both in generally and specifically) were listed then refined for type of diseases such as bronchitis, pyrexia, pneumonia, and urethritis, etc. Disorders explained only in a general sense, e.g. – "used for *abdominal disorders*" (may include constipation, diarrhea, flatulence, etc.) were not counted for any health disorder.

The use of different synonyms for the same plant species is common in the ethnobotanical literature. In the review process, plants were found to be documented with different names such as Himalayan Thyme as *Thymus serpyllum* and *Thymus linearis*. Hence, the compiled data were checked and refined for nomenclature using The Plant List database (The Plant List 2013) and Angiosperm Phylogeny Group designations (Stevens, 2001). Flora of Pakistan, (http://www.efloras.org/flora_page.aspx?flora_id=5), and Flora of China (http://www.efloras.org/flora_page.aspx?flora_id=2) were mainly consulted for the habit and source of plant species. Furthermore, to assess the medicinal importance of the reported species in the region, article quotation (AQ) was calculated for all species supposing each article reporting a taxon as one quotation.

Table 1. The attributes of ethnomedicinal literature of Gilgit-Baltistan published from 2002-2020.

Author (s)	Year	Study area	Language	Sub-Region	Mountain Range (s)	Data collection	Ethnobotanical Research type	Total species	Included	Excluded	Voucher specimens
Gorsi *et al.*	2002	Khanabad	Shina	Gilgit	Himalaya	Interviews	Descriptive	126	118	8	Yes
Shaikh *et al.*	2002	Naltar	Shina	Gilgit	Karakorum	Structured interviews	Descriptive	153	4	149	Yes
Shinwari *et al.*	2003	Astore	Shina	Giligit	Himalaya	Structured interviews	Descriptive	33	31	2	Yes
Wazir *et al.*	2004	Gojal	Brushiski	Gilgit	Karakorum	Structured interviews	Descriptive	41	0	41	No
Qureshi *et al.*	2006	Gilgit city	Shina	Gilgit	Hindu Kush & Karakorum	Structured interviews	Descriptive	27	24	3	Yes
Khan *et al.*	2007	Haramosh & Bugrote	Shina	Gilgit	Karakorum	Structured interviews	Descriptive	48	46	3	Yes
Khan *et al.*	2008	Haramosh & Bugrote	Shina	Gilgit	Karakorum	Structured interviews	Descriptive	98	89	9	Yes
Hussain *et al.*	2011	CKNP (District Ganche Khaplu Area)	Balti	Baltistan	Karakorum	Structured interviews	Descriptive	47	47	0	Yes
Khan *et al.*	2011	Khunjerab	Brushiski	Gilgit	Karakorum	Semi structured interviews	Descriptive	43	42	1	Yes
Fahad *el al.*	2012	Naltar & Karga	Shina	Gilgit	Karakorum	Structured interviews	Descriptive	16	15	1	Yes
Hyder *et al.*	2013	Hunza & Nagar	Shina, Brushishki	Gilgit	Karakorum	Interviews	Descriptive	106	77	29	No
Khan *et al.*	2013	Shinaki	Brushiski	Gilgit	Karakorum	Semi structured interviews	Descriptive	38	38	0	Yes
Abbas *et al.*	2014	Haramosh	Shina	Gilgit	Karakorum	Interviews	Descriptive	83	78	5	Yes
Bano *et al.*	2014	Deosai (Skardu site)	Balti	Baltistan	Himalaya	Semi structured interviews	Quantitative	50	45	5	No
Bano *et al.*	2014	Skardu valley	Balti	Baltistan	Himalaya	Semi structured interviews	Quantitative	50	50	0	Yes
Khan *et al.*	2014	Turmic	Balti	Baltistan	Karakorum	Interviews	Descriptive	42	33	9	Yes
Noor *et al.*	2014	Astor	Shina	Gilgit	Himalaya	Interviews	Descriptive	26	22	4	Yes
Shedayi *et al.*	2014	Ghizer	Khwar	Gilgit	Hindu Kush	Semi structured interviews	Descriptive	34	34	0	Yes
Jabeen *et al.*	2015	Ghizer	Shina	Gilgit	Hindu Kush	Interviews	Descriptive	49	44	5	Yes
Abbas *et al.*	2016	Tormik valley	Balti	Baltistan	Karakorum	Semi structured interviews	Quantitative	26	26	0	No
Akhter et al.	2016	Gilgit	Shina	Gilgit	Hindu Kush & Karakorum	Interviews	Descriptive	51	0	51	Yes
Abbas *et al.*	2017	Shigar valley	Balti	Baltistan	Karakorum	Semi structured interviews	Quantitative	84	84	0	Yes
Khan *et al.*	2018	Deosai (Astore site)	Shina	Gilgit	Himalaya	Interviews	Quantitative	51	48	3	No
Wali *et al.*	2019	Fairy meadows	Shina	Gilgit	Himalaya	Semi structured interviews	Quantitative	90	82	8	Yes

Results

The attributes of available literature (authorships, disciplinary scope, methods, ethnobotanical research approach, geographic scope, ethnographic range) and medicinal flora (taxonomic diversity, habit and source, therapeutic range, article quotation) are presented.

Literature history, Journals' disciplinary scope and number of articles

The field of ethnobotany for the region of Gilgit-Baltistan is quite new. It seems the beginning of ethnobotanical research started just eighteen years ago and harbors short history of academic publication. The monographs of Sheikh *et al.* (2002) and Gorsi and Miraj (2002) give the impression of early publications in the ethnobotanical arena of the region. Wali *et al.* (2019) seems to be the last publication so far. Twenty-four journal articles were identified dealing with the medicinal plants of the Gilgit-Baltistan region, published in the period from 2002 to 2019. These articles were published in seventeen scientific journals spanning a range of scientific scope in the field of biological sciences, plants sciences, biodiversity, conservation, bio-resource management, ethnobiology, ecology, ethnomedicine and ethnobotany. Two fields specifically predominate - ethnobotany and botany with 33.33% of the research papers. The remaining 44% articles were published in other miscellaneous journals having varied scopes. The yearly base publication indicated that six articles were published in the year of 2014 while the average of the articles was calculated as 1.4 per year.

Authorships and articles' impacts

In the course of publication, approximately 76 authors contributed to the documentation of ethnomedicinal plants of the region. Among them 68 were from local scholars (from Pakistan) and 8 were by foreigners (one from Morocco, Italy, Georgia, China; and four from Saudi Arabia). Regarding the publication, thirteen papers (50%) were published in impact factor journals and 12 papers were in peer-reviewed non-impact scientific journals. The range of title articulation of the studies discovered that above 79% articles addressed the ethno-medicinal plants only and 21% include the floristic diversity, phytosociology and ecology along with ethnomedicines.

Geographic scope and ethnographic range

The geographical distribution of the articles was assessed at three levels – mountain ranges (the Himalayas, the Karakorum and the Hindu Kush), sub-region (Gilgit and Baltistan) and administrative district (Astor, Diamir, Gilgit, Kharmang, Shigar, Skardu, Ganche, Ghizir, Hunza, Nagar). The population of GB is found in the small towns, valleys, sub-valleys, and roadsides villages of the three incredible mountain ranges. Most of the studies were conducted in the territory of Karakorum ranges i.e. 13 (54%). Seven studies (29%) focused the valleys of the great Himalayan range, and the Hindu Kush received least ethnobotanical attention with two studies only. The study area of two studies falls in the lower reaches of both the Karakorum and the Hindu Kush range. In the sub-regional research context, Gilgit predominates with 18 studies (75%) while 6 studies (25 %) research was conducted in Baltistan. Administratively, the region extended in ten districts and the findings disclosed that Gilgit district lead with six publications, from Skardu (3), Hunza (3), Astor (2), Ghizer (2), Nagar (1) and Diamer (1). No single article has been published from Kharmang and Ganche districts yet. Most specifically, Haramosh valley (3), Deosai plateau (2), Tormik valley (2), and Naltar (2) appeared to be well explored. All studies were done on a single linguistic group each, and there were no comparative or cross-cultural studies among them. Regarding ethnicity/language over 58% ethnobotanical works were carried out among the Shina ethnic group, the most surveyed community. The Balti (25%) and Brushiski communities (12.5%) were discreetly studied. The population of Khwar and Wakhi were hardly studied so far. Moreover, five articles addressed the demographic background of the respondents/informants while nineteen lack the information.

Methods, Species reported and voucher specimens

The research works were conducted solely through interview methods in order to collect the ethnomedicinal data. Eight articles used semi-structured interviews and eight structured interviews. The remaining eight studies did not specify the adopted interview approach. Eighteen studies were done with purely descriptive approaches, and six articles were enunciated with quantitative ethnobotanical indices such as frequency citation (FC), relative frequency citation (RFCs), fidelity level (Fl), used values, (UV), Pearson correlation coefficient (PCC). Among the 24 research articles, Gorsi and Miraj (2002) reported the maximum number of medicinal plants (118 species) followed by Khan and Khatoon (2008) (98 species) and Abbas *et al.* (2017a) (84 species). The average of documented species was calculated as 17 species. Among twenty-four articles, in five articles there was no mention of voucher specimens.

Medicinal flora

The comprehensive and careful listing of medicinal plants from the reviewed literature resulted 1060 entries in the excel sheet, along with their family, scientific name, local name, source (wild or cultivated), habit (herb, shrub, tree), part(s) used, ailment(s) cured and article quotation (Fig. 2).

Figure 2. The most regionally reported medicinal species A) *Bergenia stracheyi* B) *Delphinium brunonianum* C) *Hippophae rhamnoides* D) *Capparis spinosa*

Taxonomic diversity

The reviewed studies documented a total of 413 plant taxa in 224 genera and 79 families. The regional medicinal flora embodies the three major plant groups of pteridophytes (2 families, 2 genera, 5 species), gymnosperms (3 families, 7 genera, 11 species) and angiosperms (74 families, 215 genera, 397 species). Angiosperms had the maximum representation with both monocots (5 families, 13 genera, 19 species) and dicots (69 families, 202 genera, 378 species). Asteraceae, Rosaceae and Fabaceae were prevailed botanical families with 58, 36 and 32 species respectively. Polygonaceae (22 species), Lamiaceae (21), Ranunculaceae (19) and Apiaceae (17) were sub-dominating families. And among 79 families, 32% families showed least presentation with only one species. *Artemisia* was the leading genus with 11 species followed by *Prunus* (9 species). *Salix*, *Saussurea*, *Potentilla*, *Astragalus* and *Allium* contributed seven species each; *Rosa* and *Berberis* six specie while *Tanacetum*, *Rumex*, *Geranium* and *Brassica* were also prominent with 5 species each. Other 211 (51%) genera contributed less than 5 species (Table 2).

Table 2. Diversity of medicinal plants based on families, genera and species.

Family	Genera	%	Species	%
Asteraceae	28	12.5	58	14.04
Rosaceae	10	4.46	36	8.71
Fabaceae	20	8.92	32	7.74
Polygonaceae	8	3.57	22	5.32
Lamiaceae	13	5.80	21	5.08
Rananculaceae	10	4.46	19	4.60
Apiaceae	13	5.80	17	4.11
Cruciferae	6	2.67	11	2.66
Salicaceae	2	0.89	10	2.42
Gentianaceae	4	1.78	9	2.17
Cucurbitaceae	5	2.23	8	1.93
Alliaceae	1	0.44	7	1.69

Boraginaceae	5	2.23	7	1.69
Poaceae	7	3.12	7	1.69
Solanaceae	5	2.23	7	1.69
Berberidaceae	1	0.44	6	1.454
Malvaceae	3	1.33	6	1.45
Chenopodiaceae	3	1.33	5	1.21
Geraniaceae	1	0.44	5	1.21
Pinaceae	4	1.78	5	1.21
Cuppressaceae	2	0.89	4	0.96
Fumariaceae	1	0.44	4	0.96
Grossulariaceae	1	0.44	4	0.96
Moraceae	2	0.89	4	0.96
Plantaginaceae	2	0.89	4	0.96
Saxifragaceae	2	0.89	4	0.96
Scrophulariaceae	2	0.89	4	0.96
Convallariaceae	1	0.44	3	0.72
Cuscutaceae	1	0.44	3	0.72
Elaeagnaceae	2	0.89	3	0.72
Oleaceae	2	0.89	3	0.72
Onagraceae	1	0.44	3	0.72
Primulaceae	1	0.44	3	0.72
Pteridaceae	1	0.44	3	0.72
Rubiaceae	2	0.89	3	0.72
Tamaricaceae	3	1.33	3	0.72
Violaceae	1	0.44	3	0.72
Amaranthaceae	2	0.89	2	0.48
Anacardiaceae	1	0.44	2	0.48
Biebersteiniaceae	1	0.44	2	0.48
Caprifoliaceae	1	0.44	2	0.48
Caryophyllaceae	1	0.44	2	0.48
Crassulaceae	2	0.89	2	0.48
Ephederaceae	1	0.44	2	0.48
Equisetaceae	1	0.44	2	0.48
Lilliaceae	2	0.89	2	0.48
Orchidaceae	2	0.89	2	0.48
Papaveraceae	1	0.44	2	0.48
Plumbaginaceae	2	0.89	2	0.48
Urticaceae	1	0.44	2	0.48
Zygophylaceae	2	0.89	2	0.48
Asclepediaceae	1	0.44	1	0.24
Asparagaceae	1	0.44	1	0.24
Balsaminaceae	1	0.44	1	0.24
Betulaceae	1	0.44	1	0.24
Buxaceae	1	0.44	1	0.24
Campanulaceae	1	0.44	1	0.24
Canabinaceae	1	0.44	1	0.24
Capparidaceae	1	0.44	1	0.24
Convolvulaceae	1	0.44	1	0.24
Ebenaceae	1	0.44	1	0.24
Ericaceae	1	0.44	1	0.24
Euphorbiaceae	1	0.44	1	0.24
Hyacinthaceae	1	0.44	1	0.24
Iridaceae	1	0.44	1	0.24
Juglandaceae	1	0.44	1	0.24
Linaceae	1	0.44	1	0.24

Morinaceae	1	0.44	1	0.24
Oxalidaceae	1	0.44	1	0.24
Parnassiaceae	1	0.44	1	0.24
Platanaceae	1	0.44	1	0.24
Podophylaceae	1	0.44	1	0.24
Punicaceae	1	0.44	1	0.24
Rhamnaceae	1	0.44	1	0.24
Rutaceae	1	0.44	1	0.24
Thymelaeaceae	1	0.44	1	0.24
Valerianaceae	1	0.44	1	0.24
Vitaceae	1	0.44	1	0.24

Plant source and habit

The medicinal plants used of the inhabitants of the Gilgit-Baltistan were 16% in cultivation and 83% wild. Cultivated species of Rosaceae, Cucurbitaceae, and Salicaceae were the mostly used. Habit-wise the medicinal flora was also diverse but prevailing with herbaceous species (310 species, 75%). Shrubs and trees showed comparatively less contribution with 53 (12%) and 49 (11%) species.

Therapeutic range

The reported medicinal plants were used for 3160 remedies for health disorders related to dermatology, orthodontics, skeletal system, ophthalmology, respiratory system, digestive system, reproductive system, cardiovascular system, hematology, muscular system, nervous system, and oncology. These plants were also used to treat special health disorders such as typhoid, diabetes, epilepsy, migraine, fever, and hernia. The classification of these remedies against specific disorders yielded 353 disease types for example rheumatoid arthritis, bronchitis, Tonsillitis, Diabetes mellitus, etc.

Article quotation (AQ)

The evaluation of 413 species for quotation in the published research articles indicated that *Hippophae rhamnoides* and *Thymus linearis* were the most important medicinal species with highest AQ values 17 i.e. reported by 70% of the articles. *Ephedra gerardiana* was exposed as the second highly cited taxon and reported by 62% of the publication (15). Furthermore, *Juniperus excelsa*, *Mentha longifolia*, *Capparis spinosa*, *Plantago major*, *Bergenia stracheyi* were also recognized medicinal taxa with more than 45 % quotation. Medicinal plants those quoted by 10 research articles were *Plantago major*, *Juniperus communis, Elaeagnus angustifolia*, *Delphinium brunonianum*, and *Artemisia maritima*. The pattern of article quotation for other species revealed as four species scored 9; eleven species 8; seven species 7; sixteen species 6; fourteen species 5; twenty-one 4; forty-two 3 and sixty-four scored 2. AQ values of two hundred and twenty-one (221) species were calculated as 1 only (Table 3, Fig. 3).

Table 3. The most quoted medicinal plants of Gilgit-Baltistan.

Hippophae rhamnoides L.	17
Thymus linearis Benth.	17
Ephedra gerardiana Wall. ex Stapf	15
Juniperus excelsa M. Bieb.	14
Mentha longifolia (L.) L.	13
Capparis spinosa L.	12
Bergenia stracheyi (Hook.f. & Thomson) Engl.	11
Plantago major L.	11
Artemisia maritima L.	10
Delphinium brunonianum Royle	10
Elaeagnus angustifolia L.	10
Juniperus communis L.	10
Rosa webbiana Wall. ex Royle	10
Berberis lyceum Royle	9
Cichorium intybus L.	9
Punica granatum L.	9
Taraxacum officinale Weber	9
Allium cepa L.	8
Betula utilis D. Don.	8
Carum carvi L.	8

Chenopodium album L.	8
Datura stramonium L.	8
Juglans regia L.	8
Prunus armeniaca L.	8
Rumex hastatus D. Don	8
Solanum nigrum L.	8
Sophora alopecuroides L.	8

Figure 3. Representatives of least regionally documented species A) *Hedysarum falconeri* B) *Biebersteinia odora* C) *Clematis alpina* var. *sibirica* D) *Rhodiola imbricata*

Discussion

History of medical ethnobotany and status of literature

The field of ethnobotany in Pakistan is not very old and included to the curricula of a few of the universities (Aumeeruddy-Thomas *et al.*, 2004; Khan, 2012b) and probably studies started in early 1990s (Shinwari, 1996). The region of Gilgit-Baltistan is a remote, inaccessible and climatically harsh region where ethnobotanical exploration began further lately and attracted botanical attention in early 2000s i.e. ten years later than other regions. The beginning of regular scientific publications in the field of ethnobotany started from 2002 and gained speed from 2007. Still the rate of publication is slow. It may be explained by its remoteness from national academia, difficult accessibility, absence of fund and limited regional ethnobotanists/scholars (Abbas *et al.*, 2017a). It is predictable that the area has great potential of ethnomedicinal research (Abbas, 2012; Wali *et al.*, 2019). Ethnobotanical publication is getting pace year by year due to the establishment of public universities in the region. The funding of research institutions may largely underpin for broaden and comprehensive studies. The authorities/consultants of three large and typical mountainous protected areas i.e. Khunjerab National Park (KNP), Deosai National Park (DNP) and Central Karakorum National Park (CKNP) may conceive and execute holistic research projects to boost up the botanical exploration of the region. Besides, the non-governmental national and international organization dedicated to biodiversity, natural resources and communal empowerment may also take part in the research project and publication of the regional ethnobotany. No doubt, it would add new medicinal species in the current total that may be productive for new drug discovery for lethal health disorders.

Geographic distribution

Although the studies were performed in the territories of three mountain belts, they were geographically confined and dispersed. Profound disparity was found in the conduction of research based on mountain ranges and sub regions. Maximum exploratory research was conducted in the Karakorum ranges. It is by chance that most of the

local scholars grew up in the valleys of Karakorum Mountains (Hyder *et al.*, 2013; Khan and Khatoon, 2008; Khan *et al.*, 2013b). The major portion of population of GB is found in the Karakorum ranges as compared to the Himalaya and the Hindu Kush such as Hunza, Nagar, Gilgit (partially), Skardu (partially), Shigar, Ganche, etc. Similarly, most of the studies were conducted in the Gilgit sub region as compared to Baltistan. The former is the capital of the region the most research institutes are based there and provide more research opportunities. Baltistan is located in the extreme north of Pakistan bordering with India, which further promotes remoteness from facilitated and ease urban infrastructure. Moreover, the region lacks the institutes that may threshold, promote and support research activities. These factors of course strikingly hamper research activities in the region. A number of valleys are still lacking botanical exploration e.g., Darel, Tangir, Chilas, Punial, Yasin, Shimshal, Gultar, Phander, Chapurson, Stak, Gunji, Talu, Bilamik, Mendi, Basha, Braldo, Hushe, Chorbat, Gultari, Kindirik, Ulding, Gabis, Ganokh, Thale, Duro, Katisho, Shingo Shigar, Chillam, Gudai, and so on. In these localities there is an urgency to execute more comprehensive, precise and promising work for prompt documentation of sustaining plant-based traditional therapeutic knowledge. Ample literature reiterated the current scenario of traditional knowledge system (TKS) is declining at rapid rate from theses mountain communities due to rampant urbanization, local emigration, changes in lifestyle, permeating allopathic drugs, pervading modern markets with updated tools and health care innovations (Abbas *et al.*, 2019b; Abbasi *et al.*, 2013; Bussmann *et al.*, 2016).

Ethnicity, literature and respondent's background

The term "ethno" of ethno-botany is derived from Ethnology "the study of culture" (Kottak, 2005) and hence some key features of targeted ethnic group/culture/community/ are required for inclusive, well versed, and well-articulated research work (Cotton, 1996; Martin, 2004). The region offers a model society for ethnobiological studies due to ethno-linguistic diversity (Weinreich, 2015), varied culture, diverse flora and huge rural population. In the demography Shinas populate the most part of the region (Saxena and Borin, 2008) that may be a possible reason for more studies on Shina community. The remarkably disperse Shina population inhabits many different villages of Baltistan (Hook, 1990) but has not been explored ethnobotanically. A comparative study of Shinas living in both regions would be an interesting work. Few articles focused on both Balti and Brushishki communities, but on Khwar and Wakhi communities research is essentially non-existent. Ethnographically, this is a prominent research gap. Nonetheless, precise comparative ethnobotanical work would be a hallmark for the national and international scientific community. The informants' traits including ethnic name, language spoken, gender, age, social subsistence and education (qualification) provide quite clear and interesting picture of the involved community as well as the botanical work. The background of participants (respondents, informants) is essential for all ethnobiological studies which probably augment the validity and credibility of the work. On the other hand, it is also preconditioned for the genuine and reliable data collection. Because ethnobotany works with two components i.e. people and plants, or two fields i.e. Ethnology and Botany.

Methods used and research type

In ethnobotany there are variety of methods used to collect data depending upon the aims and focus of the study (Martin, 1996; Phillips *et al.*, 1994a; Soelberg and Jäger, 2016; Vogl *et al.*, 2004). Eight articles used semi-structured interviews, the current standard method in ethnobotanical literature (Martin, 2004; Tongco, 2007). Semi-structured interviews prevent or lessen interviewer's intrusions to large extent. In structured interviews informants often feel pressure (Albuquerque *et al.*, 2014a) and sometime the conversation environment leads to boredom that can affect the respondent knowledge imparting. Free listing and group discussions may also be used as data collection tool (Leitão *et al.*, 2009) but this again depends upon the objectives of the study. Eight studies did not mention the adopted interview approach. In ethnobotany, quantitative techniques or indices have been used to compare the uses and the cultural importance of different plant taxa (Albuquerque *et al.*, 2006). Most early ethnobotanical studies were based on a descriptive approach i.e. traditional compilation style (Phillips *et al.*, 1994b) including scientific/botanical classification, vernacular nomenclature, used plant part(s), drug formulation, disease treated, route of administration and sometime daily doses with no emphasis on quantitative analysis. But after the work of Phillips (1996), the publication trend highlighting quantitative indices has increased dramatically, and a variety of quantitative formulae were used (Albuquerque, 2009; Hoffman and Gallaher, 2007) for instance frequency citation (FC), relative frequency citation (RFCs), fidelity level (Fl), used values, (UV), Pearson correlation coefficient (PCC), Jaccard index (JI), etc. The quantitative techniques create further attention to the method used, and frequently recall the environment/situation of interviewing. They reflect cultural value systems (Byg and Balslev, 2001) and lead the purification and authenticity of gathered data. This not only improves the discipline of ethnobotany but also enhances the image of ethnobotany among scholars (Höft *et al.*, 1999).

Diversity, availability and habit of medicinal plants

The inventory of 413 species from the Region of Gilgit-Baltistan strongly indicated that the national flora of Pakistan indeed must possess more than 10% medicinal plants as estimated by Shinwari (2010a). The ethnobotanical literature must have reported more medicinal plants after the estimation. The regional medicinal plants showed a remarkable taxonomic diversity presenting ferns, gymnosperms and angiosperms, but there was no taxon whatsoever from bryophytes in the list of medicinal plants of Gilgit-Baltistan, which is astonishing, as a considerable number of bryophytes has been reported from the region (Gruber and Peer, 2010; Higuchi and Nishimura, 2003) and Pakistan (Higuchi, 2005; Townsend, 1993). The bryoflora of Pakistan is however not well studies yet (Higuchi and Nishimura, 2003). The lack of bryophytes in the medical flora of the region might be based in their inconspicuous nature. Moreover, lower plants (both bryophytes and pteridophytes) have so far gained limited focus in the country and very sparse works found such as (Gul *et al.*, 2016; Mazhar-ul-Islam and Fiaz). Not a single study exists addressing the medicinal importance of the regional bryoflora of Pakistan. Work specifically intending to explore the medicinal values of moss flora may discover therapeutic bryophytes. It would be a valuable contribution to the current total. The regional population was using both wild plants i.e. found in natural habitats and cultivated plants i.e. grown in home gardens, farms and agricultural fields. Rosaceae is one of the largest families in the flora of Pakistan presenting both wild and cultivated species and possesses several medicinal species (Khan and Shinwari, 2016; Saqib and Sultan, 2005). Similarly, it is also the most prominent fruit producing, and commercially important family due to its expensive dry fruits and seeds in the study area. Cucurbitaceous species have a noticeable presentation in the home gardens as vegetables. Ethnomedicinal work focusing on single plant families may disclose further traditional therapeutic details. The prevailing herbaceous species could be correlated with the semiarid and continental climatic traits (Afridi, 1988; Kreutzmann, 2006) of the region. The high elevation, and vast land area with dry and cold deserts, may hamper the growth of shrubs and trees (Eberhardt, 2004).

Pathological report

Data regarding diseases were documented with common English name and medical terms like *sore throat* and *pharyngitis*, *flu* and *sinusitis*, etc. In most of the cases the medicinal values of the plant species were described in general sense without indicating the specific health disorders for example *respiratory tract infection*, *nervous problems*, *gastrointestinal tract disorders*, *hepatic ailments*, *blood pressure*, etc. Consequently, the pathological data becomes ambiguous, and the significance of the study reduces. Ethnobotanical data with exact medical terms for health disorders probably enhance the work clarity and makes research work more captivating for readers. Similarly, for the documentation of pathological information the name of ailments should be in uniformity.

Medicinal plants quotation in articles (AQ)

The article quotation was used as quantitative tool to estimate or judge the medicinal importance of a plant species in the targeted language, ethnicity, community or study area., *Hippophae rhamnoides*, *Thymus linearis* and *Ephedra gerardiana* were the most reported species with highest AQ values. These species exhibit a broad ecological niche and copiously distributed in the region. Sea buck thorn (*Hippophe rahmnoides*) is found commonly along water channels, riverbanks, along rivulets, lake littoral zone and among cultivated fields, wet rocky slopes.

The article quotation gave a strong insight of the medicinal plants of the region and distinctly drawn the clear picture of their status. Thirteen species were reported by more than ten articles showing their therapeutic significance among regional inhabitants. A total of 221 species (53.51%) were however reported by a single article. This might reflect the great diversity of plants only used very locally, many of which may not have been investigated phytochemically. This outcome is not surprising, indicating the scare ethnobotanical work of the region. It underlines the great need for further comprehensive and holistic ethnomedicinal studies in the region.

Conclusion

The region of GB is still poorly investigated ethnobotanically, and limited literature found on this subject. Few articles focused on both Balti and Brushishki communities, but on Khwar and Wakhi communities research is essentially non-existent. Ethnographically, this is a prominent research gap. Nonetheless, precise comparative ethnobotanical work would be a hallmark for the national and international scientific community. However, the diverse medicinal flora of Gilgit-Baltistan validated the regional potential of phytomedicines despite scarce research. Furthermore, the articles address the medicinal flora of the regions distributed in the zone of three national parks viz. Central Karakorum National Park (CKNP), Deosai National Park (DNP) and Khunjerab national Park (KNP). Hence, it would be a holistic monograph to develop strategies for biodiversity conservation and natural resource management.

Declarations

Abbreviations: N/A
Ethics approval: This work is based on a literature survey and no ethics approval was needed.
Consent for publication: N/A
Availability of data and materials: N/A
Competing interests: The authors declare that they have no competing interests.
Funding: N/A

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