Medicinal plants used by inhabitants of the Shigar Valley, Baltistan region of Karakorum range-Pakistan

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Abstract

Background: The inhabitants of mountainous terrains depend on folk therapies to treat various ailments; however lack of plant based research and geographical constraints set the traditional knowledge in jeopardy. Present study is the first documentation on traditional uses of plant species by the inhabitants of the Shigar Valley, Karakorum Range, Northern Pakistan.

Method: Ethnobotanical data were collected over a period from July, 2013 to October, 2016 from 84 respondents, using semi structured questionnaire. Quantitative indices such as relative frequency citation (RFCs) and fidelity level (FL) were intended to evaluate the importance of medicinal plant species.

Results: In total 84 plant species belonging to 36 families and 72 genera were recorded. Fabaceae was dominant with 7 species, followed by Asteraceae, Lamiaceae and Rosaceae (6 species each). Leaves, root, flowers, seeds and fruits were the frequently utilized plant parts, whereas among drug formulations, decoction (49%) was ranked first. Majority of the plant species were used to treat abdominal, respiratory and dermal ailments (31, 12 and 12, respectively). RFCs value ranged 0.477 to 0.11 for Tanacetum falconeri and Allium carolinianum, respectively; while Hippophae rhamnoides and Thymus linearis depicted 100% FL. Comparative assessment with previous reports revealed that traditional uses of 26% plant species counting Hedyoserum falconeri, Aconitum violoceum var. weileri, Arnebia guttata, Biebersteinia odora, Clematis alpine var. sibirica, Corydalis adiantifolia and Saussurea simpsoniana were reported for the first time.

Conclusion: The endemic medicinal plant species and traditional knowledge of Balti community living in extremely high mountains area were explored for the first time. A comprehensive survey of this region could be significant to drive the existing knowledge in market circuit with sustainable collection, and to evaluate economic potential of the plant species. Additionally, social livelihood could be reinforced through establishing collection sites, transformation and drying centres for micro and macro marketing of medicinal plant species.

Keywords: Medicinal plants, Shigar Valley, Karakorum, Mountain, Baltistan

Background

Mountain landforms cover about one quarter of the land surface and host 12% world’s population [37]. These landforms have great influence on climatic, biological, ethnic, cultural and linguistic diversity of any region. In Pakistan, substantial rural population is living in the mountain ranges of Karakorum, Himalaya and Hindu Kush. The Karakorum ranges frame deep incised valleys in the extreme north of Pakistan, and provide several services to dwellers such as timber, fuel wood, fodder, herbal medicines etc. Because, harsh climate, remoteness and difficult access hamper development in basic services particularly, education and health [55]. Therefore, mountain people are considered as the most poorest and deprived population. Furthermore, the inhabitants of high mountain areas are more susceptible to various diseases owing to unsympathetic mountains’ environment with unexpected fluctuations in seasonal temperature,
light intensity, ultraviolet (UV) radiation and poor do-
mestic hygiene [3]. The health facilities provided by gov-
ernment and non-governmental organizations (NGOs)
are next to nothing for the inhabitants living in these re-
 mote areas. Consequently, in such circumstances plant
based traditional therapies are the primary health care
source to mitigate various health disorders.

Baltistan is an archetypal mountainous region of the
Northern Pakistan with average altitude of 3555 m above
sea level. Historically, it has often been referred as “Western
Tibet” or “Little Tibet” [6, 58]. The territories of the Balti-
stan region lie sparsely at acclivities and in deep mountains
of Karakorum and Himalaya with unique landscape, cli-
mate, flora and fauna. However, remoteness, difficult access
and inadequate funding may be the major handicaps to
conduct field survey in these areas. Only few workers [11,
12, 21], have conducted ethnobotanical survey in some
parts of Northern Pakistan. Therefore, very limited ethno-
botanical literature is available in the region [20, 31]. Shi-
gar valley is located in the Karakoram Ranges, and is the
home of various peaks (including K2), glaciers and hot
springs, which have always been the most preferred track-
ing places for visitors across the country and abroad.
Ethno-botany is a recently introduced and rapidly flour-
ishing field in this region, and is gaining adequate atten-
tion by researchers. Although, various ethnobotanical
surveys have be conducted in different parts of Pakistan.
However, Northern parts of country are still poorly ex-
 plored. Therefore, present survey aimed to provide, the
first inventory on ethno-pharmacological application of
medicinal plant species used by the inhabitants of Balti
community of Shigar valley, Karakorum Mountains-
Pakistan.

Methods
Study area
Shigar Valley is a part of the central Karakorum ranges sit-
uated in the north of Skardu town at right bank of the
river Indus (Fig. 1). It lies at 25° 25′ 32″ N latitude and 75°
42′ 59″ E longitude and covers an area of 4373 sq. km with
altitudinal amplitudes of 2, 260 to 8611 m above sea level
[45]. It borders with China fenced by K2 (Godwin Austin)
between the territories [47]. The highest zone above 6000 m encompasses maximum ridges and peaks including K2 (8611 m), Broad Peak (8047 m), Angel Peak (6858 m) and Skil Brum (7360 m). Settlements are distributed in small villages on alluvial fans, terraces and gentle slopes at altitude of 2300 m (Marapi), 2790 m (Arando) and 3050 m (Askole). The valley experiences dry, hot and sunny summer with intensive radiation providing very short growing season for native flora [48].

Shigar Valley was ruled by Raja dynasty ‘Amacha’ and the period of Raja ruling system was known as Chou-Tus (Raja’s period) in Balti dialect [6]. This autocratic system remained in power till the middle of nineteenth century (H. [26, 46]). The presence of human community in Baltistan is prior to the birth of Guatama Budha (563 BC). The indigenous people of the valley have migrated from different regions i.e. Ladakh (Indian Kashmir), Tibet (China) and Hunza-Nagar via mountainous tracks [60]. These migrants have intermixed culture and arose as single Balti ethnic group due to dominant Ladakhi and Tibetan Balti speakers. They speak an archaic non-written Tibetan dialect called Balti [14]. Balti caste has a number of lineage sub-groups (Clan), which are also known as mi-schir (pronounce as mee-ser) in local dialects. They are very traditional and still tightly knotted with Balti culture in constructions, house scheming, livestock homes; dressing, agricultural activities, domestic and farming tools, games and rustic practices.

Data collection
Ethnobotanical survey was conducted from July, 2013 to October, 2016 in seventeen sites of the study area (Fig. 2). Field trips and interviews were planned in early spring i.e. March to June (off vegetation season), while keeping in mind the cold climate and short vegetation season of the area. Eighty four people were interviewed in Balti dialect without distinction of gender after seeking the consent, while semi structured questionnaire as explained previously [16, 41] was used to collect data. Interviews were taken in houses, people gathering place, mosques and Jamias (second time Islamic schools). After inquiring the demographic background of the respondents, information were collected on local name of plant species, part used, drug preparation, mode of administration and ailments treated. Afterwards a separate list of reported medicinal plant species with local name was developed by sorting questionnaires along with their ethno-medicinal uses.

Sampling, preservation and identification
The plant sampling was done in summer. Each specimen was tagged with its local name in the field (Fig. 2), prostrated in blotting papers and kept in filed plant presser. The perplexing plant species were confirmed by local respondents showing plant materials and/or their pictures. Dried specimens were poisoned using Mercuric chloride and absolute alcohol (2 g mercuric chloride +1000 mL absolute alcohol), then mounted herbarium sheets [39]. Preserved specimens were identified by Taxonomists of Hazara University Herbarium, Mansehra Khyber-Pukhunkhwa Pakistan, Karakorum International University Gilgit-Baltistan, Pakistan and with the help of available literature i.e. Flora of Pakistan [8, 43] and the flora of China. The botanical names and plant families were confirmed by angiosperm phylogeny group and The Plant List. The plant specimens were given the voucher numbers and kept in the Herbarium of Hazara University, Mansehra, Pakistan.

Ethno-botanical data analysis
Data were analysed using ethnobotanical indices i.e. relative frequency of citation (RFCs) and fidelity level (FL) in order to evaluate the importance of the recorded species.

Relative frequency citation (RFCs)
Reveals the importance of each species and is calculated on the basis of the frequency of citation ‘FC’ (the number of informants mentioning the use of species), using formula as described before [51]. The FC value is divided by total number of informants participating in the survey (N), without considering the use-categories

\[
RFCs = \frac{FCs}{N}
\]

Where, FCs is the number of informants who mentioned the use of a plant species and N is the total number of informants.

Fidelity level (FL)
Is the ratio between number of informants who mentioned the use of a plant species for a particular purpose and total number of informants who mentioned the use of that plant species for any purpose (regardless the category). FL indicates the percentage of informants claiming the use of plant species for same major purpose. The FL of the species was calculated using the method as adopted by [7]. High FL values (100%), are obtained for plant species, where almost all uses refer to same purpose. The low FLs are usually obtained for plants that are used for numerous purposes.

\[
FL (%) = \frac{lp}{lu} \times 100
\]

lp is the number of informants who independently suggested the use of a plant species for a particular disease
and \( I_u \) is the total number of informants who mentioned the same plant for any disease.

**Results and discussions**

**Demographic feature and indigenous knowledge**

In total 84 respondents including 73.80% male and 19.67% female were interviewed to collect data on medicinal uses of plant species from seventeen villages without gender distinction (Table 1). Due to Islamic instructions, communal restrictions and isolated society, usually female avoid to participate and have knowledge, because of Islamic instructions, communal limits and isolated society. The informants were categorized in three age groups i.e. 20–40 year, 40–60 year and above the age 60 years. The middle age people (40–60 years old) had more indigenous knowledge compared to other age groups. This may be due to lack of interest in early age people about traditional remedies, and loss of mammary in elderly people because of age factor.

As far as education of the informants was concerned, majority of the respondents (75.40%) were uneducated,
however 24.60% were literate: having primary to masters level of education. Local inhabitants of the valley have different sources for survival. Most of them are farmers, shepherds, wood cutters, gemstone workers and job holders. It was interesting to know that local healers treat villagers and extend their traditional therapeutic knowledge among other people free of cost. The people of less developed and elevated zone possess adequate knowledge on medicinal use of native flora compared to those who live in towns. However, rapid modernization and effortless access to allopathic medicines might be the main causes that are diminishing the traditional knowledge of the dwellers.

Ethno-floral diversity, availability and habit

A total of 84 medicinal plant species belonging to 72 genera and 36 families were used by the inhabitants of the area to treat various health disorders. An enumeration of all recorded species including botanical name, local name, voucher specimen number, family, habit, availability, locality, parts used and drug description is provided in (Table 2). Fabaceae was the leading family with 7 species, followed by Asteraceae, Lamiaceae and Rosaceae each was represented by 6 species. The therapeutically significant of the first four families may be associated with common distribution of species belong to these families in the study area. Asteraceae is one of the largest families in the flora of Pakistan, and its prevalent distribution throughout the country may be the reason behind being dominant. Likewise, same family has been reported as a leading family in the previous studies conducted in surrounding areas of Shigar Valley [1, 12, 21]. However, Khan (2007) reported Rosaceae as the most prevailing family from various valleys of Himalaya and Karakoram ranges of mountains [29, 31]. These findings indicate the ample indigenous knowledge, varied selection and rich diversity of medicinal flora of the region.

Inhabitants of the Shigar Valley use cultivated and wild plant species (73.80 and 22.19%, respectively) in traditional drug therapies, which is in agreement with previous study conducted in Haramosh and Bugrote valleys, in Gilgit-Pakistan [34]. Except for *Equisetum arvense* and *Ephedra gerardiana* rest of the species were angiosperms. Herbs were the dominant with 69% contribution (Fig. 3), followed by shrubs, trees and shrublets (14, 13 and 4%, respectively). The climatic conditions, wide distribution and easy access may be the reasons behind prevailed herbaceous habit in the area [2, 3, 35].

### Part(s) used, drug preparation and administration

The plant part(s) and their use number i.e. use more than one part of plant as drug source, depend upon the availability and indigenous knowledge of local community. The parts of plant species used were grouped in seventeen (17) categories on the basis of their types and number such as: as branches, bulb, flower, fruit, leaves, root, seed, seedling and whole plant were one part used categories (Fig. 4), whereas fruit & floral buds (*Prunus armeniaca*), fruits & leaves (*Hippophae rhamnoides subsp. turkestanica*), inflorescence, root latex and powder (*Ferula jaeschkeana*), leaves & inflorescence (*Salix alba*), root bark & fruit (*Rosa Webbiana*), seed & leaves (*Pimpinella diversifolia*) and, stem bark and seed (*Fraxinus xanthoxyloides*) were two parts used categories. Leaves were the most frequently used plant parts (16 species), followed by fruits (12), root (12) seed (11) and flowers (10).

The inhabitants of the study area use nine types of drug formulation as mentioned in Fig. 5, to treat various ailments. Among these, decoction was dominant (45 medications), followed plant part(s) eaten fresh (17 medications), cook/boiled/toasted (13 medications), powder and paste (5 medications each) and infusion (4 medications). The modes of drug administration were divided in to three groups (Fig. 6). Around 83% recipes were taken orally, 11% were applied topically and 6% were used as oral and topical.
Classification of diseases and traditional therapies

The life of rural peoples, particularly those who live in high mountain areas is very tough. The continuous effort of these people in order to survive in the social hierarchies makes them vulnerable to various types of ailments. The inhabitants of the Shigar Valley use medicinal plant species to treat 30 different ailments (Fig. 7). These ailments were grouped into fourteen categories by emec classification method viz. abdominal disorders treated by 31 species, dermal problems (12 species), respiratory disorders (12 species), miscellaneous including cold, cough, fever, migraine, vomiting (12 species), menstrual and pregnancy problem (6 species), cardiovascular disorders (6 species), tonics (5 species), urinary tract disorders (5 species), hepatic disorders (4 species), bones and joints issues (3 species), optical disorders (2 species), tooth problems (2 species), cancer (1 species) and diabetes (1 species). These observations were correlated with previous reports [18, 30, 56]. Gastrointestinal (GIT) disorders (i.e. constipation, indigestion, gastric trouble, dysentery, acidity, and stomach ulcer), skin diseases (pimples, pustules, and ringworm), respiratory tract infections (bronchitis, asthma, pneumonia) and bones/joint ailments (back ache, arthritis) were the common health problems. The gastrointestinal (GI) disorders may attributed to domestic hygienic conditions and dietary routine. Additionally, frequent use of teas, red pepper and less fibrous food could be a reason of GI infections. Likewise, intensive ultraviolet radiations and poorly managed public sanitation may be accountable for the prevalence of dermal problems. Moreover, prolonged harsh and hostile weather and allergens make dwellers vulnerable to get respiratory infections. The bones and joints ailments could be associated with the difficult topography and laborious life style (Fig. 8). Our findings provide an enthusiastic understanding on prevalence and distribution of the public sicknesses. In this context, present work offers imperative idea to frame long term health policies in

Table 2 Family wise distribution of medicinal plants in study area

| Family           | Number of Species | Percentage% | Family           | Number of Species | Percentage% |
|------------------|-------------------|-------------|------------------|-------------------|-------------|
| Alliaceae        | 2                 | 2.380       | Juglandaceae     | 1                 | 1.190       |
| Apiaceae         | 5                 | 5.950       | Lamiaceae        | 6                 | 7.140       |
| Asteraceae       | 6                 | 7.140       | Moraceae         | 1                 | 1.190       |
| Berberidaceae    | 3                 | 3.570       | Oleaceae         | 1                 | 1.190       |
| Betulaceae       | 1                 | 1.190       | Papaveraceae     | 1                 | 1.190       |
| Biebersteiniaeae | 1                 | 1.190       | Parnassiaeae     | 1                 | 1.190       |
| Boraginaceae     | 3                 | 3.570       | Plantaginaeae    | 1                 | 1.190       |
| Brassicaceae     | 2                 | 2.380       | Plumbaginaceae   | 1                 | 1.190       |
| Capparidaceae    | 1                 | 1.190       | Poaceae          | 3                 | 3.570       |
| Chenopodiaceae   | 1                 | 1.190       | Polygonaceae     | 5                 | 5.950       |
| Cupressaceae     | 1                 | 1.190       | Punicaceae       | 1                 | 1.190       |
| Cuscutaceae      | 1                 | 1.190       | Ranunculaceae    | 6                 | 7.140       |
| Elaeagnaceae     | 2                 | 2.380       | Rosaceae         | 6                 | 7.140       |
| Ephedraceae      | 1                 | 1.190       | Saliciaceae      | 2                 | 2.380       |
| Equisetaceae     | 1                 | 1.190       | Saxifragaceae    | 1                 | 1.190       |
| Fabaceae         | 7                 | 8.330       | Solanaceae       | 2                 | 2.380       |
| Furnariaceae     | 1                 | 1.190       | Urticaceae       | 1                 | 1.190       |
| Gentianaceae     | 1                 | 1.190       | Zygophyllaceae   | 1                 | 1.190       |
| Glossulariaceae  | 3                 | 3.570       |                  |                   |             |

Fig. 3 Growth forms of used medicinal species
In order to convey health risk, precautions and effective treatment by integrated disease management. Folk therapies used by the inhabitants of Balti communities were compared with previous work done in Gilgit-Baltistan, other parts of the country and Himalayan communities of India, Nepal and China [40]. The inhabitants of Shigar Valley use *Betula utilis* to treat ringworm, however same species is used against leprosy and earache in Chapursan valley, Hunza [57]. *Delphinium brunonianum* is effective for asthma, gastric trouble and trace release after delivery, but Hussain et al. [21] reported that in central Karakoram National Park this species is used to treat baldness, stomach ache and diarrhoea. *Solanum nigrum* has therapeutic importance of being liver tonic, to alleviate indigestion and eye pain, and to treat skin infections in India and the lesser Himalayas of Pakistan [4], but the inhabitants of Shigar Valley use this species only to treat tooth ache.

The inhabitants Swat Valley use *Artemisia scopria* to treat abdominal worms [19]. Same species has been reported as purgative in Gujrat Pakistan [22] and an effective remedy against hyper-acidic stomach in Zhejiang province, China [15]. However, in Shigar Valley the infusion of *A. scopria* are used to treat diabetes. In Shigar Valley, bulb of *Allium carolinianum* is used to treat gastrointestinal disorders and joint problem, but in Khunjerab National Park, Hunza, this species is used in flu and fever treatment [25]. *Thymus linearis* is used to alleviate abdominal pain and vomiting, while in Astore same species is used to kill abdominal worms [49].

Fruits and leaves of *Hippopophae rhamnoides subsp. Turkestanica* are used in the treatment of gastrointestinal disorders and skin diseases. Same species has been reported to treat cardiac diseases, cancer and stomach ache in Haranosh and Gilgit valleys-Gilgit [33]. Likewise, in Ladakh district of India, this plant is used to treat gynaecological disorders such as irregular menstrual cycles, amenorrhea or dysmenorrhoea [10], and to improve digestion [9]. *Pimpinella diversifolia* is among the most common medicinal herbs in the study area, which is used for abdominal disorders, fever and blood purification. In Lesser Himalayan region of Pakistan and Lao PDR, this species is used to alleviate gas problems and indigestion [5, 17]. *Thalictrum foliosum* is used to cure diarrhoea and loss of appetite in Nepal [24], whereas the inhabitants of Shigar Valley use *T. foliosum* to treat eye ache. Present uses of *Ephedra gerardiana* and *Foeniculum vulgare* to treat respiratory and gastro-intestinal disorders, respectively were comparable to previous reports from Rasuwa District, Central Nepal [54] and China [59]. *Rumex nepalensis* is used against stomach pain and itching in Garhwal Himalaya.
[53], but the inhabitants of the study area use this plant species to treat delivery pain.

The comparative assessment of present applications of medicinal plant species with reported literature revealed strong heterogeneity in folk uses. These findings evidently showed that most of the species are confined in the mountains of Karakorum, which have rarely been reported before. In the regional contrast, our study showed substantial harmony with the work conducted by Hussain et al. in the central Karakorum Range (I. [21]) and to some extent with the ethnobotanical survey carried out in Deosai plateau (Western Himalaya Baltistan region [11, 12]). Although, both studies were focused on Balti communities, however present evaluation gives strong clues of the variations in ethnobotanical uses with respect to geographical location and difference in vegetation type [27, 28].

Our findings also depicted some resemblance with studies conducted in the Karakorum range of Haramosh and Bugrote valleys by ([34]; and [32]). However, no understandable resemblance was observed with the ethnobotanical surveys conducted in other regional communities (Brushiski, Shina and Wakhi) except the work [25] in Khunjerab Hunza, where less than fifteen species were similar to present report. This may be because of floristic resemblance of these two mountainous areas; however different communities hold diverse ethno-flora and related traditional knowledge. Furthermore, change in indigenous knowledge might be linked with difference in area, language and the culture of local communities. Therefore, present assessment pointed out that, phytotherapies of Balti community are diverse and unique in these mountain terrains.

The findings of present study were also compared with previous studies conducted in the Himalayas of India, China and Nepal, which revealed that only few plant species were comparable which include: Allium carolinianum, Allium cepa, Artemisia scoparia, Berginia stracheyi, Hippophae rhamnoides and Thymus linearis to India, China and Nepal. These results may be linked with the floristic and cultural similarity, because analogous to Baltistan; Ladakh is also the home of Balti and Brokpa communities [13, 61], which have similar traditional knowledge on surrounding plant biodiversity. Additionally, due to similar climatic, topographic and edaphic conditions; the flora of study area shares a number of species with Ladakh, Jammu and Kashmir state of India [36].

Quantitative assessment of ethnobotanical data
Homogeneity in the traditional knowledge of medicinal plants used by the Balti community was evaluated using quantitative indices such as frequency of citation (RFCs)
| Botanical Name/Local name /Voucher number | Family     | Availability | Habit       | Part(s) Used | Ailment(s) cured                  | Application | Formulation | RFCs | FL (%) |
|----------------------------------------|------------|--------------|-------------|-------------|----------------------------------|-------------|-------------|------|--------|
| Allium cepa L. /chong/SP-124           | Alliaceae  | Cult.        | Herb Bulb   |             | Indigestion and Vomiting         | Oral        | Cook in ash | 0.119| 60.00  |
| Allium carolinianum DC /Broq chong/SP-74| Alliaceae  | Wild         | Herb Bulb   |             | Abdominal pain                   | Oral        | Cook in ash | 0.119| 80.00  |
| Foeniculum vulgare Mill. /Badian/SP-48 | Apiaceae   | Cult.        | Herb Seed   |             | Constipation and gastric trouble | Oral        | Decoction   | 0.167| 28.57  |
| Pimpinella diversifolia DC. /Kohriod/SP-135 | Apiaceae | Wild         | Herb Seed/Leaves |    | Fever, abdominal pain and as blood tonic | Oral       | Decoction   | 0.274| 73.91  |
| Ferula jaeschkeana Vatke/Sib/SP-64     | Apiaceae   | Wild         | Herb Latex/Root powder | | Asthma, arthritis and menstrual irregulation | Oral       | Juice/decoction | 0.357| 80.00  |
| Carum carvi L./Thalae/SP-63            | Apiaceae   | Wild         | Herb Seed   |             | Asthma                           | Oral        | Decoction   | 0.167| 85.71  |
| Daucus carota L/Wafro/SP-64            | Apiaceae   | Cult.        | Herb Root   |             | Urethritis                       | Oral        | Cook in water | 0.214| 77.77  |
| Artemisia santolinifolia Turcz.ex Krasch. /Kho bustae/SP-120 | Asteraceae | Wild         | Herb Leaves | | Abdominal worms                  | Oral        | Decoction   | 0.298| 92.00  |
| Tanacetum falconeri Hook.f./Lhrtialo/SP-137 | Asteraceae | Wild         | Herb Flower |             | Back ache, abdominal pain and gastric trouble | Oral       | Decoction   | 0.476| 95.00  |
| Taraxacum officinale Weber /Shantha/SP-56 | Asteraceae | Wild         | Herb Root   |             | Hypertension                     | Oral        | Boiled root | 0.357| 83.33  |
| Saussurea symbioniana (Fielding & Gardner) Lipsch./Smanipasha/SP-138 | Asteraceae | Wild         | Herb Whole plant | | Back ache, fever and dermatitis   | Oral        | Decoction   | 0.321| 92.59  |
| Artemisia scoparia Waldst. /Khasmar/SP-118 | Asteraceae | Wild         | Herb Leaves |             | Diabetes                         | Oral        | Infusion    | 0.143| 75.00  |
| Berberis brandsiana Ahrendt /Skorbu/SP-150 | Berberidaceae | Wild         | Shrub Leaves | | Jaundice                         | Oral        | Infusion    | 0.333| 92.85  |
| Berberis orthobotrys Bien. ex Aitch. /Skorbu/SP-94 | Berberidaceae | Wild         | Shrub Leaves | | Jaundice                         | Oral        | Infusion    | 0.333| 92.85  |
| Berberis pseudumbellata subsp. gigitica Jafri /Skorbu/SP-60 | Berberidaceae | Wild         | Shrub Seed   | | Jaundice                         | Oral        | Infusion    | 0.333| 92.85  |
| Betula utilis D.Don./Staqpa/SP-114     | Betulaceae  | Wild         | Tree Papery bark | | Ringworm                         | Topical     | Warm bark | 0.190| 93.75  |
| Biebertsteinia odora Steph. ex Fisch./Chundol/SP-69 | Biebertsteiniaee | Wild         | Herb Flower | | Migraine and fever               | Oral        | Decoction   | 0.202| 94.11  |
| Onosma hispida Wall. ex G.Don. /Kangmar/SP-50 | Boraginaceae | Wild         | Herb Whole plant | | Constipation                     | Oral        | Fresh/Boiled is taken | 0.226| 89.47  |
| Myosotis alpestris F.W.Schmidt /Mandaqskor/SP-47 | Boraginaceae | Wild         | Herb Flower | | Bronchitis, fever and asthma     | Oral        | Powder     | 0.357| 90.00  |
| Arnebia guttata Bunge /Thangmarsi/SP-138 | Boraginaceae | Wild         | Herb Root   |             | Heart burn and indigestion       | Oral        | Fresh root is taken | 0.262| 90.90  |
| Descurainia sophia (L.) Webb & Berth/Khashir/SP-140 | Brassicaceae | Wild         | Herb Seed   |             | Fever                            | Oral        | Decoction   | 0.167| 57.14  |
| Brassica rapa L./Mula/SP-139            | Brassicaceae | Wild         | Herb Root   |             | Hepatitis                        | Oral        | Fresh root is taken | 0.298| 60.00  |
| Capparis spinosa Jafri/Traba/SP-147     | Capparidaceae | Shrub        | Shrub leaves |             | Arthritis and back ache          | Oral        | Decoction   | 0.214| 83.33  |
| Common Name                          | Scientific Name                        | Family             | Habitat Type | Part Used          | Condition(s)                                      | Preparation              | Dosage |
|-------------------------------------|----------------------------------------|--------------------|--------------|-------------------|--------------------------------------------------|--------------------------|--------|
| Kochia scoparia                     | Chenopodiaceae                         | Wild Herb Leaves   | Tiredness and hypertension | Oral Decoction | 0.167 35.71                                     |                          |        |
| Juniperus excelsa                   | Cupressaceae                           | Wild Tree Fruit    | Gastric trouble | Oral Decoction   | 0.286 83.33                                     |                          |        |
| Cuscuta epithymum                   | Cucurbitaceae                          | Wild Herb Stem     | Asthma        | Oral/Decoction    | 0.143 75.00                                     | 0.262 100.00             |        |
| Hippophae rhamnoides subsp. turkestanica | Elaeagnaceae                             | Wild Shrub Fruit, Leaves | Hypertension and stomach ulcer | Oral Fresh fruit is eaten |                          |                      |        |
| Elaeagnus angustifolius             | Elaeagnaceae                           | Cult. Tree Fruit   | Bronchitis    | Oral Decoction    | 0.238 85.00                                     |                          |        |
| Ephedra gerardiana Wall ex. Stapf. /Chae | Ephedraceae                            | Wild Shrub Branches | Bronchitis, Vaginal contraction | Oral/Topical Decoction | 0.179 80.00                                     |                      |        |
| Equisetum arvense                   | Equisetaceae                           | Wild Herb Whole plant | Urethritis | Oral Decoction    | 0.310 92.30                                     |                          |        |
| Pluot sativum L./Pokhstran/SP-86    | Fabaceae                               | Cult. Herb Fruit   | Constipation  | Oral Cooked fruits | 0.238 55.00                                     |                          |        |
| Tifolium repens                     | Fabaceae                               | Wild Herb Leaves   | Eye ache and wound | Topical Fresh leaves | 0.298 36.00                                     |                      |        |
| Sophora alopecuroides L. (Royle) Baker/Khakhul/SP-56 | Fabaceae                               | Wild Herb Root     | Joint pain    | Oral Decoction    | 0.214 83.33                                     |                          |        |
| Desmodium gangeticum L. /Shingnar/SP-73 | Fabaceae                               | Wild Shrub Root    | Cough, cold, asthma | Oral Decoction | 0.286 87.50                                     |                          |        |
| Hedyosmum falconeri Baker/Kharun/SP-148 | Fabaceae                               | Wild Herb Root     | Loss of appetite | Oral Fresh root is taken | 0.190 87.50                                     |                      |        |
| Vicia faba L./Naqstarn/SP-82        | Fabaceae                               | Cult. Herb Seed    | Stomach ulcer | Oral Seed is cooked | 0.238 85.00                                     |                          |        |
| Trigonella frutum-graecum L/Shalmilk/SP-152 | Fabaceae                               | Cult. Herb Leaves  | Low blood pressure and gastric trouble | Oral Fresh material with curd | 0.226 7894                                     |                      |        |
| Corydalis adiantifolia Hook. & Thomson/Shampoo/SP-49 | Fumariaceae                           | Wild Herb Root     | Hair tonic    | Topical Paste     | 0.286 87.50                                     |                          |        |
| Swertia cordata (G.Don) Clark/Tikta/SP-147 | Gentianaceae                            | Wild Herb Whole plant | Diabetes | Oral Decoction    | 0.262 90.90                                     |                          |        |
| Ribes orientale Desf./Askuta/SP-57  | Grossulariaceae                        | Wild Shrub Fruits  | Abdominal worms | Oral Eaten fresh | 0.202 88.23                                     |                          |        |
| Ribes himalense Royle ex Decne./Askuta/SP-59 | Grossulariaceae                        | Wild Shrub Fruit   | Abdominal pain | Oral Eaten fresh | 0.250 95.23                                     |                          |        |
| Ribes alpestre Decne./Askuta/SP-58  | Grossulariaceae                        | Wild Shrub Fruit   | Abdominal pain | Oral Eaten fresh | 0.262 68.18                                     |                          |        |
| Juglanis regia L./Starga/SP-98     | Juglandaceae                           | Cult. Tree Seed    | Asthma        | Oral Fresh or dry seeds are eaten | 0.179 6666                                     |                          |        |
| Draccephalum nutans L/Shundun/SP-76 | Lamiaceae                              | Wild Herb Leaves   | Asthma, gastric trouble post birth trace release | Oral Decoction | 0.262 86.36                                     |                          |        |
| Coriandrum sativum L./Naqqoshoto/SP-136 | Lamiaceae                            | Cult. Herb Seed    | Abdominal pain | Oral Fresh or dry seeds are eaten | 0.250 47.61                                     |                          |        |
| Mentha royleana Benth./Foling/SP-75 | Lamiaceae                              | Wild Herb Leaves   | Fever and gastric trouble | Oral Decoction | 0.262 81.81                                     |                          |        |
| Nepeta leucolaena Benth./Azumal/SP-149 | Lamiaceae                             | Wild Herb Leaves   | Indigestion and abdominal pain | Oral Decoction | 0.167 85.71                                     |                          |        |
| Mentha arvensis L./Piono/SP-78      | Lamiaceae                              | Cult. Herb Leaves  | Pimples and pustules | Oral paste | 0.357 83.33                                     |                          |        |

**Table 3** Enumeration of medicinal plant species of Shigar Valley, Baltistan Karakorum, Pakistan (Continued)
Table 3: Enumeration of medicinal plant species of Shigar Valley, Baltistan Karakorum, Pakistan (Continued)

| Plant Name                  | Scientific Name | Family      | Use                  | Part Used | Application Method |
|-----------------------------|-----------------|-------------|----------------------|-----------|--------------------|
| Thymus linearis             | Benth.          | Lamiaceae   | Oral                 | Leaves    | Decoction          |
| Morus nigra                 | L.              | Moraceae    | Oral                 | Fresh     | Fresh material     |
| Fraxinus xanthoxyloides     | (G.Don.) DC.    | Oleaceae    | Oral                 | Bark      | Applied            |
| Papaver nodicaule           | L.              | Papaveraceae| Oral                 | Flowers   | Powder             |
| Hordeum vulgare             | L.              | Poaceae     | Oral                 | Seedlings | Topical powder     |
| Triticum aestivum           | L.              | Poaceae     | Oral                 | Bread     | Oral               |
| Zea mays                    | L.              | Poaceae     | Oral                 | Carpels   | Decoction          |
| Rumex nepalensis            | Spreng.         | Polygonaceae| Oral                 | Seeds     | Fresh stem material|
| Fagopyrum esculentum        | Meth.           | Polygonaceae| Oral                 | Seeds     | Powder             |
| Polygonum tataricum         | L.              | Polygonaceae| Oral                 | Leaves    | Powder             |
| Rheum webbianum             | Royle.          | Polygonaceae| Oral                 | Stem      | Fresh stem material|
| Rumex patientia             | L.              | Polygonaceae| Topical              | Paste     | Oral               |
| Punica granatum             | L.              | Punicaeae    | Oral                 | Fruit     | Eaten fresh        |
| Aconitum violaceum          | var. weileri    | Ranunculaceae| Oral                 | Root      | Paste              |
| Clematis alpina             | subsp. sibirica | Ranunculaceae| Oral                 | Whole plant| Topical powder     |
| Delphinium brunonianum      | Royle           | Ranunculaceae| Topical              | Paste     | Oral               |
| Thalictrum foliolosum       | DC.             | Ranunculaceae| Oral                 | Fresh material| Topical paste      |
| Prunus armeniaca            | L.              | Rosaceae    | Oral                 | Root      | Powder with oil    |
| Rosa indica                 | L.              | Rosaceae    | Oral                 | Root      | Whole plant        |
| Cerasus alpinus              | L.              | Rosaceae    | Oral                 | Root      | Whole plant        |
| Malus prunifolia             | L.              | Rosaceae    | Oral                 | Root      | Whole plant        |
| Pyrus communis               | L.              | Rosaceae    | Oral                 | Root      | Whole plant        |
| Sorbus aucuparia             | L.              | Rosaceae    | Oral                 | Root      | Whole plant        |
| Scientific Name                    | Family       | Growth Form | Part Used  | Use/Method            | Route of admin | Quantity | Effective%  |
|-----------------------------------|--------------|-------------|------------|-----------------------|----------------|----------|-------------|
| Spiraeae canescens D.Don/Khabber/SP-54 | Rosaceae     | Wild Shrub  | Branches   | Abdominal pain        | Oral Decoction | 0.167    | 42.85       |
| Prunus avium (L.) Gilas/SP-102     | Rosaceae     | Cult. Tree   | Fruit     | Constipation          | Oral Cooked fruit | 0.238    | 55.00       |
| Malus pumila Mill/Kushu/SP-103     | Rosaceae     | Cult. Tree   | Fruit     | Weakness, blood tonic | Oral Eaten fresh | 0.202    | 58.82       |
| Rosa webbiana L/Sia/SP-71          | Rosaceae     | Wild Shrub   | Root Bark, Fruit | Hypertension, cold and flu | Oral Decoction | 0.286    | 95.83       |
| Salix alba L/Hilangma/SP-89        | Salicaceae   | Cult. Tree   | Leaves, Inflorescence | Post-birth bleeding, Lactation | Oral Decoction | 0.167    | 85.71       |
| Populus nigra L./Naghbiar/SP-92    | Salicaceae   | Cult. Tree   | Bark      | Jaundice, ring worm   | Oral/Topical Decoction | 0.202    | 64.70       |
| Berginia ciliata (Haw.) Sternb./Schapur/SP-43 | Saxifragaceae | Wild Herb | root | Stomach ulcer | Oral Decoction | 0.310    | 96.15       |
| Solanum nigrum L./Drumbahokhlo/SP-156 | Solanaceae    | Wild Herb    | Fruit     | Tooth ache            | Oral Fruits are toasted | 0.179    | 86.66       |
| Datura fastuosa L/Datura/SP-83     | Solanaceae   | Wild Herb    | Leaves    | Pimples and pustules  | Topical Fresh material | 0.155    | 76.92       |
| Urtica dioica L/Khashoshing/SP-157 | Urticaceae   | Wild Herb    | Whole plant | Constipation          | Oral Cooked material | 0.250    | 76.19       |
| Tribulus terrestris L/Kokoring/SP-143 | Zygophyllaceae | Wild Herb    | Fruit    | Urethritis            | Oral Decoction | 0.238    | 90.00       |
and fidelity level (FL). Relative frequency of citation (RFCs) of the reported species was ranged between 0.049 to 0.377. *Tanacetum falconeri* and *Thymus linearis* exhibited high RFC value (0.377), followed by *Taraxacum officinale* (0.344) and *Mentha arvensis* (0.327), whereas lowest RFCs value (0.049) was calculated for *Ranunculus repens*. These findings were in agreement to Mutheeswaran et al. [42] in case of *Allium cepa*, whereas disagree in the case of *Tribulus terrestris*.

Fidelity level (FL) indicates the most preferred species mentioned by local people to treat a particular disease. According to Lozada et al. information about FL of a species is of significant value compared to other plant based information [38]. The fidelity level of reported species ranged from 28.50 to 100%. Two species i.e. *Hippophae rhamnoides* and *Thymus linearis* depicted 100% fidelity level, whereas lowest FL was calculated for *Foeniculum vulgare* (28.50%). These findings were in agreement to [23]. Additionally, *Ribes himalayense*, *Rosa webbiana*, *Tanacetum falconeri*, *Beibersteinia odora* and *Betula utilis* were the most preferred species with FL more than 90%. The high FL of these species may be attributed to availability, distribution and detail information regarding therapeutic uses, dosage and recipes of these species.

**Novelty and future impact**

Present survey is the first comprehensive report on ethnomedicinal uses of plant species in Shigar valley, and reveals that the inhabitants of study area possess ample traditional knowledge on local flora. A careful probe on documented plant species for their medicinal and traditional uses from different areas of Pakistan revealed that, 22 plant species were reported for the first time from the study area, including five species: *Aconitum heterophyllum*, *Salix alba*, *Prunus avium*, *Ranunculus repens*, *Populus nigra* and *Malus pumila*, which were new to regional flora. Two endemic species i.e. *Aconitum violaceum* subs. *Weileri* and *Arnebia guttata* were used to treat women sterility, abdominal worm, tonsillitis, inflammation and indigestion by the inhabitants of the study area (Table 3). Among others: *Artemisia santolinifolia* was used against abdominal worms, *Biebersteinia odora* to treat migraine and fever; *Corydalis adiantifolia* as hair tonic, *Clematis alpina* var. *sibirica* and *Desmodium guineicum* against cough, cold and asthma, *Acantholimon lycopoidioides* for stomach ulcer, *Dracocephalum nutans* to treat asthma, gastric trouble, and post birth trace release, *Ferula jaesa keana* for arthritis, asthma, menopause, *Fraxinus xanthoxyloides* to expel ringworm and tooth ache, *Hedysarum falconeri* in case of indigestion, loss of appetite and constipation, *Myosotis alpestre* to treat asthma, bronchitis, and fever, *Parnassia nubicola* for low blood pressure, gastric trouble, *Saussurea simpsoniana* to treat back ache, fever and dermatitis, *Sophora alopecuroides* against arthritis and *Rumex patientia* for boils and pustules.

Present study illustrated diverse medicinal flora in the territories of Gilgit-Baltistan mountains. The exclusive alliance of medicinal plants, mountain restricted distribution and high level disagreement in traditional uses corroborate the significance of this study. Being the first inventory on medicinal flora of Shigar valley, present study offers baseline data for researchers, particularly interested in high mountains phyto-diversity and related traditional knowledge. The sub-alpine species in environs are practicable for conservation and cultivation [44, 50, 52]. The abundance of medicinal plant species in the study area could enhance the economic status of local communities by marketing and sustainable utilization. Local inhabitants can make their home gardens or micro park system of medicinally important species on their own land. However, illiteracy and lack of developmental packages are the major handicaps in the operation of such implications.

**Conclusion**

The wealth of endemic and indigenous plant knowledge of the Balti community living in extremely isolated and high mountain Shigar valley, Karakorum ranges-Pakistan is reported for the first time. This study presented ethnomedical flora and traditional knowledge of the local inhabitants of the area. However, it would be in jeopardy; if further inclusive research is not conducted. Because mountain dwellers are oblivious of the values of bio-cultural diversity and the rate of transformation of plant knowledge decreasing with the passage of time due to infusing allopathic drugs and changing life style. Therefore, a comprehensive study in high mountain areas could be of significant value to conserve the medicinal plant wealth and related traditional knowledge. Moreover, extensive ethnomedicinal studies could discover the hidden knowledge and may provide unique plant species for chemical screening, consequently may leads to novel drugs discovery.

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**Availability of data and materials**

We have already included all data in the manuscript collected during the field surveys.

**Declaration**

Medicinal plants used by the inhabitants of Shigar Valley, Baltistan region, Karakorum Range-Pakistan
Authors' contributions
ZA conducted field survey and collect data, wrote first draft of the manuscript. JA and SWK provided support in field survey, sampling and plant species identification. AP provided technical support and helped in write up and revision. SWK designed study and supervised the project, AMA helped in data collection, analysis and write up. All authors read and approved the final manuscript.

Ethics approval and consent to participate
Present study is purely based on filed survey instead of human or animal trials. However, formal consent was received from informants regarding data collection and publication; then the Participatory rural appraisal (PRA) approach as mentioned in the Kyoto Protocol was applied with the consent of the informant. Ethical guidelines of the International Society of Ethnobiology (http://www.ethnobiology.net/) were strictly followed.

Consent for publication
Our manuscript does not contain any individual's person data; therefore we didn't take any consent for publication.

Competing interests
The authors declare that they have no competing interests.

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