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LP, ZP, CT, and VV jointly designed the research; NK and AK screened titles and abstracts; LP screened full text articles; IS and MS provided taxonomic identification of species and contributed to the discussion with botanical and environmental aspects; LP, ZP, and CT conducted data analysis; LP, ZP, and VV drafted the article narrative and LP generated all figures and tables; LP and AK generated the study area map; all authors read and approved the final manuscript

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ORIGINAL RESEARCH PAPER

Medical ethnobotany of herbal practitioners in the Turkestan Range, southwestern Kyrgyzstan

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Abstract
This study recorded and analyzed traditional knowledge of medicinal plants in the Turkestan Range in southwestern Kyrgyzstan, where ethnobotanical knowledge has been largely under-documented to date. Data was collected through participant observation and both semi-structured and in-depth interviews with 10 herbal specialists. A total of 50 medicinal plant taxa were documented, distributed among 46 genera and 27 botanical families. In folk medicine they are applied in 75 different formulations, which cure 63 human and three animal ailments. Quantitative ethnobotanical indices were calculated to analyze traditional knowledge of the informants and to determine the cultural importance of particular medicinal plants. *Ziziphora pamiroalaica*, *Peganum harmala*, and *Inula orientalis* obtained the highest use value (UV). The best-represented and culturally important families were Lamiaceae, Asteraceae, and Apiaceae. Gastro-intestinal system disorders was the most prevalent ailment category. Most medicinal plants were gathered from nearby environments, however, species with a higher cultural value occurred at distant rather than nearby collection sites. The findings of this study proved the gap in documentation of traditional knowledge in Kyrgyzstan, indicating that further studies on the traditional use of wild plant resources could bring important insights into ecosystems' diversity with implications to human ecology and bio-cultural diversity conservation in Central Asia.

Keywords
Central Asia; ethnomedicine; human ecology; quantitative ethnobotany; traditional knowledge; bio-cultural diversity; gathering environments

Introduction

Currently, traditional medical systems, and in particular herbal remedies, still play an important role in the healthcare of millions of people in developing countries, who do not have access to modern medical care or cannot afford it [1]. However, these cultures and societies are undergoing rapid environmental, socioeconomic, and cultural changes. Much of traditional medical knowledge, which is considered an intangible

cultural heritage, is being irretrievably lost before it is documented, studied or even touched by science [2].

Although Central Asian traditional medicine has a very old and rich history, it is not as widely understood and studied as neighboring medical systems such as traditional Chinese medicine or Ayurveda [3]. It is recognized that Central Asian medicine was influenced mainly by the Unani Tibb (Greco-Arabic) system and its broad range of scholars. Yet, current folk medical practices have not been widely studied and various questions remain. Examples include how the relationship between plants and people developed further in particular regions with regards to the movement and isolation of ethnic groups, and the current status and importance of traditional knowledge (TK) among indigenous Central Asian societies after Soviet Union rule.

This period, over 70 years, was characterized by the unsustainable use of natural resources and by the neglect or even suppression of local beliefs, traditions and practices, which resulted in the significant loss of TK [4]. During this time, phytotherapy and the activities of local healers were restricted and botanical medicines were regulated by the government [3]. Consequently, people were rather obliged to leave behind their folk medicine and participate in comprehensive governmental health services. As a result, indigenous knowledge lost its natural importance until the collapse of the subsidized system of the Soviet Union, after which the revival of TK is supposed to have been of crucial importance. For example, Stickley et al. [5] studied the use of complementary and alternative medicine in eight former Soviet republics. Among all, they found the most prevalent use of folk medicine practices for the treatment of selected common health disorders in Kyrgyzstan. Another study [6] reported the revival of spiritual healing and shamanism in urban areas of Kyrgyzstan and Kazakhstan.

Although limited information on the use of medicinal plants in Kyrgyzstan is available in international sources of literature [7], there is evidence of several publications from Soviet times (e.g., [8,9]). However, this literature considered mainly scientifically recognized medicinal plants, or those manufactured for herbal medicaments and pharmacological preparations. Medicinal plant species used in folk medicine were poorly documented, not scientifically recognized and not included in the literature published at that time [10].

Remarkably, after the break-up of the Soviet Union, medicinal plants have rapidly regained the attention of rural communities in Central Asian countries [11]. From the recent study on the Tajik-Afghan border [12], it is obvious that natural vegetation may still be crucial in the primary healthcare and resilience of local people. Egamberdieva et al. [13], in the Uzbek Chatkal reserve, noted that medicinal plant resources also generate additional income. Comparable studies from Kyrgyzstan, however, are still lacking.

An English-language monograph concerning the medicinal plants of Central Asia has reviewed scattered literature sources on the medicinal plants of Kyrgyzstan and Uzbekistan [7]. The authors claim that numerous plants used in Kyrgyz folk medicine have not been documented and they have called for ethnomedicinal field studies to facilitate the identification of medicinal species used.

According to MEP [14], in distant and less accessible mountainous regions of the country, the collection of wild plants and non-timber forest products remains a fundamental livelihood strategy for the local people. There are medicinal herbs with promising economic value which could alleviate poverty in rural areas, but there is a lack of information on the use of these wild plants, their habitats and the sustainability of continuous harvesting [15].

To prevent further decline in Kyrgyz TK, again under threat nowadays due to substantial depopulation and urbanization – ethnobotanical studies documenting local knowledge, analyzing collection-use patterns and identifying traditional medicinal plant species are urgently needed. According to our best knowledge, there are no publications or studies documenting data on medicinal plant use in the Turkestan Range of Kyrgyzstan.

This study aimed to: (***i***) document the traditional use of medicinal plant species using standard ethnobotanical methods, (***ii***) assess the homogeneity of TK of the informants and determine culturally important species, (***iii***) analyze the collection patterns of medicinal plants, and (***iv***) do a comparative analysis of the medicinal plant species used on the basis of relevant studies from neighboring countries.

Material and methods

Study area

The study was performed in the villages of Oezgerush (39°75′ N and 70°05′ E) and Katran, including the surrounding mountainous area of the Turkestan Range in the most western part of southern Kyrgyzstan, bordering with Tajikistan (Fig. 1). This area belongs to the Leilek district of the Batken Province, with the administrative center being the town of Isfana. The Batken Province represents one of the poorest regions of the country, with more than 80% of population living below the poverty line [16]. Considering the health care options, in the Katran there is a small drugstore with only limited assortment of the basic medicaments. However, the hospital and convenient medical services are available in Isfana town located approximately 70 km (about 3 hours by local minibus) from Oezgerush and 50 km (about 2 hours by minibus) from Katran. Although there is possibility to access conventional healthcare, majority of rural population have constrains to afford it. Moreover, during the winter-time Isfana is generally inaccessible. In the mountainous regions, local families derive their livelihoods from subsistence farming systems consisting of extensive livestock (predominantly sheep, goats, and donkeys) and/or the cultivation of mainly potatoes, maize, apples and apricots.

The southern part of the province, along the Kyrgyz-Tajik border where our study area was located, is formed by the Turkestan Range which belongs to the Pamir-Alay Mountains. It is characterized by a semi-arid continental climate with significant changes in temperature and precipitation as a result of high elevation differences [17]. The average annual precipitation is estimated at 513 mm, varying from 150 to 500 mm in the plains of the dry lowlands to over 1000 mm in the mountains [18]. The study area, with an altitudinal range from 1450 to 3350 m a.s.l., is covered by three main types of natural vegetation. In the lowlands semi-desert/mountain steppe occurs

Fig. 1 Map of the study area.

(*Acanthophyllum-Stipa-Artemisia-Euphorbia-Ferula*). Riverbanks are dominated by riparian forest (*Salix-Populus-Betula-Tamarix-Hippophae*). The highest altitudes are formed by juniper forest (*Juniperus* spp.), and high plateaus by grassy alpine meadows [18,19]. Steep rocky slopes occurring throughout the area are dominated by various xerophytic shrubs and herbaceous species.

Data collection

The study was carried out over the period of July to August 2012. We targeted the most knowledgeable community representatives who were capable of providing specific information concerning the traditional medicinal use of local plant resources [20]. Therefore, the purposive sampling and snowball methods were applied in the selection of informants [21]. The study was undertaken with the participation of 10 key informants (one woman and nine men) whose age ranged from 26 to 78 years.

All participants in the study were ethnic Kyrgyz people. Since the time of the Soviet Union, most of the Kyrgyz population speaks Russian, which has remained the official language in Kyrgyzstan. Therefore, interviewees were free to choose the language (Kyrgyz or Russian) in which they wished to communicate. A local bilingual assistant accompanied the investigator for translation.

The Code of Ethics of the International Society of Ethnobiology (http://ethnobiology.net/code-of-ethics/) was followed. Prior to any research activity, each participant was familiarized with the project objectives, the survey was discussed and informed consent was obtained verbally.

Data was collected through semi-structured interviews and in-depth discussions [22], complemented with direct participant observation [23]. When possible, participants were observed and offered help primarily during home gardening, mowing hay, herding animals and collecting plant resources. Initially, respondents were asked to provide basic socioeconomic information (age, living place, occupation, and ethnicity). Subsequently, ethnobotanical information including the vernacular names of medicinal plant species used, plant parts used, their specific medicinal use, collection season, collection site, mode of preparation, and administration of the herbal remedies was documented. Three most knowledgeable informants were visited several times in order to capture the local knowledge and practices thoroughly.

Finally, respondents were asked to show the plant species mentioned on-site for preparation of a herbarium reference collection. Thereby, plant specimens were collected during informant-guided field excursions: "walks-in-the-woods" sensu Alexiades [24]. All plant material was collected by the first author and subsequently taxonomically identified in collaboration with the Gareev Botanical Garden of the National Academy of Sciences of the Kyrgyz Republic in Bishkek and the Department of Botany and Plant Physiology, Faculty of Agrobiology, Food and Natural Resources of the Czech University of Life Sciences in Prague. Voucher specimens were deposited in the herbarium of the National Museum in Prague (PR) and duplicates in the herbarium of the Gareev Botanical Garden in Bishkek. Species' botanical names were verified according to The Plant List (http://www.theplantlist.org). The spelling of local plant names was cross-checked with the most knowledgeable informants. Transliteration of the folk names into the English followed the style of Eisenman et al. [7].

Data analysis

Quantification of ethnobotanical data. At first, the ethnobotanical information collected was converted into use reports (UR). One UR corresponds to the event where the informant (i) mentions the use of a species (s) for the treatment of an ailment category (u) [25]. In the present study, if an informant used a particular species for the treatment of more than one health disorder belonging to the same ailment category, it was considered as one UR [26].

The health disorders reported by informants were classified into 15 ailment categories according to Cook [27]. A few of these categories were slightly modified in compliance with informant-defined medicinal uses to uncover significant local health

problems [e.g., plants for the treatment of haemorrhoids were placed in a separate category. Also the category veterinary (VET) was added].

Informant consensus factor (ICF). In traditional medical systems, the same plant species is often reported to be used for the treatment of various unrelated ailments. To verify the homogeneity of ethnomedicinal knowledge, an ICF suggested by Heinrich [28] was calculated. The ICF shows whether or not there is agreement among respondents in the use of plant species in particular ailment categories.

The factor was calculated as: $ICF = (N_{ur} - N_t)/(N_{ur} - 1)$, where N_{ur} is the number of UR in each ailment category and N_t is the number of species used in the same category by all informants interviewed.

ICF values range from 0 to 1. Low ICF values (close to 0) indicate that there is disagreement among informants over which plants they use for the treatment of particular ailment categories. A high ICF thus means that there is a well-defined selection criterion of species used for the treatment of diseases in a particular ailment category, which indicates that the knowledge between respondents is exchanged extensively and precisely [20].

Informant agreement ratio (IAR). The consensus on the individual species was determined by calculating the IAR [29] for each species. The IAR was calculated using the formula: $IAR = (N_r - N_a)/(N_r - 1)$, where N_r is the total number of UR registered for species and N_a is the number of ailment categories that are treated with this species. Also, this value varies between 0, when the number of ailment categories is equal to the number of UR, and 1, whereby all the respondents agree upon the use of the species for ailments of only one ailment category.

Fidelity level (FL). The FL developed by Friedman et al. [30] was used to determine the most frequently used species to treat a particular ailment category. This index was calculated for each species in a particular ailment category. The formula to calculate this index is: $FL(\%) = N_p/(N \times 100)$, where N_p is the number of UR for a plant species in a particular ailment category and N is the total number of UR for the same plant species [31]. Medicinal plants with the highest FL ratio are considered as the most preferred for a particular ailment category. A low FL of a given plant reveals its use within various ailment categories.

Use value (UV). This was a quantitative index which we used to demonstrate the relative importance of locally used species. The UV proposed by Phillips et al. [32] was calculated using the formula: $UV = U/N$, where U is the number of UR cited by each informant for a given plant species and N is the total number of informants interviewed. The UV index discloses the cultural importance of plant species, where the most frequently cited plant species will obtain a high UV [30].

Comparative analysis

Overlap analysis for medicinal plants. Firstly, medicinal species in the study area were compared with the all available recent ethnobotanical studies from Central Asia [11–13]. The large-scale study comprising different regions of Uzbekistan [11] was divided into three particular provinces with purpose to obtain comparable data. Medicinal plants' diversity was compared and Jaccard similarity indices were calculated following the methodology of González-Tejero et al. [33]. Jaccard index = $[C/(A + B - C)] \times 100$, where A is the number of species in sample A, B is the number of species in sample B and C is the number of species common to A and B.

Secondly, the medicinal species used from all the above-mentioned studies were divided and compared geographically according to their location within particular mountain systems. For example, in our study area *Achillea millefolium* L. was not documented, however it is included in the Pamir-Alay Mountains because it was encountered in this mountain system by another author [11].

Results

Diversity of medicinal plants, their uses, and custodians of ethnomedicinal knowledge

At present, due to traditions, but also the economic situation and isolation in a mountainous environment, local people still utilize various medicinal plants for primary or complementary health care. We documented 50 medicinal plant taxa (49 species and two distinct forms of one species, i.e., *Perovskia scrophulariifolia* Bunge) distributed among 46 genera and 25 botanical families. One medicinal plant could only be identified down to genus level (*Taraxacum* sp.). Lamiaceae is the best-represented family with eight species, followed by the Asteraceae (7), Apiaceae (6), and Rosaceae (6) families. Among the medicinal plants investigated, the dominant plant habit is herb consisting of 36 taxa, followed by shrub (11), tree (2) and vine (1).

The ethnobotanical data is shown in Tab. 1, where ethnomedicinal information on each species is complemented with two quantitative indices to demonstrate species' cultural value (UV) and consensus (IAR) on their medicinal uses among informants. Twelve medicinal plants were used only historically, in other regions or could not be found during field visits, so they were not identified taxonomically. To prevent loss of knowledge, ethnobotanical information on these folk species is provided in Tab. 2, whereas they are not further considered in data analysis.

For the 46 plant taxa reported by at least two informants, 420 medical citations were converted to 327 UR with the intention of ensuring relevant quantitative calculations. The highest number of UR was recorded for gastro-intestinal system disorders (GISD; 86), followed by circulatory system disorders (CSD; 46) and infections/infestations (41; II), as shown in the Tab. 3. The most often quoted health disorders are presented in Tab. 4, together with the most widespread plant species used to treat them.

The key informants were represented by the last Kyrgyz traditional healer known in the Leilek district (78 years old), whose source of livelihood has been for whole life selling of medicinal herbs on local markets. Afterwards we interviewed the most knowledgeable community members such as home-based herbalists and regular medicinal plant collectors-users. Informants occasionally share knowledge among themselves. Furthermore, they were observed to advise other members of the community when needed. In the study area medicinal plant knowledge is thus not only transmitted vertically among generations in a family model, but also horizontally within community. Although several publications about medicinal plants were published during the Soviet times, any informant referred to a book during interviews. Only one participant showed newspaper clipping about *Hypericum perforatum* L.

The role of women in traditional medicine is similar in many Islamic cultures, where specific ethnomedicinal knowledge remains customarily a male-exclusive domain, as for example found by Chellapandian et al. [25] and Keusgen et al. [34]. Among our informants there was only one elderly woman. She had, however, a considerable knowledge of medicinal plants acquired during her lifetime spent in the mountainous region. Hence, we believe that women are also eminent custodians of ethnobotanical knowledge. Based on the low frequency of citation of women and child health disorders, male researcher could miss some information due to cultural boundaries. Further gender-sensitive studies with female investigators are necessary to better approach this issue. In general, younger women and children were observed as regular gatherers of the most useful plants (firewood, fruits from orchards and economic plants).

Quantitative ethnobotany

The ICF values and related aspects are associated with ailment categorization reported in Tab. 3. The ICF value in our study varies from 0 to 1, with the mean value being 0.49. The highest ICF was calculated for the VET category (ICF = 1), followed by the categories of haemorrhoids (HMR; ICF = 0.83) and Skeleto-muscular system disorders (SMSD; ICF = 0.76). The most frequently cited category, GISD (86 UR), showed the broadest spectrum of 33 species used, with overall consensus relatively high (ICF

Tab. 1 Traditional uses of medicinal plants among herbal practitioners in the Turkestan Range (Leilek district, Kyrgyzstan, Pamir-Alay Mountains).

Botanical name and voucher specimen No.	Family	Gathering environment	Vernacular name[a]	Plant life-form	Part used	Local medicinal use/ailments treated	Mode of preparation	Mode of application	Detailed administration	Seasonal availability	UV[b]	IAR[c]
Achillea arabica Kotschy PR 837022	Asteraceae	Anthropic (nearby)	Мин жалбрак сарыбаш (K), Тысячелистник (R) Min zhalbrak saribasch, Tysyachelistnik (E)	Herb	Aerial part	Stomach ache, digestion problems	Decoction	Oral	Drink 1 cup of tea 2–3 times per day. Infuse long (for 20–30 minutes).	Jun–Aug	0.3	1
Achillea asiatica Serg. PR 837047	Asteraceae	Anthropic (nearby)	Мин жалбрак (K), Тысячелистник (R)	Herb	Aerial part	Stomach ache, digestion problems	Decoction	Oral	Drink 1 cup of tea 2–3 times per day. Boiling should last 20–30 min.	Jun–Aug	0.2	NC[d]
			Min zhalbrak, Tysyachelistnik (E)		Leaf	Wounds	Fresh	Topical	Attach crushed leaves.			
Allium carolinianum DC. PR 837033	Alliaceae	Mountainous slopes (distant)	Сасык матал, Тоу пияз (K) Sasyk matal, Tou piyaz (E)	Herb	Bulb	Tonic, appetite stimulator, jaundice	Fresh	Oral	Eat the fresh bulb.	Jul–Sep	0.5	0
						Skin and eye inflammation		Topical	Attach the fresh cut bulb.			
Althaea officinalis L. PR 837020	Malvaceae	Semi-dessert/steppe (nearby)	Гулкайр (K) Gulkair (E)	Herb	Seed	Heart disorders	Fresh, dried, infusion	Oral	Eat the seeds or prepare a tea	Sep–Oct	0.1	NC[d]
Amygdalus bucharica Korsh. PR 837027	Rosaceae	Mountainous slopes (distant)	Бадам (K) Badam (E)	Tree	Seed	Stomach ache, gastritis, gastric ulcer angina, asthma, toothache	Fresh, dried	Oral	Consume 4–5 seeds 3 times per day.	Sep–Oct	1	0.67
						Hemorrhoid	Paste	Topical	Spread paste made from fresh seeds.			
Anethum graveolens L. PR 837003	Apiaceae	Anthropic (nearby)	Укроп (R) Ukrop (E)	Herb	Aerial part	Digestion, appetite stimulator, kidney stones	Fresh, dried, infusion	Oral	Prepare a tea, 1 teaspoon per small teapot, or add it fresh into dishes and salads.	Jun–Sep	0.3	0.5

Tab. 1 Continued

Botanical name and voucher specimen No.	Family	Gathering environment	Vernacular name[a]	Plant life-form	Part used	Local medicinal use/ailments treated	Mode of preparation	Mode of application	Detailed administration	Seasonal availability	UV[b]	IAR[c]
Angelica ternata Regel & Schmalh. PR 837032	Apiaceae	Mountainous slopes (distant)	Алхорот (K) Alkhorot (E)	Herb	Aerial part	Headache, nerves, hypertension, flu, angina, sore throat, stomach ache, digestion, appetite stimulator, kidney and liver disorders, cleaning of blood, heart emasculation	Infusion Dried	Oral Oral	Prepare a tea from 1 tablespoon per teacup. Drink 3 times per day 1 cup of tea. Use as a (medicinal) spice for soups and dishes.	Jul–Aug	1.3	0.5
Arnebia euchroma (Royle) I.M.Johnst. PR 837014	Boraginaceae	Mountainous slopes, Juniper forest (distant)	Тогенек, Тогендык (K) Togenek, Togendyk (E)	Herb	Root	Tuberculosis, cough, flu	Decoction	Oral	Prepare a decoction of the root in the milk.	Jul–Aug	0.6	0.8
Artemisia absinthium L. PR 837046	Asteraceae	Anthropic (nearby)	Эрмен (K) Ermen (E)	Herb	Leaf, flower	High blood pressure, headache, kidney stones	Infusion	Oral	Dry it shaded and then prepare a tea, use 1 teaspoon per small teapot. Drink in the morning, noon and evening.	Jun–Aug	0.9	0.75
Berberis integerrima Bunge. PR 837043	Berberidaceae	Riparian forest, Anthropic (nearby)	Каратат (K) Karagat (E)	Shrub	Root, bark	Fractures	Decoction	Oral	Prepare a decoction from fresh or dried bark of the trunk, branches or roots. Use 1–2 teaspoons per small teapot. Drink 2 times per day for 2 or 3 days.	May–Oct	0.7	1
Bunium persicum (Boiss.) B. Fedtsch. PR 837001	Apiaceae	Mountainous slopes (distant)	Зире (K) Zire (E)	Herb	Seed	Appetite stimulator, gastritis, stomach ache, headache, flu, cold	Infusion Dried	Oral Oral	Prepare a tea from dried seeds. Use as a (medicinal) spice for dishes.	Jul–Aug	0.8	0.57

Tab. 1 Continued

Botanical name and voucher specimen No.	Family	Gathering environment	Vernacular name[a]	Plant life-form	Part used	Local medicinal use/ailments treated	Mode of preparation	Mode of application	Detailed administration	Seasonal availability	UV[b]	IAR[c]
Capparis sicula subsp. *herbacea* (Willd.), D. Rivera, Obón & Alcaraz PR 837023	Capparaceae	Semi-desert/steppe (nearby)	Koopry (K) Koorgu (E)	Shrub	Seed, root	Haemorrhoid, leg, and back pain	Fresh, dried Infusion	Internal Wash/bath	Insert a seed into the rectum. Prepare an infusion from seeds and/or roots and wash the body.	Sep	0.5	0.75
Cichorium intybus L. PR 837024	Asteraceae	Anthropic (nearby)	Талкы (K) Talky (E)	Herb	Root	Scabies Stomach problems	Infusion Decoction	Wash/bath Oral	Prepare an infusion from the root and then clean (wash) the body. Drink a decoction every day 1–3 times in order to release pain.	Aug	0.3	0.5
Conioselinum vaginatum (Spreng.) Thell. PR 837030	Apiaceae	Mountainous slopes, Juniper forest (distant)	Геренч (K) Gerench (E)	Herb	Root	Heart pain and heart disorders	Fresh, dried	Oral	Chew small piece of the root every day. Or consume the piece of the root 3 times per day.	Aug–Sep	0.3	1
Convolvulus arvensis L. PR 837012	Convolvulaceae	Anthropic (nearby)	Печек чоп (K) Pechek chop (E)	Herb	Leaf	Wounds	Fresh	Topical	Crush the fresh leaves and apply topical on the wound.	Aug–Sep	0.5	1
Corydalis fedtschenkoana Regel PR 837000	Papaveraceae	Mountainous slopes (distant)	Опмон кара (K) Orman kara (E)	Herb	Aerial part	Fractures, leg pain, liver and kidney disorders	Infusion	Oral	Prepare a tea from 2 teaspoons per small teapot. Drink a tea 1–2 times every day (for 2–3 days) mainly before sleeping.	Aug–Sep	0.8	0.71

Tab. 1 Continued

Botanical name and voucher specimen No.	Family	Gathering environment	Vernacular name[a]	Plant life-form	Part used	Local medicinal use/ailments treated	Mode of preparation	Mode of application	Detailed administration	Seasonal availability	UV[b]	IAR[c]
Cuscuta campestris Yunck. PR 837004	Cuscutaceae	Anthropic (nearby)	Зар печек (K) Zar pechek (E)	Vine	Aerial part	Kidney and liver disorders, jaundice	Infusion	Oral	Prepare a tea and drink every day for 10 days.	Jul–Aug	0.4	0.33
Dracocephalum stamineum Kar. & Kir. PR 837034	Lamiaceae	Mountainous slopes (distant)	Возноч (K) Voznoch (E)	Herb	Aerial part	High blood pressure, kidney stones, liver and heart disorders, jaundice	Infusion	Oral	Prepare a tea, use 1 teaspoon of dry plant per 1 teapot. Let it infuse around 20 minutes. Drink 3 times every day.	Jul–Aug	0.8	0.57
Ephedra equisetina Bunge PR 837025	Ephedraceae	Mountainous slopes (distant)	Чекенде (K) Chekende (E)	Shrub	Aerial part, fruit	Wounds	Powder	Topical	Grind dried fruit in a hand and put it on the wound to recover and heal it.	Sep–Oct	0.6	0.6
						Fractures, disorders of internal organs	Infusion	Oral	Drink watery tea – herbal remedy has strong flavor.			
						Leg pain, rheumatism	Decoction	Wash, bath	Boil it and pour to big bowl, then put legs inside and steam them.			
Euphorbia monocyathium (Prokh.) Prokh. PR 837026	Euphorbiaceae	Mountainous slopes (distant)	Аюот (K) Медведь Корень (R) Ayuuvot, Medvedi koren (E) ("the bear's root")	Herb	Root	Disorders, ulcers and inflammations of all gastrointestinal and urinary system, angina, toothache, jaundice	Fresh, dried	Oral	Chew and eat pieces around 3 mm, 3 times a day 1 piece. Use up to 30 days.	Aug–Sep	1.2	0.64
							Tincture	Oral	Extract the root in a spirit for 15 days in a dark place. Ingest 3 times per day 1 teaspoon.			

Tab. 1 Continued

Botanical name and voucher specimen No.	Family	Gathering environment	Vernacular name[a]	Plant life-form	Part used	Local medicinal use/ailments treated	Mode of preparation	Mode of application	Detailed administration	Seasonal availability	UV[b]	IAR[c]
Ferula kokanica Regel & Schmalh. PR 837040	Apiaceae	Mountainous slopes (distant)	Ак чайир (K) Ak chair (E)	Herb	Sap	Angina, cough, bronchitis, runny nose, flu, cold, stomach ache	Dried	Oral	Make an incision to the plant and after certain time collect the rigid sap. Then chew/bite small pieces 3 times a day.	Jun–Jul	1.3	0.83
					Stem, branch		Infusion	Oral	Prepare a tea from dried stem or branches. One stick around 10 cm per tea cup. Drink a tea 2–3 times every day.			
Heracleum sphondylium subsp. *montanum* (Schleich. ex Gaudin) Briq. PR 837002	Apiaceae	Anthropic (nearby)	Балтырган (K) Baltyrgan (E)	Herb	Root	High blood pressure	Infusion	Oral	Prepare a tea from 1 small teaspoon of dried chopped roots per teapot. Drink 2 times per day for several days.	Jul–Aug	0.3	1
Hippophae turkestanica (Rousi) Tzvelev PR 837044	Eleagnaceae	Riparian forest (nearby)	Чычырканак, Ашкаэан (K) Chychyrkanak, Ashkazan (E)	Shrub	Fruit	Gastric ulcer, gastritis, stomach ache, gastroenteritis, diarrhoea	Paste	Oral	Squash fruits and make oily paste. Consume 3 teaspoons every day, or mix a paste with warm water and drink up. Should be drunk 3 times before noon.	Aug–Sep	0.8	1

Tab. 1 Continued

Botanical name and voucher specimen No.	Family	Gathering environment	Vernacular name[a]	Plant life-form	Part used	Local medicinal use/ailments treated	Mode of preparation	Mode of application	Detailed administration	Seasonal availability	UV[b]	IAR[c]
Hypericum perforatum L. PR 837049	Hypericaceae	Anthropic (nearby)	Чай чоп (K), Зверобой (R) Chay chop, Zveroboy (E)	Herb	Aerial part	Stomach ache, digestion, high pressure, headache, jaundice	Infusion	Oral	Prepare a tea from dried herb.	Jun–Jul	1	0.56
						Scabies	Decoction	Wash, bath	Clean or wash the affected places on skin.			
Impatiens parviflora DC. PR 837017	Balsaminaceae	Anthropic (nearby)	Чтыр (K) Chtyr (E)	Herb	Seed	Stomach ache	Infusion	Oral	Prepare a tea, use 1 teaspoon of seeds per small tea pot. Infuse for 15 minutes and drink 3 times per day.	Aug	0.1	NC[d]
Inula orientalis Lam. PR 837041	Asteraceae	Mountainous slopes (distant)	Антыз (K) Antyz (E)	Herb	Root	Cough, sore throat, infections, infestations, toothache, diabetes	Decoction	Oral	Drink a tea 3 times per day.	Jul–Sep	1.4	0.54
						Common cold, cough and internal infestations of animals	Decoction	Oral	Give the cold decoction drink to animals.			
Juglans regia L. PR 837007	Juglandaceae	Anthropic (nearby)	Жангак (K) Zhangak (E)	Tree	Leaf	Scabies	Infusion	Wash/ bath	Prepare an infusion and clean or wash the affected places on skin.	May–Aug	0.3	0.5
					Seed	Vitamins and minerals deficiency	Fresh, dried	Oral	Consume a few seeds.	Sep		
Juniperus semiglobosa Regel PR 837031	Cupressaceae	Juniper forest (distant)	Арча (K) Ёлка (R) Archa, Jolka (E)	Shrub	Branch	Flu, runny nose, bronchitis	Smoke	Inhalation	Burn the dry branches and inhale the antimicrobial smoke.	Apr–Oct	0.6	0.6
					Fruit	Stomach ache	Infusion	Oral	Prepare a tea from several fruits.			

Tab. 1 Continued

Botanical name and voucher specimen No.	Family	Gathering environment	Vernacular name[a]	Plant life-form	Part used	Local medicinal use/ailments treated	Mode of preparation	Mode of application	Detailed administration	Seasonal availability	UV[b]	IAR[c]
Malva neglecta Wallr. PR 837005	Malvaceae	Anthropic (nearby)	Нан чоп, Маи токоч (K) Nan chop, Mai tokoch (E)	Herb	Aerial part Seed	Woman uterine disorders, pregnancy and obstetric complications Digestion problems	Infusion Infusion	Oral Oral	Prepare a tea, drink regularly. Prepare a tea from a few seeds.	Aug–Sep	0.2	0
Marrubium anisodon K.Koch PR 837016	Lamiaceae	Anthropic (nearby)	Котур чоп (K) Kotur chop (E)	Herb	Aerial part	Skin eczemas and scabies	Infusion	Wash, bath	Prepare an infusion and when it is lukewarm wash the skin.	Jul–Aug	0.3	0.5
Mentha longifolia var. *asiatica* (Boriss.) Rech.f. PR 837015	Lamiaceae	Anthropic (nearby)	Жалпыз (K) Zhalpyz (E)	Herb	Aerial part	High pressure, stomach ache, ulcers of gastro-intestinal system, kidney disorders, source of vitamins	Fresh, dried	Oral	Prepare a tea, use 1 teaspoon per small tea pot. Drink 2–3 times per day.	Jul–Aug	0.8	0.51
Origanum vulgare subsp. *gracile* (K. Koch) letsw. PR 837013	Lamiaceae	Anthropic (nearby)	Душиез (K) Dushies (E)	Herb	Aerial part	Flu, angina, high pressure, internal organ disorders	Infusion	Oral	Prepare a tea from 1–2 teaspoons per small teapot. Use 2–3 cups daily for 10 days. Infuse for 15–20 min.	Jul	0.4	0.5
Peganum harmala L. PR 837019	Zygophyllaceae	Semi-desert/ steppe (nearby)	Абдырашман, Усырык (K) Abdyrashman, Usyryk (E)	Herb	Root Aerial part	Skin disorders, scabies Cough, bronchitis	Decoction Smoke	Wash/ bath Inhalation	Clean affected places on skin. Burn a dry plant material and inhale smoke in enclosed room.	Aug–Sep	1.6	0.73

Tab. 1 Continued

Botanical name and voucher specimen No.	Family	Gathering environment	Vernacular name[a]	Plant life-form	Part used	Local medicinal use/ailments treated	Mode of preparation	Mode of application	Detailed administration	Seasonal availability	UV[b]	IAR[c]
					Aerial part, seed	Stomach ache, headache, inflammations of gastrointestinal system, digestion problems, lowering blood pressure	Infusion	Oral	Prepare a tea from 1 teaspoon per teapot.			
					Seed	Toothache	Fresh, dried	Topical	Attach on tooth to inhibit toothache.			
Perovskia scrophulariifolia Bunge (white form) PR 837011	Lamiaceae	Semi-desert/steppe (nearby)	Ак-коэн-тамук (K) Ak-koyen-tamuk (E)	Herb	Leaf	High blood pressure	Infusion	Oral	Prepare a tea, use 1–2 teaspoons per small teapot, drink 3 times every day.	Aug	0.5	0.5
						Scabies	Fresh, dried	Wash, bath	Clean or wash the affected places by infusion.			
Perovskia scrophulariifolia Bunge (purple form) PR 837010	Lamiaceae	Semi-desert/steppe (nearby)	Коэн тамук (K) Koyen tamuk (E)	Herb	Leaf	Skin disorders, wounds	Fresh	Topical	Apply the crushed leaves on desirable spots on the skin.	May–Sep	0.3	0.5
Plantago major L. PR 837021	Plantaginaceae	Anthropic, Riparian forest (nearby)	Бакажалбрак (K) Bakazhalbrak (E)	Herb	Leaf	Stomach ache, gastric ulcer, gastritis, digestion, headache, high pressure, kidney disorders, raised temperature	Infusion	Oral	Prepare a tea from 2 leaves per small teapot. Drink daily, 3 times a day for 10 days.	Jun–Aug	1.4	0.54
						Wounds	Fresh	Topical	Apply externally on wounds.			

Tab. 1 Continued

Botanical name and voucher specimen No.	Family	Gathering environment	Vernacular name[a]	Plant life-form	Part used	Local medicinal use/ailments treated	Mode of preparation	Mode of application	Detailed administration	Seasonal availability	UV[b]	IAR[c]
Polygonum hissaricum Popov PR 837035	Polygonaceae	Mountainous slopes (distant)	Кымызйек (K) Kymyzyek (E)	Herb	Stem, leaf	Immunostimulant, flu	Fresh	Oral	Consume the fresh stem and leaves rich in vitamins. Also refreshing wild vegetable snack.	May–Jul	0.7	0.67
Prunus armeniaca L. PR 837009	Rosaceae	Anthropic (nearby)	Урук (K) Uruk (E)	Tree	Fruit	Stomach ache, heartburn	Fresh, dried	Oral	Eat 5 mature fruits.	Jun–Aug	0.1	NC[d]
Prunus erythrocarpa (Nevski) Gilli PR 837028	Rosaceae	Mountainous slopes (distant)	Карачеке (K) Karacheke (E)	Shrub	Fruit	Nerves, headache, high pressure, limbs ache and stomach ache	Infusion Fresh	Oral Oral	Prepare a tea, 5 seeds per teapot. Drink 3 times per day for 1–2 days. Eat a several fresh fruits – medicinal snack.	Aug	0.7	0.25
Rhaponticum repens (L.) Hidalgo. PR 837048	Asteraceae	Anthropic (nearby)	Кекре чоп (K) Kekre chop (E)	Herb	Aerial part	Stomach ache, digestion problems, diarrhoea	Infusion	Oral	Prepare a tea from dried plant, use one teaspoon per small teapot. Keep drinking for 10 days, 2–3 times per day.	May–Jul	0.6	1
Rhodiola gelida Schrenk. ex Fisch. & C.A. Mey. PR 837038	Crassulaceae	Mountainous slopes (distant)	Алтын тамып (K), Золотой корень (R) Altyn Tamyr, Zlotoy koren (E) ("the golden root")	Herb	Root	Blood pressure harmonization, nerves and headache, gastritis, gastro-intestinal organ ulcers, heart problems and its strengthening	Tincture	Oral	Cut the fresh root on small pieces and extract for 40 days in a spirit, use daily for 10 days 1 teaspoon 3 times a day.	Jul–Aug	1.3	0.75

Tab. 1 Continued

Botanical name and voucher specimen No.	Family	Gathering environment	Vernacular name[a]	Plant life-form	Part used	Local medicinal use/ailments treated	Mode of preparation	Mode of application	Detailed administration	Seasonal availability	UV[b]	IAR[c]
Ribes meyeri Maxim. PR 837039	Grossulariaceae	Riparian forest (nearby) Mountainous slopes (distant)	Бопу карагат (K) Boary karagat (E)	Shrub	Leaf, fruit Fruit	Kidney and urinary disorders, increasing level of blood	Infusion Fresh/ dried	Oral Oral	Prepare a tea and drink 3 times per day for 10 days. Consumed in fresh or dried form.	Aug	0.5	0.75
Rosa ecae Aitch. PR 837042	Rosaceae	Mountainous slopes (distant) Anthropic (nearby)	Ит мурун (K) It murun (E)	Shrub	Leaf, flower, fruit Fruit	Stomach disorders, heart disorders, bronchitis Insect bites	Infusion Fresh, powder	Oral Topical	Prepare a tea and drink regularly. Attach the fresh fruit or powdered dry fruit on bitten place.	Jun–Aug Aug	0.5	0.25
Rosa fedtschenkoana Regel PR 837029	Rosaceae	Mountainous slopes (distant) Anthropic (nearby)	Гул согар (K), Шиповник, (R) Gul sogar, Shipovnik (E)	Shrub	Fruit	Cough, angina, flu, runny nose, immunity, heart defects, high pressure, gastric ulcers, gastritis	Infusion	Oral	Prepare a tea and drink 1 cup every day, use 2–3 fruits per small teapot.	Aug–Sep	1	0.56
Rubus caesius L. PR 837006	Rosaceae	Anthropic, Riparian forest (nearby)	Булдургон (K) Buldurgan (E)	Shrub	Fruit	High pressure, headache	Fresh, preserved	Oral	Eat fresh or preserved fruit.	Jun–Jul	0.3	0.5
Taraxacum sp. PR 837045	Asteraceae	Anthropic (nearby)	Мама каймак (K) Mama kaymak (E)	Herb	Aerial part	Stomach ache	Infusion	Oral	Prepare a tea from 1 heaped tablespoon per teapot. Drink every day for 10 days.	May–June	0.2	1
Thymus seravschanicus Klokov PR 837037	Lamiaceae	Mountainous slopes (distant)	Мин тамыр (K) Min tamyr (E) ("the plant of thousand roots")	Herb	Aerial part	Woman genital disorders, problem with fertility	Infusion	Oral	Prepare a tea from dried plant material.	Jun–Aug	0.1	NC[d]

Tab. 1 Continued

Botanical name and voucher specimen No.	Family	Gathering environment	Vernacular name[a]	Plant life-form	Part used	Local medicinal use/ailments treated	Mode of preparation	Mode of application	Detailed administration	Seasonal availability	UV[b]	IAR[c]
Tribulus terrestris L.[e]	Zygophyllaceae	Anthropic (nearby)	Темир текен (K) Temir teken (E)	Herb	Aerial part	Skin allergy, inflammations	Infusion, fresh	Wash, bath, topical	Clean the affected places by warm infusion or attach crushed fresh plant.	Apr–May	0.3	1
Urtica dioica L. PR 837018	Urticaceae	Anthropic (nearby)	Чаган чоп (K) Chagan Chop (E)	Herb	Aerial part	Purification of blood and urinary system, disorders of internal organs	Infusion	Oral	Prepare a tea and drink regularly for a longer time.	May–Jun	0.9	0.38
						Radicular and leg pain, rheumatism	Fresh	Topical	Use fresh plant externally on skin against rheumatism and muscular pain.			
Zea mays L. PR 837008	Poaceae	Anthropic (nearby)	Жугору (K) Кукуруз (R) Zhygoru, Kukuruz (E)	Graminoid	Flower	Liver and kidney problems, jaundice	Infusion	Oral	Prepare a tea from male flower and drink up to 3 times a day.	Aug–Sep	0.4	0.33
Ziziphora pamiroalaica Juz. PR 837036	Lamiaceae	Mountainous slopes, Juniper forest (distant)	Кийгот (K) Kiygot (E) ("the herb of the wild goat")	Herb	Aerial part	Flu, cough, cold, angina, runny nose, infections, blood cleaning, blood pressure harmonization, headache, stomach ache, gastritis, antiemetic	Infusion	Oral	Prepare a tea from 1–2 teaspoons per small teapot.	Aug–Sep	2	0.68

[a] K – Kyrgyz language; R – Russian language; E – English transliteration, the term in quotation marks express a popular folk meaning. [b] UV: species use value. [c] IAR – informant agreement ratio. [d] NC – not calculated (reported only by one informant). [e] not collected (identified in the field by the first author).

Tab. 2 Ethnobotanical information on taxonomically unidentified medicinal plants.

Vernacular name[a]	Number of informants	Local medicinal use	Plant part used	Preparation and application	Note
Улкон (K) Ulkon (E)	5	Stomach disorders, headaches, kidney disorders, immunity enhancer	Leaf Root	Consumed or chewed Infusion drunk	Not found
Мандил (K) Mandil (E)	4	Rheumatism, pain of joints, tonic, stabilization and strengthening of heart functions, high blood pressure	Root	Consumed/chewed fresh or dried, or decoction/tincture is prepared and ingested	Not found
Чечендир (K) Chechendir (E)	3	Skin inflammations and other skin disorders	Leaf	Applied fresh topically, or infusion for wash/bath	Not found
Шакыл дак чоепте (K) Shakul dak choepte (E)	2	Kidney stones and kidney disorders	Flower	Infusion drunk	Not found. Occur earlier in the season.
Жылан чоп (K) Zhylan chop (E)	2	Aphrodisiac for men	Root	Consumed/chewed dried, or infusion is drunk	Not found
Ак шубак (K) Ak Shuvak (E)	2	Scabies, body odor (feet/leg), high blood pressure	Aerial part	Infusion drunk for high blood pressure, or decoction for wash/bath	Not found
Кункурама (K) Kunkurama (E)	1	Haemostasis	Leaf	Dried ground and applied externally	Not found
Долоно (K) Dolona(E)	1	Unknown medicinal use	Fruit (black color)	Consumption of fresh/dried/canned fruits	Not found. Occur in other regions.
Уйбеде (K) Uibede (E)	1	Kidney disorders	Leaf	Infusion drunk	Not found. Not used anymore.
Сабиз чоп (K) Saviz chop (E)	1	Unknown medicinal use	-	-	Not found. Not used anymore, forgotten use.
Кызыл-ычак (K) Kyzyl-ychak (E)	1	Unknown medicinal use	-	-	Not found. Not used anymore, forgotten use.
(Дук) шилби (K) (Duk) Schilbi (E)	1	Unknown medicinal use	-	-	Not found. Not used anymore, forgotten use.

[a] K – Kyrgyz language; E – English transliteration.

= 0.62). Accordingly, there is an assumption of well-developed knowledge and exchanged information on herbal treatment in those categories. The lowest value, with no consensus at all, was determined for dental and mouth care (DMC) and the other uses (OTH) categories.

An agreement on the use of particular plant species for the treatment of various disorders in a given ailment category was assumed by the IAR presented in Tab. 1. *Rhaponticum repens* (L.), *Achillea arabica* Kotschy, *Taraxacum* sp., *Conioselinum vaginatum* (Spreng.) Thell., *Heracleum sphondylium* subsp. *montanum* (Schleich. ex Gaudin) Briq., *Berberis integerrima* Bunge., *Hippophae turkestanica* (Rousi) Tzvelev, *Convolvulus arvensis* L., and *Tribulus terrestris* L. have shown a 100% agreement among informants.

Through use of the FL index, highly preferred plants within particular categories were determined (Tab. 5). Notably, GISD includes the most plant species, obtaining a

Tab. 3 Ailment categories presented according to the descending order of the informant consensus factor (ICF).

Ailment category	ICF	No. of species[a]	No. of UR[b]	% of total UR
Veterinary (VET)	1	1	3	1
Haemorrhoids (HMR)	0.83	2	7	2
Skeleto-muscular system disorders (SMSD)	0.76	6	22	7
Respiratory and throat disorders (RTD)	0.63	14	36	11
Gastro-intestinal system disorders (GISD)	0.62	33	86	26
Circulatory system disorders (CSD)	0.56	21	46	14
Infections/infestations (INF)	0.5	21	41	13
Injuries/wounds (INJ)	0.5	6	11	3
Neurological problems (NEU)	0.47	10	18	6
Immunity disorders (IMD)	0.44	6	10	3
Genito-urinary system disorders (GUSD)	0.4	13	21	6
Skin disorders (SKD)	0.38	8	13	4
Blood system disorders (BSD)	0.2	5	6	2
Dental and mouth care (DMC)	0	4	4	1
Others (OTH)	0	3	3	1

[a] A taxon may be reported in more than one ailment category. [b] UR – use report.

100% FL. The highest cultural importance demonstrated by the UV index was calculated for *Ziziphora pamiroalaica* Juz. (UV = 2), *Peganum harmala* L. (UV = 1.6), *Inula orientalis* Lam., *Plantago major* L. (UV = 1.4), *Ferula kokanica* Regel & Schmalh., *Angelica ternata* Regel & Schmalh., *Rhodiola gelida* Schrenk. ex Fisch. & C.A. Mey. (UV = 1.3), and *Euphorbia monocyathium* Prokh. (UV = 1.2). Based on the sum of species UV, the most culturally important families were Lamiaceae (total UV = 5.2), Apiaceae (total UV = 4.3), and Asteraceae (total UV = 3.9).

Tab. 4 Ten most frequently reported health problems and species with highest citation frequency for their treatment.

Health disorder	No. of citations	Prioritized species
Stomach aches	59	*Hippophae turkestanica*, *Rhaponticum repens*
Kidney disorders	16	*Ribes meyeri*
Headaches	16	*Prunus erythrocarpa*
Fractures	14	*Berberis integerrima*
Influenza	14	*Ziziphora pamiroalaica*
Coughs	14	*Ferula kokanica*
Angina	14	*Ziziphora pamiroalaica*, *Ferula kokanica*
Wounds	11	*Convolvulus arvensis*
Scabies	11	*Peganum harmala*

Mode of preparation, administration, and plant parts used

The herbal remedies were prepared according to various modes of preparation (Fig. 2). Principally, there was no report on the use of herb mixtures, and all remedies were prepared from single plant species. The most frequent method of preparation was infusion (37%). Infusions were prepared in the form of herbal tea, usually in a local teapot with an approximate volume of 0.5 L. The majority of plants were infused for between 5–10 minutes. Cold

Tab. 5 The prioritized species in particular ailment categories based on the fidelity level index.

Ailment category	Fidelity level	Plant species
Gastro-intestinal system disorders	100%	*Hippophae turkestanica*, *Taraxacum* sp., *Rhaponticum repens*, *Achillea arabica*
Circulatory system disorders	100%	*Heracleum sphondylium* subsp. *montanum*, *Coniioselinum vaginatum*
Skeleto-muscular system disorders	100%	*Berberis integerrima*
Skin disorders	100%	*Tribulus terrestris*
Infections/infestations	83%	*Arnebia euchroma*
Injuries/wounds	80%	*Convolvulus arvensis*
Haemorrhoids	80%	*Capparis sicula* subsp. *herbacea*
Immunity disorders	71%	*Polygonum hissaricum*
Respiratory and throat disorders	67%	*Juniperus semiglobosa*
Genito-urinary system disorders	60%	*Ribes meyeri*
Neurological problems	57%	*Prunus erythrocarpa*
Blood system disorders	40%	*Ribes meyeri*
Veterinary	21%	*Inula orientalis*
Others	20%	*Allium carolinianum*, *Perovskia scrophulariifolia*[a]
Dental and mouth care	10%	*Amygdalus bucharica*

[a] Purple form of *Perovskia scrophulariifolia*.

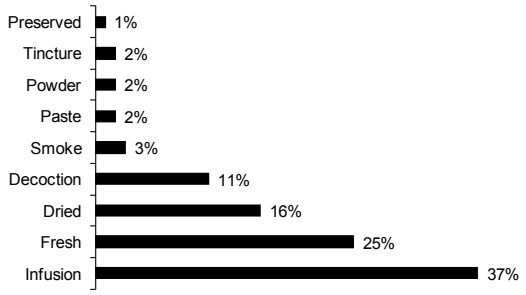

Fig. 2 Proportional distribution of species according to the mode of preparation.

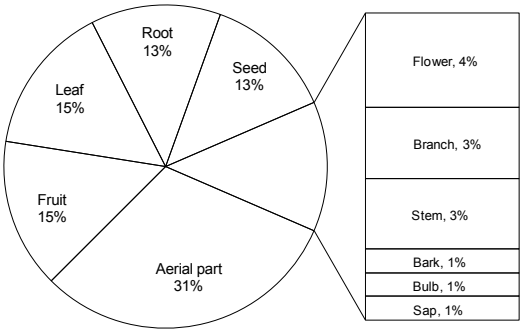

Fig. 3 Plant parts used for medicinal purposes.

or gently warmed infusions were applied as washes and baths for the treatment of scabies and other skin disorders. The direct consumption of fresh fruit and seed was popular, and in some cases the chewing of various plant parts. Fresh plants were often applied topically to cure skin problems, injuries and wounds. For the preparation of a decoction, plants were boiled for 10–20 minutes in water, or, as in the case of *Arnebia euchroma* (Royle) I.M. Johnst., in milk, in order to increase drug efficiency against tuberculosis.

With regard to the application methods reported by informants, 77% of remedies were used internally, i.e., oral (73%), inhalation (3%), and insertion (1%). The remaining 23% of herbal preparations were applied externally, i.e., topical (15%) and wash/bath (8%). The largest variability in terms of application methods was recorded for *Peganum harmala* (oral, topical, and inhalation) and *Ephedra equisetina* (oral, topical, and wash/bath).

The proportion of different plant parts used for medicinal purposes is shown in Fig. 3. Above all, aerial plant parts (31%) are used for the preparation of plant-based medicaments. Stem from only two species were used. The raw stems of *Polygonum hissaricum* Popov, a popular diet-enriching vegetable snack, were consumed to enhance immunity. Its medicinal use had not been previously recorded. The stem and branches of *Ferula kokanica* contain a valuable sap which is used to treat angina, coughs, bronchitis, runny noses, flu, colds, and stomach aches. Interestingly, many plants of *F. kokanica* are notched,

the solidified sap collected the next day and then stored, usually in a matchbox, and always carried personally throughout the year. Bark used only in one case from *Berberis integerrima* was prepared as a decoction in order to help set fractures and aid in their healing. The use of bulbs was recorded for *Allium carolinianum* DC merely as an immunity and appetite stimulator, and occasionally prepared as a treatment for jaundice.

Food-medicine continuum

Nearly one quarter of documented taxa (24%) were commonly used as sources of food. In the present study *Amygdalus bucharica*, *Angelica ternata*, *Bunium persicum* B. Fedtsch, and *Hippophae turkestanica* were the sources of medicinal food. We observed a changing pattern from medicinal food to medicine based on the method of preparation. For instance, in order to achieve a particular medicinal effect, *A. ternata* and *B. persicum* are prepared as an infusion instead of being used for seasoning. Other edible species are generally considered healthy, therefore according to Pieroni and Quave [35] rather fit into the category of functional food (*Anethum graveolens* L., *Juglans regia* L., *Polygonum hissaricum*, *Ribes meyeri* Maxim., *Rubus caesius* L., *Prunus armeniaca* L.). Although, from the local perspective consumption of these species has a beneficial effect on particular organs or body systems, they are not ingested as a highly effective medicine. A third group of food/medicinal species we distinguished has separate functions as food or medicine, which means that the culinary use of the species is unrelated to the medical application [*Juglans regia*, *Mentha longifolia* var. *asiatica* (Boriss.) Rech.f, *Zea mays* L.]. Some remarkable culturally important medicinal food species are shown in Fig. 4.

Collection patterns and seasonal availability

Medicinal plants are primarily gathered from the wild (86% of documented taxa). The remaining plants are either collected or cultivated (five species), with three species cultivated only.

Fig. 4 Culturally important medicinal food plants. **a** *Angelica ternata*. **b** *Bunium persicum* (being sundried). **c** *Prunus erythrocarpa* (fruiting branch). **d** *Polygonum hissaricum*.

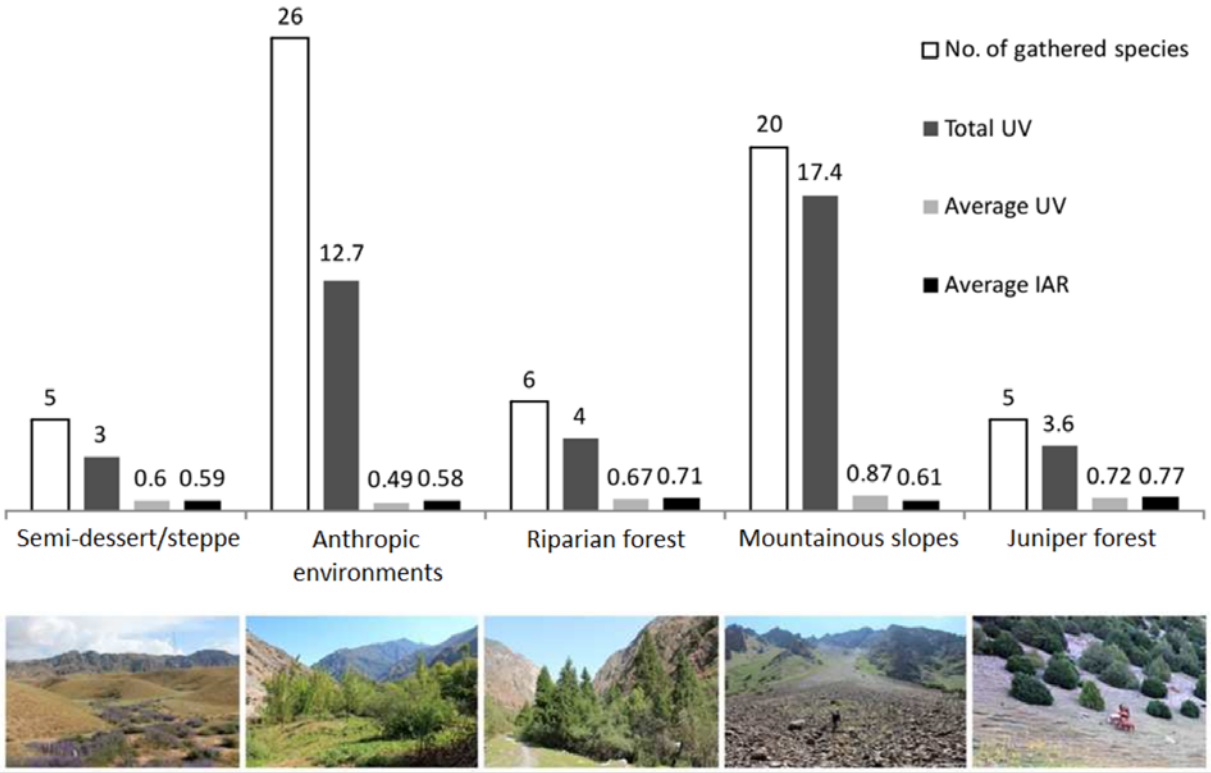

Fig. 5 Ethnobotanical characteristics of the gathering environments. UV – use value index; IAR – informant agreement ratio (certain taxa are gathered in more than one environment).

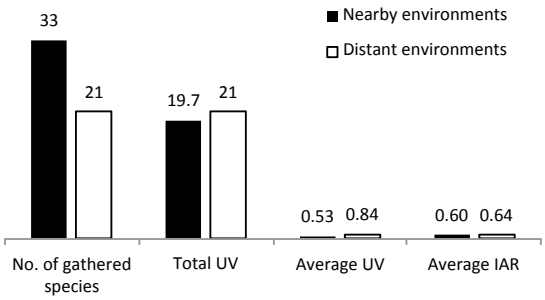

Fig. 6 Comparison of nearby and distant gathering environments. UV – use value; IAR – informant agreement ratio.

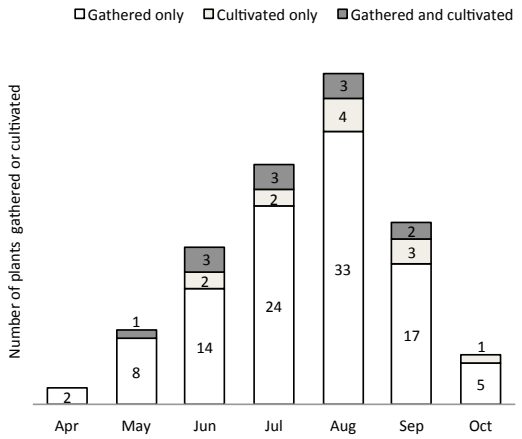

Fig. 7 Seasonal availability of gathered and cultivated medicinal plants

The majority of taxa (64%) are obtained from nearby locations (up to 1 hour walking distance from informants' homesteads). Within nearby localities, the highest diversity of medicinal plants gathered (52% of taxa) was found in anthropic environments like homegardens and orchards (Fig. 5). The most common medicinal plants were collected from nearby environments, while commercially valued species and those with strong treating effects were gathered in distant mountainous areas such as mountainous slopes and juniper forests at higher altitudes. As shown in Fig. 5, the highest IAR (0.77) was calculated for medicinal plants gathered in high altitude juniper forests, one of the most distant environments. Notably, the highest total UV showed species gathered from mountainous slopes at distant sites. Although the number of species gathered in particular environments is positively correlated to the total UV ($r = 0.89$, $p < 0.05$), there is no significant relationship between the number of gathered species and the average UV ($r = -0.14$, $p > 0.05$), and average IAR ($r = -0.63$, $p > 0.05$).

Afterwards, we compared the merged data for nearby (semi-dessert/steppe, anthropic environments, riparian forest) and distant environments (mountainous slopes, juniper forest) in Fig. 6. Although distant environments provide less medicinal species, their total UV (Fig. 6) and average IAR (Mann–Whitney test, $p = 0.206$) are slightly higher, whereas average UV reached significantly higher values (Mann–Whitney test, $p < 0.05$).

The period of species' availability is shown in Fig. 7. The duration of the collection season varies for particular plants from 1 month to a maximum of 7 months, with an average duration of 2.5 months per species. Medicinal plants were commonly dried to ensure their availability all year round.

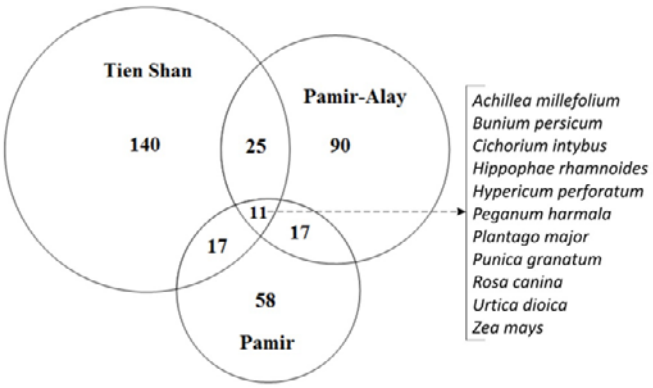

Fig. 8 Venn diagram comparing medicinal species used within major Central Asian mountain systems.

Comparative analysis of medicinal plant species used

Overlap between the mountain systems is shown through a Venn diagram (Fig. 8), and Jaccard similarity indices are presented in Tab. 6.

Interestingly, the highest degree of similarity at generic and species level was determined for the medicinal plants used in the Badakshan region of the adjacent mountain system of Pamir. Notable commonalities were detected with regions in other parts of the Pamir-Alay Mountains. The lowest level of similarity was found with studies from the mountain ranges of Tien Shan.

So far, the greatest number of medicinal species used has been documented in the Tien Shan Mountains – 140 spp. [11,13], followed by the Pamir-Alay – 90 spp. (present study and [11]) and lastly Pamir Mountains – 58 spp. [12]. Although Pamir-Alay and Tien Shan have the highest number of species in common (25 spp.; Jaccard index = 12.20), a slightly higher Jaccard index (12.98) was calculated between Pamir-Alay and Pamir (Tab. 6). The lowest similarity was found between Pamir and Tien Shan (Jaccard index = 9.39). Our comparative analysis revealed 11 species that are used in folk medicine across all the major Central Asian mountain systems along with the different cultures of Uzbeks, Kyrgyz, Tajiks, and Afghans (Fig. 8).

Medicinal food plants and sustainability

Besides their medical applications, two plant species are frequently used as aromatic plants for food seasoning. *Bunium persicum* (UV = 0.8, IAR = 0.57) was, with the exception of cultivated dill (*Anethum graveolens*), observed to be the most utilized local condiment. *Bunium persicum* is well-known to the study area population and it

Tab. 6 Geographical comparison of medicinal plant species documented in Leilek district (Kyrgyzstan) and neighboring regions based on available ethnobotanical studies.

Region and reference	Geography (mountain system)	No. of recorded genera	No. of recorded species	No. of identical genera	No. of identical species	Jaccard index for genera	Jaccard index for species
Gorno Badakhsan Oblast (Tajikistan) and Badakhsan Province, Afghanistan [11]	Afghan and Tajik Pamirs (Pamir Mountains)	54	58	27	13	**36.99**	**13.68**
Djizzax Province, Uzbekistan [9]	Nuratau mountains and Turkestan Range (Pamir-Alay)	24	28	14	9	25.00	13.04
Samarqand Province, Uzbekistan [9]	Zarafshan Range (Pamir-Alay)	38	43	21	9	33.33	10.71
Toskent Province, Uzbekistan [9]	Pskem mountain range (Tien Shan)	27	34	13	7	21.66	9.09
Chatkal Biosphere Reserve, Uzbekistan [12]	Chatkal Range (Tien Shan)	94	117	24	13	20.69	8.44
Leilek district, Kyrgzystan	Turkestan Range (Pamir-Alay)	46	50	N/A	N/A	N/A	N/A

possesses significant economic value when commercialized [up to 500 KGS (Kyrgyzstan Som) – nearly 10 USD per kg]. Its seeds are sundried, stored, and sold regularly at local and regional markets. Because of its high economic profitability there is a strong effort among local people to collect as many seeds as possible. After being dried, the seeds are sold immediately, or in many cases they are stored and sold during the wintertime, when the market price increases considerably. According to some informants, it is also traded across the border with Tajikistan, where it is extremely popular but less abundant in nature.

Angelica ternata (UV = 1.3, IAR = 0.5), another aromatic species with extensive medicinal effects, is used as a popular condiment especially for seasoning soups. In comparison with *B. persicum* it grows at a higher altitude (above 3000 m a.s.l.) and is less abundant. Therefore, the gathering of this species is more difficult and less common, unlike *B. persicum*. Perhaps due to the lower abundance, *A. ternata* was observed to be consumed within households rather than sold on markets. However, both species might be under pressure due to extensive gathering.

Discussion

Ethnomedicinal knowledge and health sovereignty in the Turkestan Range

Although arid and semi-arid environments are considered less biologically diverse, people have evolved various life strategies to cope with such environments, often extensively utilizing local plant resources [36]. The provision of proper health services in the mountainous areas of Kyrgyzstan is challenging, but TK of medicinal plants provides important options for health sovereignty in the mountains of Central Asia [12]. It is considered that the persistence of TK is directly related to its continuous use. A partial loss of TK due to Soviet influence has been observed in the Leilek district, especially a decrease in the spiritual value and use of plants. We noticed that the use of *Peganum harmala* and *Juniperus semiglobosa* for fumigation with a sacred meaning had importance in the past, while currently its spiritual value is no longer recognized and people were rather ashamed to speak about it.

While searching for informants using a snowball method, we briefly asked lay people about the medicinal plants they know. Almost all were familiar with several common medicinal plants and their medicinal use. They were also aware of more plants having medicinal properties, however, they had unfortunately forgotten their medical applications. According to Kassam [4], the transfer of knowledge of medicinal plants in the former Soviet republics may even skip a generation of people who did not use these plants during the Soviet period. Kassam [4] demonstrated the difference between the Afghan and Tajik sides of the Pamir Mountains. The author observed that the traditional ecological knowledge on the Afghan side of the Pamir Mountains was not lost to the same extent as the Tajik side, which was influenced by the Soviet Union rule. In the Turkestan Range, the TK is nowadays under threat again because of high unemployment, urbanization, and the adoption of western lifestyles especially attractive to younger generations. Along with the erosion of ethnomedicinal knowledge, communities also lose their access to natural/complementary health care. While hospitalization is an important option, high costs, limited access and the lack of medical professionals put Central Asian societies at risk [12]. Although access to public health care is improving in Kyrgyzstan, the affordability of modern health care remains a widespread problem [37]. The practical wisdom to use medicinal plants as an alternative or in combination with conventional health care systems underpins the resilience of rural communities [2].

Major ailment categories and their herbal treatment

Tab. 4 gives a picture of the most widespread health problems treated by medicinal plants in the study area. Looking at the ailment categories, GISD has also been documented as the most common category in other studies from Central Asia [11–13].

This might be explained by the fact that sanitary problems and a significant lack of drinking water are common in most Central Asian countries [18]. Interviewees distinguished a remarkably wide array of gastro-intestinal problems. Among those, the most frequently mentioned were stomachaches and gastritis. *Hippophae turkestanica* is particularly popular for the treatment of both ailments.

The second most commonly treated ailment category in the study area is circulatory system disorders (CSD), which corresponds with national health report [37], stating that cardiovascular diseases are the leading causes of death in Kyrgyzstan. Our study has documented 21 medicinal plant species helping people with cardiovascular disorders (ICF = 0.58). Hypertension, as the most frequent, is lowered mainly by herbal infusion from *Artemisia absinthium* L., *Angelica ternata*, *Dracocephalum stamineum* Kar. & Kir., and a tincture prepared from *Rhodiola gelida*. Nevertheless, according to the FL, *Heracleum sphondylium* subsp. *montanum* and *Conioselinum vaginatum* were determined as the most preferred species within this category. Contrary to our results, in Uzbekistan the treatment of cardiovascular diseases is not much reflected in folk medicine [11,13]. As pointed by Penkala-Gawęcka [6] the treatment of certain categories might be interconnected with knowledge acquisition from media sources and also official doctors during and after the Soviet Union rule.

According to Ibraimova et al. [37], the second and third most fatal health problems are cancer and respiratory diseases, respectively. In addition, Kyrgyzstan is among the 27 highest multidrug-resistant tuberculosis burden countries in the world [38]. For the treatment of tuberculosis only one plant species (*Arnebia euchroma*) was reported by our informants. This species obtained the highest FL (83%) in the category of infections/infestations (INF) and according to internationally available literature sources it is pharmacologically a very interesting species [39]. This plant has been known in the neighboring Himalayas since ancient times and used as natural dye for silk as well as various food products. Shikonin, a remarkable naphthoquinone-based compound, was found in the roots of *A. euchroma*. Shikonin has a current value of 4000 USD per kilogram (wholesale price) and possesses antibacterial, antifungal, anti-inflammatory, and wound-healing properties [39].

Concerning infectious diseases in the study area, the most prevalent was influenza, which is treated predominantly by *Ziziphora pamiroalaica*. Afterwards, respiratory and throat disorders (RTD; ICF = 0.6) are very frequent. The most cited respiratory health problems, coughs and angina, are treated by *Ferula kokanica* and *Z. pamiroalaica* mostly in the form of an infusion. As previously mentioned, Kyrgyz people also chew resin extracted from the stem of *F. kokanica*. Only a limited number of studies on *F. kokanica* are available, focusing mainly on the presence and activity of terpenoid coumarins [40]. Traditional medicinal use of *Z. pamiroalaica* in Kyrgyzstan was previously reported as the treatment of tachycardia, gastralgia and heart disorders [8]. In Uzbekistan Sezik et al. [11] recorded the current use of *Z. pamiroalaica* as a sedative and for hypotensive purposes. While many studies have shown significant antimicrobial activity of *Ziziphora clinopodioides* Lam. there exist only one laboratory assessment of *Z. pamiroalaica*, showing even higher antioxidant activity compared to *Z. clinopodioides* [41]. Despite obtaining the highest FL in the category of RTD, *Juniperus semiglobosa* has not been previously reported to treat ailments in this category. Eisenman et al. [7] found that branches of *Juniperus* spp. are burned in Central Asia to produce a pleasant odor and to treat rheumatism.

The most culturally important botanical families and plant species

Based on our data and the results of other authors [11–13], currently the most represented botanical families of medicinal plants used in Central Asia are Asteraceae and Lamiaceae, followed by Apiaceae and Rosaceae. This could be related to the long scientific discussion that medicinal plants are not a random selection of the available flora, but that specific botanical families are used more extensively than others (see e.g., [42]). As we did not make an inventory of the floristic composition of the gathering habitats, we cannot demonstrate whether or not there could be a relationship between medicinal plant species richness, over- or under-representation of botanical families and the overall floristic diversity.

Certain medicinal plants with high UV are known to have been used for a long time in traditional Central Asian medicine, and some are used almost worldwide, e.g., *Plantago major* and *Hypericum perforatum* L. Syrian rue (*Peganum harmala*) is one of the most phenomenal Central Asian medicinal plants [7]. It has a broad range of medical uses and it has been reported in all of the ethnobotanical studies in Central Asia [11–13]. *Ziziphora pamiroalaica* "the herb of the wild goat" with the highest UV has been recorded in Pamir-Alay and Pamir but not in Tien Shan, where other species of the genus *Ziziphora* are used.

Apart from several reports on *Ferula kokanica* dating from the Soviet era's pharmacological screening, there is not much recent information available. *Inula orientalis* was previously reported to be used in Uzbekistan [11,13], but is utilized in more different ailment categories in our study area. *Rhodiola gelida* is also used in the Pamir Mountains [11]. Different authors stated that the roots of *Rhodiola* genus have become popular, particularly since the Soviet period (e.g., [43]). Although undocumented by recent ethnobotanical studies, *Angelica ternata* is known to be used in Tajikistan [44]. Despite obtaining a high UV, *Euphorbia monocyathium* seems to be a newly discovered medicinal plant species, with any available records on its traditional medicinal use in previously published literature.

Collection patterns, sustainability and the role of gathering environments

In order to develop appropriate systems for the sustainable use of plant resources, it is crucial to understand how the traditional use of plants influences biodiversity in these ecosystems [45]. Although many ecosystems are resilient and have survived a long history of human disturbance, they can be pushed beyond recovery through habitat destruction or overexploitation [23].

We have documented different acquirement patterns for medicinal plants in comparison to the study of Kassam et al. [12]. In Afghan-Tajik Pamir 46% of medicinal species are gathered exclusively in the wild, while in the Turkestan Range 86% are gathered entirely from the wild. This means that our study area shows a very poor or almost no practice of the cultivation of medicinal plants. As pointed out by Rokaya et al. [31], this situation may, in the long term, lead to the depletion or even extinction of plant resources. This could possibly happen if the plant species are harvested in large amounts especially for sale.

Although we raised awareness of intensive and frequent collection of *Angelica ternata* and *Bunium persicum*, the collecting of leaves, seeds and fruits is likely to have a rather small impact on the overall populations [23]. Contrarily, although less intensively gathered, the collection of *Arnebia euchroma*, *Euphorbia monocyathium*, and *Rhodiola gelida* roots should be done with caution regarding the long-term sustainability of harvest practices.

Basically, plant availability and richness are considered as shaping drivers of ethnobotanical knowledge [32]. Moreover, there is a hypothesis that readily available and apparently visible plant species are of higher cultural importance [32,46]. Martin [22] adds that longer travel distances decrease the utilization of remote plant resources. Nonetheless, this claim is accepted for tropical humid environments, whereas in arid areas it is not evident [46]. The results of a study conducted by Ladio et al. [47] in the arid Patagonia region of Argentina, however, support the hypothesis that the use of medicinal plants is primarily based on the utilization of species belonging to the nearest ecological environments. Also, Thomas et al. [48] positively correlated the accessibility and usefulness of plant species in the arid zone of the Bolivian Andes.

In our study we assume that the question of distance depends mostly on the usefulness and additional value of particular species. In the Turkestan Range, characterized as a semi-arid region, vegetation resources are rather scarce and do not provide a wealth of non-timber forest products as is the case for tropical forest zones. On the other hand, both villages investigated are positioned at the junction of different vegetation zones, indicating a common livelihood strategy that helps communities to be more flexible and resilient through the use of more diverse floral and faunal elements [49]. In the present study, medicinal plant species diversity was highest in anthropic environments. These sites are often characterized by a high productivity

rate and the availability of useful plants [47], and medicinal species in particular [50]. Yet our results partially contradict the hypothesis that readily available and also apparent medicinal plants from disturbed sites are of higher cultural importance. Even though nearby environments provide more medicinal species, a total UV is slightly higher for the fewer species collected at distant sites. Accordingly, average UV for species from distant environments reached significantly higher values (Mann–Whitney test, $p < 0.05$), demonstrating their crucial role in the local folk medicine. These results could reflect a methodological approach including only key informants, who practically, but not exclusively, appreciated medicinal species growing naturally at higher altitudes.

There is also evidence from the Mapuche community in northwestern Patagonia, which was found to obtain the most useful medicinal plants at more distant gathering sites [51]. In seasonal dry forests of Brazil, Albuqeurque et al. [52] found that despite the studied community knowing more medicinal species of the disturbed areas, people prefer to use species of native vegetation from remote areas.

There is a divergent understanding of gathering environments' cultural importance among ethnobotanists [52]. Some authors tend to only look at a number of species acquired in particular environments in the context of supply source, regardless of the species' cultural importance. We argue that only considering a number of useful plant species in gathering environments does not truly reflect their cultural importance. It is necessary to realize that one medicinal species could be much more useful than the other. Therefore, calculating the average values of indices which represent the cultural importance of species (in our case UV) in particular environments, accompanied by their sum resulting in a total cultural value for a given environment, may further shed light on the profound question of the sociocultural and ecological circumstances of plant gathering (Fig. 5, Fig. 6). Phillips et al. [53] reported, how average values can reveal significantly different results than the proportion of useful species expressed as a percentage. Our results showed that average consensus (IAR) for species in particular environments may disclose the level of agreement for gathering sites. Further analysis of gathering environments' floristic composition as well as the inclusion of lay people into the research objectives could further confirm these patterns for semi-arid mountainous environment in Central Asia.

Cross-cultural comparison of mountain systems

A geographical-cultural comparison showed a close relationship between species used in Pamir-Alay and the Pamir Mountains, which might be explained by the interconnection and similar ecological conditions of both areas. The remarkable level of concordance between genera, as well as species used in the Leilek district and Badakshan region in Pamir, is primarily the result of similar natural conditions and a nearly equal number of species documented thus far.

Furthermore, Kassam et al. [12] found a significant number of Kyrgyz nomadic pastoralists, who interact with other ethnic groups in the Pamir and thus might disseminate traditional Kyrgyz knowledge. On the other hand, the Tien Shan Mountains are home to a greater number of plant species and a higher level of endemism [13]. The Pamir Mountains, with 58 species, showed 17 species in common with Tien Shan (out of 140 species) as well as 17 species in common with Pamir-Alay, from significantly fewer medicinal species used in there (90). However, this comparative analysis should be considered as preliminary and might be limited by the level of research effort in particular regions and sometimes unspecified methodological factors such as gender issues.

Considering plant parts used, in the Afghan-Tajik Pamir proportions are very similar, however there is a slightly higher rate of root use compared to Kyrgyz Pamir-Alay. In western Tien Shan, Uzbekistan [13], proportions are comparable to our study, except Uzbeks utilize a greater proportion of flowers. In a more complex study in Uzbekistan [11], authors documented a high number of medicinal species from which underground parts are used. The use of herbaceous species and underground organs is likely to increase with the aridity of the environment [47].

Concerning local plant names, various Kyrgyz folk names are similar to those in Uzbekistan, with more similarities found with the Uzbek parts of Pamir-Alay than with the Uzbek Tien Shan. In general, our informants used Kyrgyz folk names. They were aware of Russian names predominantly for the typical species of Russian pharmacopoeia, nevertheless also for culturally important species, which are occasionally translated into Russian (e.g., *Euphorbia monocyathium* is named *Аюуот* (*Ayuuvot*) in Kyrgyz and sometimes is called in Russian *Медведь Корень* (*Medvedi koren*), both meaning "the bear's root").

Health hazard aspects of some medicinal species

Although there is no information on *Angelica ternata* available in internationally published literature sources, Nuraliev [44] reported a harmful effect of this species on human health. The plant is quite common in the Tajik mountains, and its roots or aerial parts are prepared in dried form as tea or added to dishes as a condiment. Some folk healers apply the aqueous extracts of the roots and aerial parts to treat hypertension and heart disease [44]. According to a later study [54], the ability of *A. ternata* to both lower blood pressure and increase the risk of blood clotting at the same time creates favorable conditions for the formation of blood clots causing venous thrombosis, heart attacks and a number of other fatal diseases. This herb can be particularly dangerous for people who have previously had heart attacks, suffer coronary heart disease or diabetes. Accordingly, it is hazardous to use *A. ternata* in cardiology, as an anti-diabetic drug, or as an herbal tea or dietary supplement.

Conclusions

Currently, medicinal plants in the Turkestan Range are predominantly used for common health problems, while serious health disorders are rather treated with conventional healthcare. However, the related expenses and the geographical isolation are pushing the community to rely extensively on natural resources.

The wild habitats of the Turkestan Range were found to be major pools of medicinal plants, with 86% of taxa gathered entirely from the wild. The results of this study show that plant species with a high cultural importance are not only found in nearby ecological environments, but even in distant sites which have a comparatively lower diversity in medicinal plant species gathered.

This is the first ethnobotanical study performing a quantitative and comparative analysis in the geographical context of Central Asia. The highest degree of species similarity was found with medicinal plants traditionally used in the Pamir Mountains. The present study uncovered two novel (*Euphorbia monocyathium*, *Polygonum hissaricum*) and several less-known medicinal plants (*Conioselinum vaginatum*, *Corydalis fedtschenkoana*, *Dracocephalum stamineum*, *Rosa ecae*).

In the often-overlooked and poverty stricken regions of the Central Asian mountains with a low development perspective, ancestral knowledge may be particularly crucial to the resilience of the poorest population undergoing rapid socioeconomic, cultural and environmental changes.

The results of this study may contribute to biodiversity conservation, the preservation of national bio-cultural heritage, the understanding of folk medicine to allopathic medical workers, and to community resilience and development. Subsequent studies, especially ethnobotanical market surveys, could generate further important information on the amount of plant material collected and sold, gathering frequency, and species prioritization. On the other hand, ecological studies of the gathering environments could assess to what extent wild plants' collection influences the respective vegetation communities.

This study contributes to filling the gap in documentation of Central Asian indigenous knowledge, which if studied by modern ethnobotanical approaches, is capable of identification of neglected and underutilized plant species.

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