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MEDICINAL PLANT DIVERSITY USED FOR LIVELIHOOD OF PUBLIC HEALTH IN DESERTS AND ARID REGIONS OF SINDH-PAKISTAN

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Abstract

Ethnopharmacological surveys require novel approaches to obtain successful hits in drug discovery. The objectives of the present study were to document the traditional uses of medicinal plants from the Deserts of Sindh and to authenticate the documented traditional uses. The traditional uses were documented from informants using semi-structured questionnaires and open-ended interviews. The data were analyzed using relative frequency of citation (RFC), Use value (UV), Informant consensus factor (ICF), Fidelity level (FL) and Relative Importance (RI), and their uses were validated through Metanalyses (MAs) and Systemic reviews (SRs). Overall, 74 plant species were reported from 207 informants and their traditional uses were validated from 299 published ethnobotanical studies. *Aloe vera* and *Ricinus communis* were more frequently cited in published literature. *Blepharis ciliaris* and *Echinops echinatus* either due to lack of pharmacological or phytochemical studies. The leaves were the most frequently used (36 reports), and decoctions (27 reports)) followed by powder (26) were predominantly reported. The UV varied from 0.49 (*Cynodon dactylon*) to 0.2 (*Tribulus terrestris*); the RFC from 0.38 (*Calotropis procera*) to (*Aerva javanica*); and the RI from 50.74 (*Acacia nilotica*) to 5.61 (*Salvia santolinifolia*). The maximum FL was found for 14 species, and the ICF varied from 0.61 (Digestive disorders) to 0.16 (Nervous disorders). The deserts (Sindh-Pakistan) provides many important plant species with most authenticated traditional uses. The plant species having most authenticated uses, highest correlated ethnobotanical index values, and lacking pharmacological or phytochemical studies, may yield desired results in limited time with most cost-effective resources.

Key words: Ethnopharmacology; Traditional knowledge; Integrative medicine**,** Ethnobotany; Medicinal plants, Drug Development

Introduction

The preservation of traditional folk knowledge, preference of traditional medicine over others and conservation of biodiversity have gained popularity among various communities, researchers, academicians and policy makers (Heinrich, 2001; Hulley *et al*., 2016; Khan *et al*., 2017). Traditional medicinal knowledge (a source of low-cost herbal medicine) requires novel approaches to find hits in successful bioprospecting. Currently, the development of drugs is becoming more expensive and less successful, with a meager number of new entries (Verpoorte *et al*., 2009). Due to globalization and economic growth, many countries have developed traditional medical systems that are either used alone or in combination with modern medicine (Boer & Cotingting, 2014; Semwal *et al*., 2014; Tariq *et al*., 2016).

In bioprospecting, holistic and reductionist approaches are followed, and although the latter is more frequently applied, it is not always successful (Verpoorte *et al*., 2005) due to its high cost and time, as well as funds and facilities available at the workplace. A single drug may take up to 10 years to reach the market, with an estimated cost exceeding 800 US dollars (Dimasi *et al*., 2003; Honig & Lalonde, 2010; Khan and Shinwari, 2016). In many studies, selection of a plant species based on a strong ethnobotanical record has proved to be more successful than random selection (Sosnowska & Balslev, 2009). In both cases, it involves three major steps, including identification of the drug source, optimization, and drug development (Balunas & Kinghorn, 2005). To obtain successful hits in bioprospecting, selection of a species is based on authenticated traditional medicinal uses through comprehensive meta-analyses (MAs) and systemic reviews (SRs), which may act as time- and cost- saving techniques. Furthermore, this approach may lead to the development of systems biology, including physiological, developmental and environmental parameters, during the treatment of diseases (Verpoorte *et al*., 2005) as both biotic and abiotic stress are related to the diversity of metabolites (Avancini *et al*., 2003; Moura *et al*., 2005).

Many ethnobotanical studies have been published from all around the world, including Pakistan. Approximately, 30000 to 70000 plant species worldwide have been reported to be used as medicines and many may have great potential as novel products (Verpoorte, 2012; Habiba *et al*., 2016); however, little attention has been paid to the quality of ethnobotanical work. There is great variability in the quality, focus, and content of ethnopharmacological studies, resulting in less acceptability in global research communities (Chan *et al*., 2012; Ahmad *et al*., 2015). Ethnobotanical studies with poor quality, authentication and validity as well as redundancy in reporting the same uses and invalid taxonomic names are frequently published (Rivera *et al*., 2014) and pose a challenge in maintaining the quality of the scientific literature (Lu *et al*., 2014). These studies threaten to discredit and erode authentic traditional knowledge in various ethnic cultures. Thus, advanced methods and strategies are needed to support research and maintain traditional knowledge, which is an important gateway for future generations.

To enhance the acceptability of ethnopharmacological knowledge, the data recorded from local wisdom should be compared, authenticated and validated at the local, regional and global levels using multiple approaches. Ethnopharmacological uses that are found to be the most authenticated may be selected or preferred for further studies. In evidence-based complementary medicine, MA and SRs are good tools (Chung *et al*., 2015) for the authentication of traditional uses reported in ethnopharmacological studies. However, the authentication and validation of the traditional uses of medicinal plant species for bioprospecting using such approaches are still scarce (Mabona *et al*., 2013).

The concepts of MA and SRs in ethnobiological studies have been put forth in many studies (Moerman, 1989, 1996; Kapur *et al*., 1992; Moerman *et al*., 1999; Leonti *et al*., 2003; Hernández *et al*., 2005; Bourbonnas-Spear *et al*., 2005; Amiguet *et al*., 2006; Douwes *et al*., 2008; Saslis-Lagoudakis *et al*., 2011). Other studies compiled published information and treated them quantitatively to find plant use patterns (De Albuquerque *et al*., 2007). Application of such techniques can merge previously reported uses onto a common platform, which can be used to select any plant species for further studies in bioprospecting. Authentication of traditional uses of medicinal plant species by applying the MA and SRs may also highlight issues regarding nomenclature and ambiguous taxonomic names published in research articles (Rivera *et al*., 2014). The MA and SRs in ethnobotany may provide results that have greater statistical power by using many such similar studies.

In Pakistan, much work has been done on ethnobotanical studies in northern hilly areas and plains, but the vegetation of the deserts has been ignored for many reasons. Pakistan occupies a distinct geographical location in the Deserts of Asia. The deserts of Pakistan present a unique plant biodiversity, with an estimated 400 to 600 medicinal plants out of a total of 7000 plant species in the country (Khatri *et al*., 2011; Yaseen *et al*., 2015). Based on a review of previous studies, we found only a few references to medicinal plants from the Deserts of Sindh-Pakistan. In the desert communities of Sindh, traditional medicines obtained from plants are still more popular than available allopathic and biomedical medicine. Specifically, people with low income and socioeconomic status rely on traditional medicine because of the low or lack of availability of medicines and inaccessibility to modern health care systems.

The present study was aimed to document the traditional uses of the medicinal plants of the Deserts of Sindh; authenticate and validate the documented traditional uses of reported plant species using the MA and SRs for successful hits in bioprospecting; and highlight the important medicinal plants with the most authenticated use or those lacking previous ethnobotanical, pharmacological and phytochemical studies. Specifically, the aim of the present study was to report the most authentic uses of medicinal plant species commonly used in the study area.

Methodology

Study Area: Sindh is one of the 4 provinces of Pakistan comprising various desert regions, including the Thar Desert, which occupies the largest area (Yaseen *et al*., 2015), and its adjoining regions, including the Nara desert, Achro Thar, and arid regions of the Kirthar range (Qureshi *et al*., 2010) (Fig. 1). In the Kirthar range, the desert occupies the two districts of Jamshoro and Dadu (Panhwar & Abro, 2007). The Nara desert is situated in the Khairpur district and its adjoining areas. Achro Thar is situated in Sanghar. The Thar Desert is located in 4 districts, namely, Tharparker, Umerkot, Mirpur Khas and some areas of Badin. The Thar Desert shares its border with Barmer and Jaisalmer of India in the south-east and Rannkachh of India in the south, while the Mirpur Khas region of the Thar Desert shares its border with Rajasthan (Yaseen *et al*., 2015). The Nara desert is linked to the Thar via Sanghar and Mirpur Khas. The vegetation is represented by vascular plants, including Nangerparkar which is somewhat rich in floral diversity. The average temperature ranges from 15 to 52°C. May, June, and July are extremely hot, whereas December and January are cool (Qureshi *et al*., 2010). From an ethnographic point of view, the deserts of Sindh are mostly occupied by *Thari*, *Dhatki,* and *Parkari* speaking communities, which are predominant in the area. Rural communities lack good health facilities and have a high rate of infant mortality.

Field Surveys: During field surveys, informants were interviewed using the standard methods described by (Martin, 1995). The selection of informants was random as well as specific (only when interviewed traditional health practitioners (THPs). Pre-informed consent was obtained from each informant before the interview, and the objectives of the study were clearly explained before each informant was interviewed. The informants were requested to indicate the medicinal plants used to treat various diseases. The data on medicinal uses, plant parts used, and mode of utilization were documented using semi-structured questions, open-ended interviews, and group discussion. Semi-structured questionnaires were used in most cases, while open-ended interviews were conducted with informants who helped in the field during plant collection. Group discussions were carried out at specific places where informants of the same community gathered for social events.

During field surveys, various strategies were applied to obtain information on medicinal plant species. In most cases, plants were collected, digital photography was performed, and plant samples were brought to the informants for data documentation. However, we enlisted the help of the informants for the collection of field specimens of any unknown species that were commonly used in herbal recipes. During the interviews, many local informants helped in the collection and photography of plant species in the field. For plants collected before the interviews, photographs and plant specimens were shown to the informants for data documentation.

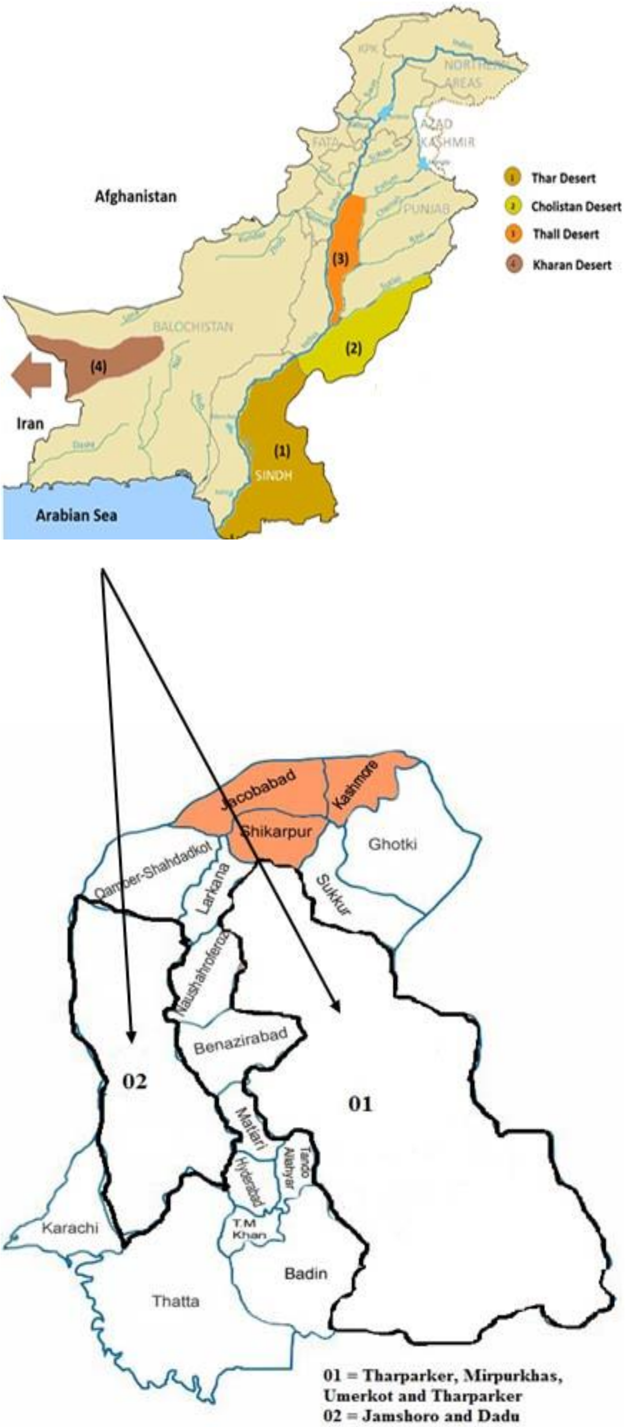

Fig. 1. Map of study area.

Questionnaire: The questionnaire was designed to document the phytomedicinal therapies used by the local people living in rural communities of the Deserts of Sindh. The questionnaire consisted of two sections. The first section comprised the demographics of the informants, such as their names, tribe, gender, age, education, address, occupation, and experience of using plant-based recipes. The second section dealt with knowledge related to the plant, such as the local name of the plant, disease treated, part used, mode of utilization and administration, dosage, plant preference and specific disease treated.

Plant Identification and preservation: The collected plant samples were dried, preserved and mounted on the herbarium sheets using the standard methods described by (Martin, 1995). The plant species were identified using the Flora of Pakistan as well as taxonomists and herbaria of the Quaid-i-Azam University, Islamabad (ISL). The voucher specimens were deposited in the herbarium for future reference by assigning them specimen accession numbers. The correct taxonomic names and their families were verified from different databases, including the plant list (http://theplantlist.org) and medicinal plant name service at the Kew Botanical gardens (http://mpns.kew.org/mpns-portal).

Data Analysis

The data were analyzed using qualitative approaches (life forms, plant part used, mode of utilization) as well as quantitative approaches such as MA and SRs (see below for details) of the previously published literature on ethnobotanical as well as on phytochemical and pharmacological aspects and using quantitative ethnobotanical indices.

Systemic reviews (SRs) and meta-analysis (MAs): Standard methods were applied with some modifications in the study by (Chan *et al*., 2012) (Fig. 2). To determine the authenticated and novel uses of the reported plant species, we reviewed ethnobotanical studies from different databases (ISI web of knowledge, PubMed, ScienceDirect, Scopus) with specific keywords (ethnobotany, ethnopharmacological, and traditional uses of medicinal plants, cultural medicinal uses, and traditional knowledge etc), whereas for the phytochemical and pharmacological aspects, botanical names were searched in Google Scholar with an advanced search.

Overall, 299 publications were reviewed for ethnopharmacological uses published in different research journals. The inclusion criteria for ethnobotanical comparison were: studies published during 1996-2015; at least one plant species from our study; traditional uses; full-length research articles; and availability in English. Articles that did not meet the above criteria were excluded. The inclusion criteria for pharmacological and phytochemical comparison were: current literature, description of pharmacological activities and phytochemicals, accessible for review and available in English. Plant species for which the related literature was not found were comprehensively reviewed in the databases mentioned above.

The data were extracted from all the included research articles. The traditional/ ethnobotanical/ folk/medicinal uses were extracted in the table. The uses were compared with our reported uses. The most authenticated uses (Having at least 5 records in reviewed literature) were separately written, whereas the uses that were novel in our study (based on the reviewed data) were written in bold fonts (Table 1).

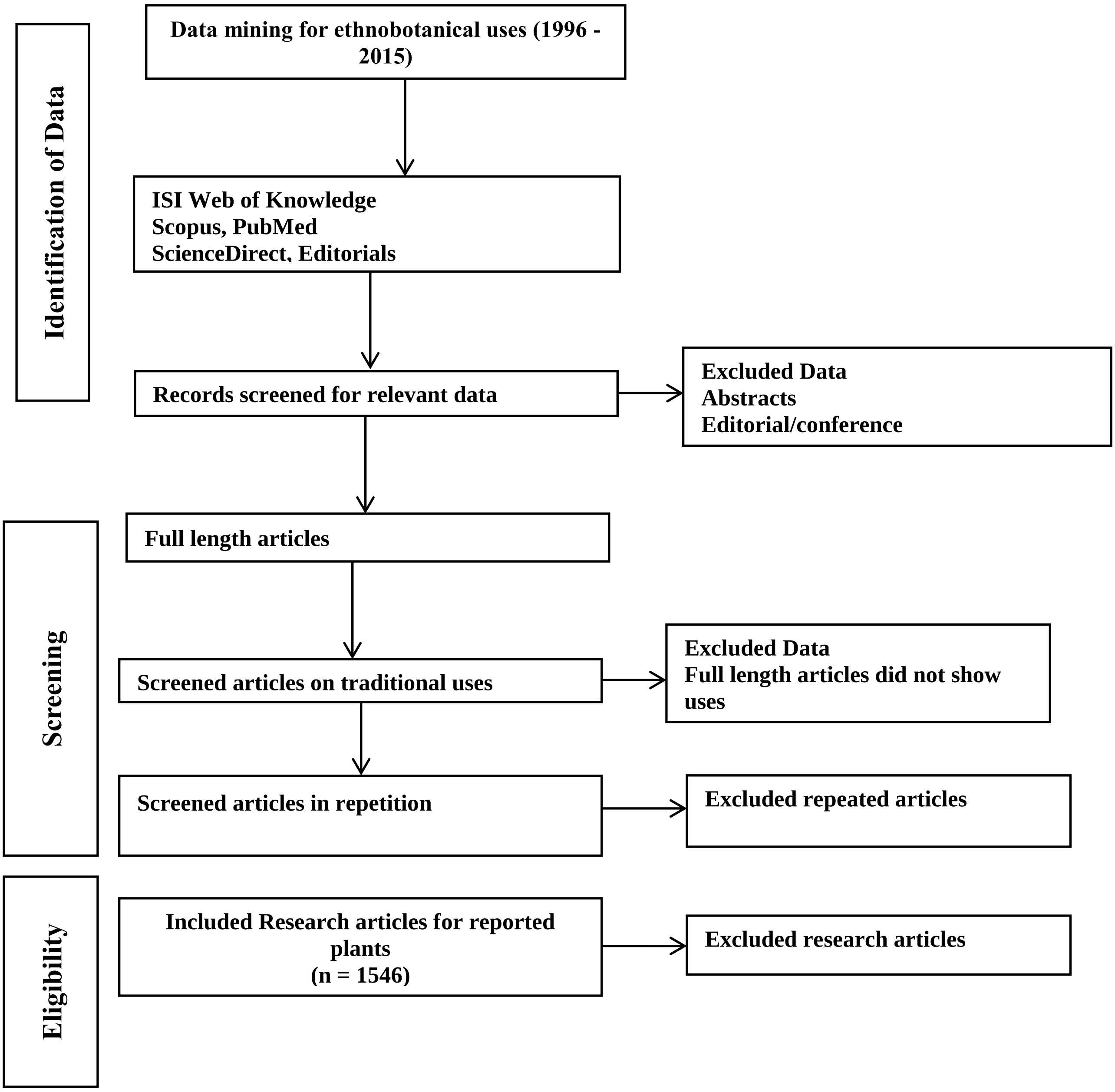

Fig. 2. Flowchart of meta-analyses and systemic review for ethnobotanical data.

Quantitative ethnobotanical indices

Relative importance (RI): The importance of a plant species based on the relative use reports (uses reported for each species) and relative number of body organ systems treated by a species (Bennett & Prance, 2000) was highlighted.

It was calculated using the formula:

$$RI = (PP+AC) \times 100/2$$

"PP" represents relative use reports. The relative use report of each species was calculated by dividing the UR by the maximum number of UR attributed to any plant species. AC indicates the relative number of body systems treated and was calculated by dividing the body systems treated with the maximum number of body systems treated attributed to any plant species.

Informant consensus factor (ICF): ICF determines the consensus of the informants regarding plant use in treating disease categories (Canales *et al*., 2005; Heinrich *et al*., 1998). Its values range from 0 (lowest) to 1 (highest) for different categories of diseases. The highest value (1 or near to 1) indicates that a large number of reported medicinal plants are commonly used for treating a disease category, whereas values 0 or near zero indicated that the informants did not use common medicinal plants for the reported disease category (Abu-Irmaileh & Afifi, 2003; Kloutsos *et al*., 2001). ICF was calculated by applying the formula used by Heinrich *et al*., (1998).

$$ICF = \frac{Nur - Nt}{Nur - 1}$$

Where 'N_{ur}' indicates the number of use-reports for a particular ailment category and 'Nt' refers to the number of taxa used for a particular ailment category.

Fidelity Level (FL): The FL represents the informants who preferred a species for treating a specific disease (Friedman *et al*., 1986). The FL highlights an ideal species for treating a specific disease (Musa *et al*., 2011). It was calculated as:

$$\mathrm{FL} = \frac{Ip}{Iu} \times 100$$

"Ip" indicates the number of informants stating the use of a species for a particular ailment category, and "Iu" is the total number of informants interviewed for a mentioned species. The highest FL (100 or near 100%) shows the maximum number of informants who agreed to the treatment of a specific disease by the selected plant species (Musa *et al*., 2011).

Use value (UV): The UV demonstrates the relative importance of a species based on number of uses reported (Use reports) (Trotter and Logan, 1986). It was calculated using the following formula:
$UV = \Sigma U/n$

Where "U" is the total number of use reports for a species and "n" represents the total number of informants interviewed for a given species.

Relative frequency citation (RFC): The RFC shows the relative importance of a species based on a number of informants interviewed for a species and the total number of informants in the whole study. It was calculated as:
$RFC = FC / N$

Where FC (Frequency of citation) represent the number of informants mentioning the use of the species and "N" stands for the total number of informers contributing in the survey (Vitalini *et al*., 2013).

Results and Discussion

Diversity of traditional medicine among informants: Overall, 74 medicinal plant species belonging to 31 families were reported from various communities in the Deserts of Sindh. The traditional medicinal uses of the reported species were documented from 207 informants, including 27 traditional health practitioners and 180 local people. Among the plant families, the most highly reported families based on the number of species reported were: Fabaceae (07 species), Asteraceae (04) and Solanaceae (04). In many studies (Ahmad *et al*., 2006; Bibi *et al*., 2014; Kayani *et al*., 2015; Vijayakumar *et al*., 2015), these families were reported as the most dominant medicinal plant families in various regions. The dominance of the species of these families is indicated by their frequent use in traditional medicines, which are easily available or preferred over others. We speculate that the relative dominance of plant families in a study of medicinal plants of an area largely depends upon the relative richness of species in each family present in the local flora. In growth forms, most plants are herbs (32 species), followed by trees (7 Species). The detail regarding families and life forms is mentioned in Table 1.

Leaves (36 reports) are the most commonly used plant parts, followed by whole plants (23 reports) and seeds (17 reports). In the modes of utilization, decoction was predominantly used as reported in 27 reports, followed by juices and powders (26 reports). In various traditional healthcare systems, the leaves are preferred over other plant parts (Heinrich, 2010; Leonti *et al*., 2003). Leaves contain more active phytochemicals compared to other parts. Thus, they may have more potential in treating various diseases. In our study, various informants stated that leaves are the most vital part and are commonly used in local communities; however, the whole plant is most commonly used for herbaceous plants. In the mode of utilization, decoctions are commonly reported in many studies (Canal *et al*., 2000; Kamatou *et al*., 2008; Chen *et al*., 2012) for many reasons. One of the important cited reasons is that boiling of some plant metabolites activates them to function in healing, whereas boiling may trigger synergism for more than one plant species used in a decoction (Obolskiy *et al*., 2009; Van Vuuren and Viljoen, 2008). The majority of THPs prefer a powder as a common mode of utilization. In herbal clinics, powders have a longer shelf-life compared with decoctions, which spoil faster, thus justifying the common use of powders in our study.

Authentication of Reported Traditional uses: The detailed MA and SRs showed the most authentic uses (MAU) of the reported plant species published from different ethnic communities all over the world. The novel uses of each species are written in bold font, and the uses represented with an asterisk are the preferred uses mentioned by the informants. The most authenticated use was determined as that published in at least four studies. The previous frequency of citation (PFC) of the reported plant species varied from 58 to 0 (Fig. 3). The highest PFC was found for *Aloe vera*, while the lowest was found for 10 species written in bold font (Table 1). The number of previously reported uses varied from zero to 129. The highest PRU was reported for *Ricinus communis*, followed by *Aloe vera* and *Cynodon dactylon* (122). Among the authenticated plant species, 23 plant species were validated for diabetes, 9 for cough, 7 for asthma, 7 for jaundice and liver disorders, 6 for hypertension, 3 for blood-related diseases, and 5 for snake and scorpion bites (Table 1). The highly validated species along with authenticated reported uses are good candidates for bioprospecting using a holistic approach (Skirycz *et al*., 2016).

The plant species that were not found in the reviewed studies or were found in species with very limited exploration in science, including ethnopharmacology, were novel records (with PFC 0 in this study: Table 1). Among these, the species with a high number of informants were *Datura innoxia*, *Cyperus rotundus*, *Fagonia bruguieri* and *Corchorus depressus*. The above-cited species are either endemic to some regions or neglected in science.

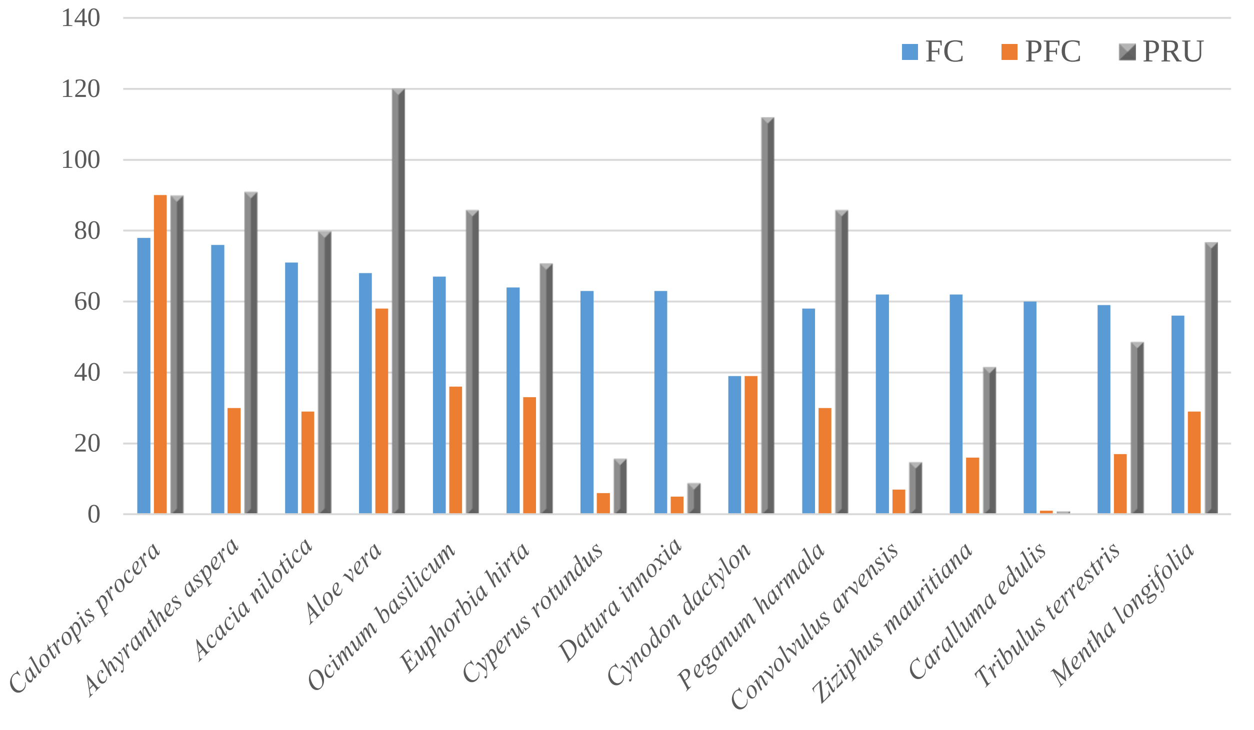

Fig. 3. Frequency of citation (FC), previous frequency of citation (PFC) and Previous reported uses (PRU) of most important plant species of study area.

Pharmacological activities and phytochemicals of reported plants: In the present study, the reported plant species were comprehensively reviewed regarding their pharmacological activities and phytochemistry. Among the reported species, *Blepharis sindica* and *Echinops echinatus* did not have reports of their pharmacological and related activities, while *Opuntia monacantha*, *Carthamus oxyacantha*, *Corchorus depressus*, *Amaranthus albus*, *Cucumis melo* subsp. *aggestris* var. *aggestris*, *Salvia santolinifolia*, and had limited published records related to their activities. These species may be screened out for various pharmacological activities.

The diversity of phytochemicals is considered to be important for the therapeutic potential of any plant species. In the present study*, Opuntia monacantha* and *Blepharis ciliaris* have few reports regarding their phytochemistry. Moreover, only well-known species are repeatedly studied with the same results in either pharmacological or phytochemical studies. Thus, species selected for any study should either have been rigorously reviewed in past studies or not screened out at all in the past.

The plant species that are not studied or have limited published records should be studied and preferred over other species in pharmacological or phytochemical study as both fields are considered to be pillars for drug discovery and development (Verpoorte, 2012). In addition to the reductionist approach, the holistic approach, which has been a milestone for drug development in the past 50 years may be applied using guidelines recommended by Verpoorte *et al*., (2005). In our view, the latter approach may lead to successful results in a short span of time with limited resources and may be maximally cost-effective in the field of medicinal plants.

Comparative similarities and dissimilarities of reported traditional medicinal uses: The reported medicinal plant species were compared at the local, regional (Regional countries) and global level (Fig. 4). At the local level, the maximum species were matched with ethnopharmacological studies published from Baluchistan, while the minimal species were from the northern areas. At the regional level, the maximum studies compared were reported from India (52 studies) and the lowest from Iran and China. At the global level, the highest number of studies showing one or more species were reported from Africa, while very few were from Australia. These results not only show cultural relationships but also number of common species due to phytogeographic relationships between Study area and communities of Africa.

The most prominent studies along with number of matched species from our study area are: (Upadhyay *et al*., 2010) (21 species), (Bhatia *et al*., 2014) (20), (Ullah *et al*., 2014) (18), (Bibi *et al*., 2014) (16), (Jain *et al*., 2005) (15), (Ayyanar & Ignacimuthu, 2005) (14), (Adnan *et al*., 2014) (14), (Ahmad *et al*., 2009) (13), (Mussarat *et al*., 2014) (13), (Shadangi *et al*., 2012) (13), (Ahmed *et al*., 2015) (13), (Saqib *et al*., 2014) (12), (Kayani *et al*., 2014) (12), (Ibrar *et al*., 2015) (12), (Mootoosamy & Mahomoodally, 2014) (11), (Akhtar *et al*., 2013a) (11) and (Sreekeesoon and Mahomoodally, 2014) (11). The species that are common in the previously published studies may have a wide ecological amplitude, showing similarities with other flora, while those that did not match the compared studies have a narrow ecological amplitude.

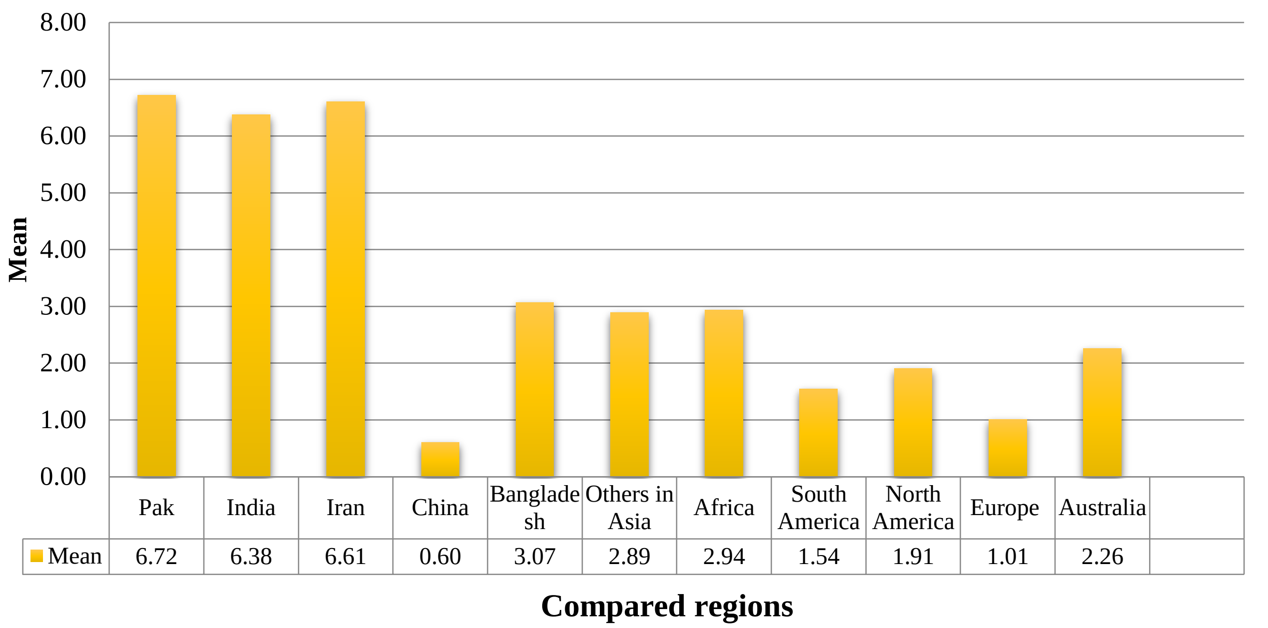

Fig. 4. Comparative similarity of flora and their traditional uses at local, regional and global level.

Quantitative Ethnopharmacological data analysis: The documented ethnopharmacological uses of the reported plant species were analyzed using various quantitative ethnobotanical indices. The values of the applied indices fluctuate from minimum to maximum values, where later values represent the importance of a species (Medeiros *et al*., 2011). In the present study, the UV varied from 0.49 to 0.2. The highest UV was reported for *Cynodon dactylon*, while the lowest was for *Tribulus terrestris*. The RFC varied from 0.38 to 0.1. Based on the RFC, *Calotropis procera* was the most commonly known species to the informants, whereas *Aerva javanica* was the least known species. The RI varied from 50.74 to 5.61. The highest RI was observed for *Acacia nilotica*, while lowest was for *Salvia santolinifolia* and *Tamarindus indica*. The FL varied from 39.39 to 100. Fourteen species with the maximum FL, indicating specific uses, are marked with asterisks. The most commonly known species was *Acacia nilotica*, which has been reported to be used for treating infertility in females, while *Senna occidentalis,* specifically cited for treating constipation, was less known. The ethnobotanical indices are helpful in selecting species for the desired study in the field of herbal medicine (Khan *et al*., 2014). The plant species with the highest values (Fig. 5) in the correlation of all of the ethnobotanical indices may be selected for in further *in vitro* or *in vivo* studies.

In the present study, the ICF varied from 0.16 to 0.61. The highest value was observed for digestive system disorders, while the lowest was for nervous disorders (Table 2). This consensus showed that the common human health problems include digestive system disorders and that people use well-known plant species to treat them. The use of specific plants for treating a disease category always leads to the highest ICF (Prasad *et al*., 2013). The plant species commonly reported for treating digestive disorders and that were not screened out regarding their potential for use in pharmacological studies may be selected for use in future studies.

Table 2. Informant consensus factor of medicinal plants used in the Deserts of Sindh-Pakistan

S. No	Disease Category	N_{ur}[1*]	% N_{ur}	N_t[2*]	N_t%	ICF[3*]
1.	Digestive System Diseases	169	22.09	67	88.16	0.61
2.	Respiratory diseases	88	11.5	51	67.11	0.43
3.	Nervous Disorders	32	4.18	27	35.53	0.16
4.	Sensory organs diseases	117	15.29	58	76.32	0.51
5.	Sexual diseases	79	10.33	42	55.26	0.47
6.	Urinary system diseases	48	6.27	33	43.42	0.32
7.	Glandular Disorders	86	11.24	56	73.68	0.35
8.	Muscular and skeletal system diseases	37	4.84	28	36.84	0.25
9.	Blood Circulatory system diseases	92	12.03	50	65.79	0.46
10.	Antidote	17	2.22	14	18.42	0.19

[1*]Nur = Number of use reports; [2*]N_t= Number of taxa used in disease category; [3*]ICF= Informant consensus factor

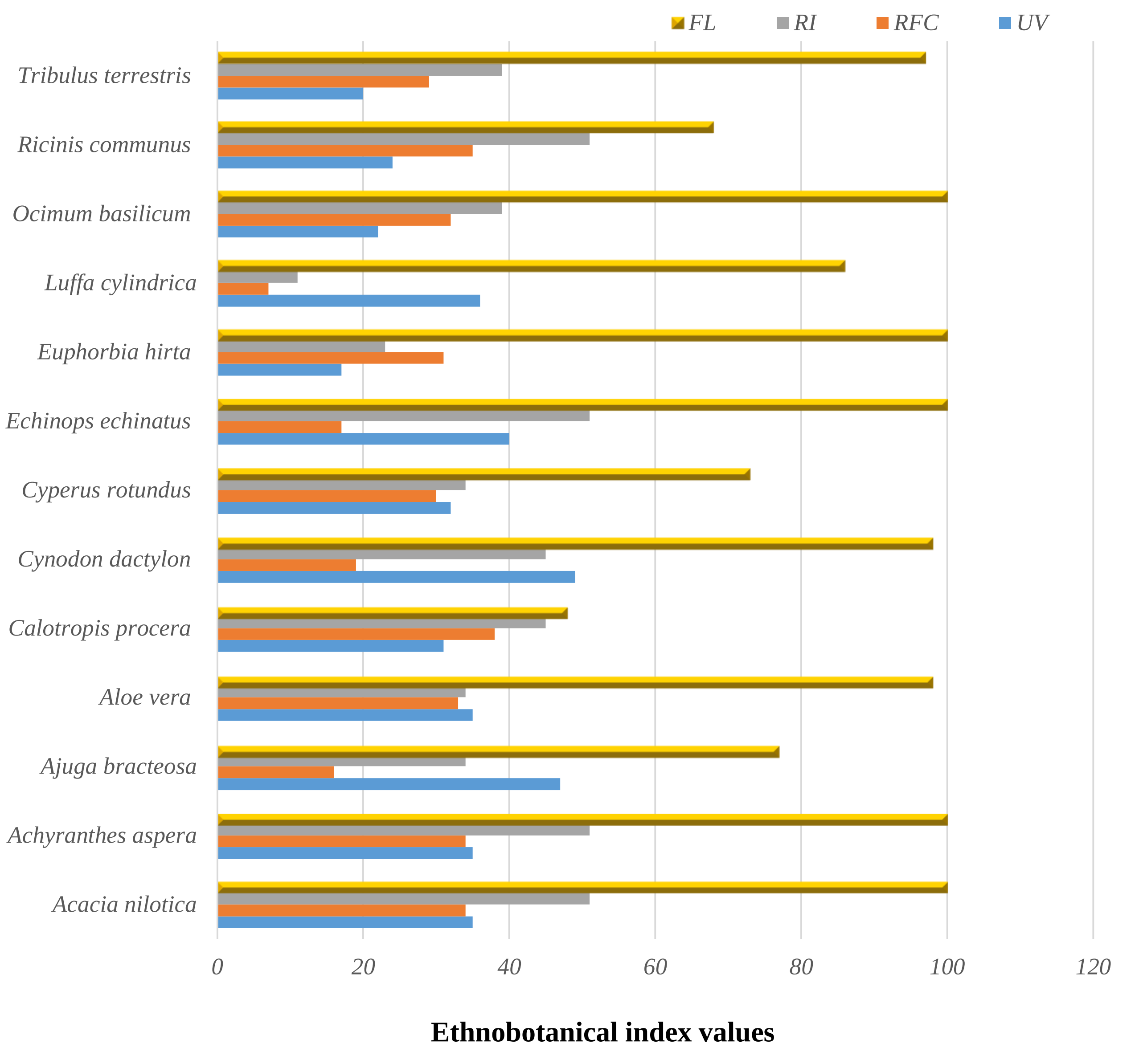

Fig. 5. Fidelity Level (FL), Relative Importance (RI), Relative Frequency of Citation (RFC) and Use Value (UV) of most important plant species of the study area

Promising medicinal plant species: The traditional medicinal uses reported during extensive ethnopharmacological surveys authenticated by the MA and SRs are helpful for highlighting important plant species for drug discovery and development in evidence-based herbal medicine. In the present study, the plant species with the most authenticated uses (Table 1) are considered to be promising plant species.

The plant species that have the most authentic validated traditional uses in various studies are: *Amaranthus albus* for snake and scorpion bite (Asad *et al*., 2011; Bibi *et al*., 2014; Butt *et al*., 2015; Nasim *et al*., 2013) and asthma (Abo *et al*., 2008; Akhtar *et al*., 2013a; Chander *et al*., 2014; Sher *et al*., 2015), *Ziziphus mauritiana* for leucorrhea (Abo *et al*., 2008; Inta *et al*., 2013), *Withania somnifera* for asthma (Jain *et al*., 2004; Mahishi *et al*., 2005; Philander, 2011; Shadangi *et al*., 2012), *Senna occidentalis* for diabetes (Andrade-Cetto & Heinrich, 2005; Chander *et al*., 2014; Ezuruike & Prieto, 2014; Katemo *et al*., 2012; Mootoosamy & Mahomoodally, 2014), *Ajuga integrifolia* for epilepsy (Akhtar *et al*., 2013b; Sher *et al*., 2015), *Cynodon dactylon* for diabetes (Andrade-Cetto & Heinrich, 2005; Lans, 2006; Tahraoui *et al*., 2007; Tarafdar *et al*., 2015), , *Ocimum basilicum* for hypertension (Idu *et al*., 2009; Jouad *et al*., 2001), *Tribulus terrestris* for urinary and sexual diseases (Kumar *et al*., 2015; Ullah *et al*., 2014; Yaseen *et al*., 2015), and *Achyranthes aspera* for asthma (Ahmad *et al*., 2014; Kayani *et al*., 2015; Singh *et al*., 2012). The above cited plant species have the most authenticated uses, but lack proper pharmacological studies, and thus may be selected for preclinical or clinical trials.

The selection of plant species based on the most authenticated ethnopharmacological uses may yield good results within the limited time and cost of studies (Verpoorte *et al*., 2009). The plant species with the most authenticated uses, high previous frequencies of citation and large number of previously reported uses in the compared literature (Fig. 3) and highest ethnobotanical indices (Fig. 5) may be helpful to the researchers working in various fields related to herbal medicine while those having limited records in previous studies require more attention for their probable potential in herbal medicine.

Study strengths and future prospective: The present study focused on the authentication of traditional uses of reported medicinal plant species based on extensive MA and SRs. Specifically, it highlights the most promising species of the Deserts of Sindh based on ethnobotanical interviews and surveys combined with documentation of medicinal uses of these species reported worldwide in various studies. The uses that are frequently cited in the ethnopharmacological studies are mentioned along with the number of citations, and the species that have no or limited data in ethnobotanical, pharmacological and phytochemical studies are also mentioned. This study also describes the important species of the region and highlights the need for the conservation of species and preservation of related traditional knowledge. Moreover, this study also refreshes and updates the traditional uses of the species reported in past studies but no longer practiced at present.

According to ethnopharmacological surveys, the reliability and proper documentation of traditional medicinal uses is a major challenge (Leonti *et al*., 2013; Verpoorte, 2012). The knowledge obtained from local people and its reliability is another issue because the ethnopharmacological reported uses include a chain of all activities, such as drug development. This issue can be resolved by authenticating the of uses of these plants based on previously published studies (Taylor *et al*., 2001). The present study may introduce new trends in the field of ethnopharmacology by highlighting the important uses of medicinal plant species in a single study and by comparing large datasets of ethnobotany, pharmacology, and phytochemistry. Our study may serve as a model to help revolutionize the field of herbal medicine by avoiding overemphasis on the most familiar species. Moreover, these approaches also highlight the ambiguities in taxonomic names, such as the use of illegitimate names, mistakes in spellings and repetition in the use of similar names for different species. Adaptations of the present approaches may enable the development of an online repository of traditional uses at the local level, which may be enhanced at the regional and global level by bringing many researchers and academicians to one database. One may select the species of interest based on the most authenticated uses from the online repository (Verpoorte, 2008). This approach may help ethnobotanists to focus on species with little published data instead of duplicating published results with a long list of plants. Moreover, species that have no records in the published ethnobotanical, pharmacological or phytochemical literature may also be easily selected for future studies.

Conclusions

Plant biodiversity is a potentially valuable source of novel drugs. In bioprospecting, the selection of a plant species having authenticated ethnopharmacological uses based on the MA and SRs along with the correlation of quantitative ethnobotanical indices may be a powerful tool for future drug discovery and development. In various ethnic communities of the Deserts of Sindh-Pakistan, herbal medicine has been a well-anchored practice for centuries. In the Deserts of the Sindh, many important plant species are used in traditional medicine for curing various diseases. In the present study, medicinal species were reported from various communities of the Deserts of the Sindh and their ethnopharmacological uses were documented using basic ethnobotanical tools. The documented data were analyzed using the MAs, SRs, and ethnobotanical indices. The important species were highlighted along with the most authenticated uses developed by comparing previously published studies from all over the world. Besides, the novel uses of the plant species along with preferred uses (mentioned by the informants) are also highlighted. In addition, the important species lacking pharmacological and phytochemical studies are also mentioned. In the results, the species most frequently reported by informants were *Calotropis procera*, *Achyranthes aspera*, *Ricinus communis* and *Acacia nilotica*. Based on SRs and MA, the most frequently cited species were *Aloe vera*, *Ricinus communis*, *Psidium guajava*, *Cynodon dactylon* and *Ocimum basilicum* while 36 species have novel uses and four species lack pharmacological studies, three species have no phytochemical record, while 17 species have very few (average 5) published studies in pharmacology and phytochemistry. In comparative similarity of the medicinal flora, the maximum similarity was found with the flora of India, at the regional level, whereas at the local level the various species matched with the studies published from Baluchistan. Overall, the highest number of ethnobotanical studies reviewed were found from Africa while very few species were found in the studies published from Australia. In ethnobotanical studies, the application of systemic reviews and meta-analyses may bring authenticated traditional uses while it also highlights the species that are either ignored or yet not studied for their potential in herbal drugs. In bioprospecting, the plant species with most authenticated traditional uses yet whose potential applications in drug development have not been adequately should be preferred. In addition, species with only a few documented traditional uses may be further explored for preservation of traditional knowledge to them. Avoiding the repetition of analyses of the most familiar species and prioritizing the plant species having most authenticated ethnopharmacological uses, highest correlated ethnobotanical index values, and or lacking pharmacological or phytochemical studies, may yield desired results in limited time with most cost-effective use of resources.

Acknowledgment

We are highly thankful to the local communities of the Deserts of Sindh for their cooperation in giving time and sharing traditional knowledge about reported plant species. Especial thanks go to the THPs for their given precious time during data documentation. We also acknowledge the HEC-Pakistan for providing funds (IRSIP) which made easy access to data analysis. We are highly grateful to GBIF for Project grant (BIFA: 57) on georeferencing and Mobilization of plant occurrence data from Pakistan. We are also thankful to HEC-Pakistan for providing funding under Prime minister fee reimbursement scheme for less developed areas.

Table 1. List of medicinal plant species used in the Deserts of Sindh-Pakistan.

Plant name/ (Family) / Voucher specimen no	Local name (life form)	Part used / modes of utilization	Diseases treated (with asterisk)[1*] and (written in bold fonts)[2*]	Reported biological activities	FC[3*]	PFC[*]	RI[5*]	FL[6*]	RFC[7*]	UV[*]	Reported Phyto-constituents
Acacia nilotica (Linn.) Delile (Fabaceae) ISL:933	Babool (Tree)	Gum, Pod, Seeds, Leaves, Flower, Bark, Shoot / Decoction, Powder, Paste, Juice	Toothache (DS), Diarrhea (DS), Dysentery (DS), Diabetes (GS), Cough (RT), Sexual weakness in male (RS), Asthma (RT), Respiratory tract disorders (RT), Digestive problems (DS), Urinary disorders (US), **Vomiting** (DS), **Gonorrhea** (RS), Leucorrhea (RS), Milk production in females (GS), Infertility in females (RS), Eyes infections (SO), **Hepatitis A*** (GS), Jaundice (GS), Nerve tonic (NS) Brain weakness (NS), Sore throat (RT), **Malaria** (CS), Chronic fever (CS), Premature ejaculation (RS)	Anticancer (Ali *et al.*, 2012)	71	29	50.74	100	0.34	0.35	Tannins, Saponin, Glycosides, Volatile oils, Phenols, Triterpenes, Flavonoids and Alkaloid (Solomon-Wisdom & Shittu, 2010)
Achyranthes aspera Linn. (Amaranthaceae) GY-ISL:635	Phut kanda (Herb)	Whole plant, Leaves, Root/Decoction, Powder, Juice, Paste, Ash	Enhance urination (US), Digestive disorders (DS), **Amenorrhea** (RS), used for causing Abortion (RS), Labor pain (RS), Toothache (DS), Insect bites (CS), **Thorn infection in foot** (CS), Piles (DS), **Leprosy** (SO), Asthma* (RT), Cough (RT), Stomachache (DS), **Skin eruption** (SO), Kidney stones (US), **Heart diseases** (CS), **Night blindness** (SO), **Hydrophobia** (NS), Ophthalmia (SO), Urinary bladder stones (US), Blood purifier (CS), Pneumonia (RT), Bowel complaints (DS), Nausea (RT), Scorpion sting (CS), Micturition (US), Dysentery (DS), Joint pain (SS), Pimples (SO), Boils (SO), **Sterility in females*** (RS)	Antiviral (Mukherjee *et al.*, 2013); Anticancer (Subbarayan *et al.*, 2012)	76	30	45.44	97.37	0.37	0.45	Steroids, Terpenoids, Flavonoids, Phenols, Tannins, Phytosterols, Fixed oils, Cardiac glycosides Saponins, Oleanolic acid, Dihydroxy ketones, Alkaloids (Srivastav *et al.*, 2011)
Aerva javanica (Burm. f.) Juss. Ex Schult (Amaranthaceae) GY-ISL:736	Booh (Herb)	Whole plant, Leaves, Flower, Root / Paste, Decoction	**Toothache** (DS), **Hemorrhoids*** (DS), Skin dryness (SO), Eye problems (SO), Wounds and inflammation (GS)	Nephroprotective (Movaliya & Zaveri, 2014); Antimicrobial (Mufti *et al.*, 2012)	21	5	16.81	90.48	0.1	0.24	Acylated flavones Glycosides, Nonacosane, Hentriacontane, Heptacosane, octacosane, Pentacosane, Hexacosane Triacontane (Samejo *et al.*, 2012)
Agave americana L. (Asparagaceae) GY-ISL: 778	Kanwar Phara (Herb)	Leaves / Paste	Jaundice* (GS), Liver tonic (GS), **Blood purifier** (CS), Boils and Pimples (SO)	Antimicrobial, Antifungal, (Babu *et al.*, 2015)	28	4	22.37	92.86	0.14	0.18	Alkaloids, Volatile oils, Tannins, Steroids Cardiac and Saponin glycosides (Kadam *et al.*, 2012)

Table 1. (Cont'd.).

Plant name/ (Family) / Voucher specimen no	Local name (life form)	Part used / modes of utilization	Diseases treated (with asterisk)[1*] and (written in bold fonts)[2*]	Reported biological activities	FC[3*]	PFC[*]	RI[5*]	FL[6*]	RFC[7*]	UV[*]	Reported Phyto-constituents
Ajuga integrifolia Buch. Ham ex D. Don (Syn: *Ajuga brateosa* Wall. Ex Benth.) (Lamiaceae) GY-ISL:739	Kouri Booti (Herb)	Leaves, Whole Plant / Powder, Decoction, Juice	Throat infection (RT), Fever (CS), Headache (CS), Pimples (SO), **Measles*** (CS), Stomach acidity (DS), Jaundice (GS), Hypertension (CS), Constipation (DS), **Ear & eye diseases** (SO), Gum infections (DS), Stomachache (DS), Blood purifier (CS), **Kidney problems** (US), Malaria (CS), Diabetes (GS)	Anti-plasmodial, Anti-inflammatory, Anti-arthritic (Gautam *et al*., 2011; Kaithwas *et al*., 2012)	34	9	33.8	76.47	0.16	0.47	Bractic Acid, Bractin A and B (Riaz *et al*., 2007)
Aloe vera (L.) Burm. f. (Xanthorrhoeaceae) GY-ISL:712	Kawar ghandal (Herb)	Leaves / Powder, Juice, Paste	Constipation (DS), Digestive troubles (DS), **Inflammation of the abdominal viscera** (DS), Irritant and itching skin (SO), Rheumatic pain (SS), **Abortion** (RS), **Leucorrhoea** (RS), Blood purifier (CS), Blood pressure (CS), Diabetes (GS), Hair tonic (SO), **Piles** (DS), Jaundice (GS), Eye diseases (SO), Uterus inflammation (RS), Tonsils (GS), Stomach trouble & acidity (DS), Burn (SO), Amenorrhea (RS), Hepatitis (GS), Liver tonic (GS), **Fractured bone** (MS)	Antiulcer, Anti-diabetic, Anti-inflammatory (Reynolds & Dweck, 1999)	68	58	34.04	97.06	0.33	0.35	Alkaloids, Anthrones Anthraquinones, Benzene and Furan derivatives, Chromones, Coumarins, Flavonoids, Phytosterols, Pyrans and Pyrones (Cock, 2015)
***Amaranthus albus* L.** (Amaranthaceae) GY-ISL:443	Mareero (Herb)	Leaves, Whole Plant / Paste	**Scorpion sting** (CS), **Body heat** (CS), **Kidney & ureter stones*** (US)	Antioxidant (Ishtiaq *et al*., 2014)	31	0	11.23	93.55	0.15	0.13	Flavonoids, Saponins, Sterols, Tannins (Kamil *et al*., 2012)
***Blepharis ciliaris* (L.) B.L. Burtt** (Acanthaceae) GY-ISL:797	Khol meer (Herb)	Seeds, Root / Powder	**Wounds** (SO), **Antiseptic** (GS), **Antimony for eyes irritating eyes*** (SO), **Eye diseases** (SO), **Diabetes*** (GS), **Cooling agent** (DS), **Urinary disorders** (US), **Liver disorders** (GS)	Not Known	27	0	22.46	100	0.13	0.3	Stigmasterols, Apigenin, Lucopyranosides (El-Shanawany et al., 2014), Blepharisides A and B (Mohamed *et al*., 2015)
***Calendula arvensis* (Vail) L.** (Asteraceae) GY-ISL:749	Gul-e-Ashrafi (Herb)	Flower, Leaves / Paste	**Body spasm** (SS), **Induce sweating*** (GS), **Amenorrhea** (RS), **Wounds** (SO), **Eye sigh**t (SO), **Heart diseases** (CS), **Skin infections** (SO)	Antiviral (De Tommasi *et al*., 1991)	34	0	28.01	73.53	0.16	0.24	Essential oils, Caffeic acid, Chlorogenic acid, Rutin (Loescher *et al*., 2014)

Table 1. (Cont'd.).

Plant name/ (Family) / Voucher specimen no	Local name (life form)	Part used / modes of utilization	Diseases treated (with asterisk)[1*] and (written in bold fonts)[2*]	Reported biological activities	FC[3*]	PFC[*]	RI[5*]	FL[6*]	RFC[7*]	UV[*]	Reported Phyto-constituents
Calotropis procera (Aiton.) Dryand (Asclepiadaceae) GY-ISL:759	Akk (Shrub)	Whole Plant Leaves, Latex Flower/ Juice, Decoction, Paste, Smoke	Toothache (SS), Stomachache (DS), Cough (RT), Anthelmintic (DS), **Induce sweating** (GS), Dog bites (CS), Asthma (RT), Malaria (CS), **Cholera** (DS), **Arthritis** (SS), Blood pressure (CS), Snake bite (CS), Jaundice (GS), Skin disorders (SO), **Blood coagulation** (CS), **Scabies** (SO), **Hepatitis** (GS), Diabetes (GS), **Sexual weakness in male** (RS), Ringworm (SO), Constipation (DS), **Dandruff** (SS), Leprosy (SO)	Anticancer, Anti-diabetic, Hepatoprotective, Anti-inflammatory, antioxidant (Choedon *et al*., 2006; Setty *et al*., 2007)	78	25	45.15	48.72	0.38	0.31	Tannins, Steroids, Saponins, Flavonoid (Kawo *et al*., 2010)
Carthamus oxyacantha M. Bieb. (Asteraceae) GY-ISL:703	Kantri, Pholi (Herb)	Seeds/ Oil, Juice, Powder	**Stomach ulcer** (DS), Skin itching (SO), **Jaundice*** (GS), Urine enhancer (US), **Male infertility** (RS), Scabies (SO)	Hepatoprotective, Antihyperlipidemic (Bukhsh *et al*., 2014)	48	2	27.95	93.75	0.23	0.13	Lignan glucosides, Glycosides, Caffeic acid, Flavanols (Johansen *et al*., 2011)
Cleome scaposa L. (Capperidaceae) GY-ISL:757	Hul hul (Herb)	Whole plant, Leaves, Seeds, Root / Juice	Earache (SO), Stomach ulcer (DS), Carminative (DS), Ear infection* (SO), Deafness (SO)	Hepatoprotective, Psychopharmacologic (Parimala Devi *et al*., 2004); Antipyretic (Devi *et al*., 2003)	30	7	11.35	73.33	0.14	0.27	Linoleic, palmitic, stearic, oleic, linolenic acid, viscocic acid and viscosin, cleosandrin, cleomiscosin A and B (Mali, 2010)
Convolvulus arvensis L. (Convolvulaceae) GY-ISL:718	Hiran Khuri, (Herb)	Whole plant, Root, Leaves / Powder, Juice Decoction	Evacuation of bowels (DS), Skin diseases (SO), Constipation (DS), Appetizer (DS), Brain tonic* (NS), Enhance urination* (US), Sedative (NS), Boils inflammation (SO), **Piles** (DS), **Jaundice** (GS), **Menstrual problems** (RS)	Anti-angiogenesis, Antitumor (Ali *et al*., 2013; Kaur & Kalia, 2012)	62	7	33.66	96.77	0.3	0.18	Saponins, steroids, flavonoids and alkaloids, proteins and lipids (Kaur & Kalia, 2012)
***Corchorus depressus* (L.) Stocks** (Malvaceae) GY-ISL:790	Mundairi (Herb)	Whole plant, Leaves, Root, Seeds/ Powder, Juice, Paste Decoction,	**Menstrual problems*** (RS), **Hepatitis** (GS), **Enhance urination** (US), **Male sexual weakness*** (RS), **Stomachache** (DS), **Gastric problems** (DS), **Pneumonia** (RT), **Spermatorrhoea** (RS), **Premature ejaculation** (RS), **Piles** (DS), **Fever** (CS), **Gonorrhea** (RS), **Swelling of urinary bladder** (RS)	Aphrodisiac, Hepatoprotective (Kataria *et al*., 2013a; Pareek *et al*., 2013)	56	0	28.16	100	0.27	0.23	Alkaloids, Steroids, Flavonoids, Saponins, Tennins, Phenols (Kataria *et al*., 2013b)
Cucurbita maxima Duch. ex Lam. (Cucurbitaceae) GY-ISL:761	Wun (Herb)	Fruit / Powder, Paste	Burns (DS), **Jaundice*** (GS), **Nervous disorders** (NS), **Stomach ulcer** (DS), Digestive problems (DS), Stomachache (DS), **Heart tonic*** (CS)	Anticancer, Immunomodulatory (Ranganathan and Selvasubramanian, 2015; Saha *et al*., 2011)	45	6	16.87	86.67	0.22	0.16	Protocatechuic, Caffeic acid, Syringic, Vanillic, p-coumaric, Ferulic acids (Rezig *et al*., 2012)

Table 1. (Cont'd.).

Plant name/ (Family) / Voucher specimen no	Local name (life form)	Part used / modes of utilization	Diseases treated (with asterisk)[1*] and (written in bold fonts)[2*]	Reported biological activities	FC[3*]	PFC[*]	RI[5*]	FL[6*]	RFC[7*]	UV[*]	Reported Phyto-constituents
Cynodon dactylon (L.) Pers (Poaceae) GY-ISL:764	Khabal Ghass (Herb)	Whole plant, Seeds, Root, Leaves, Shoot / Decoction, Juice, Powder	Constipation (DS), Pile (DS), **Irritation of urinary organs** (US), Dropsy (GS), Vomiting (DS), Dysentery (DS), **Redness of eyes** (SO), **Relieve eye pain** (SO), Skin injuries and wounds (SO), Blood purifier* (CS), Asthma (CS), Kidney stones (US), Jaundice (GS), **Nose bleed*** (RT), Gonorrhea (RS), Urinary disorders (RS)	Hepatoprotective, Hypoglycaemic, Anti-nephrolithiasis, Anticancer, Anticonvulsant, Cardiotonic (Shendye & Gurav, 2014)	39	39	45	97.44	0.19	0.49	Flavonoids, Glycosides Sterols, Steroidal saponins, Phenols, Alkaloids, Tannins (Shendye and Gurav, 2014)
Cyperus rotundus L. (Cyperaceae) GY-ISL:765	Deela, Kabh (Herb)	Root, Leaves, Whole Plant / Powder, Paste, Oil, Decoction, Juice	Fever (CS), Nausea (DS), **Muscle relaxation** (SS), Dyspepsia (DS), Vomiting (DS), **Cholera** (DS), Diarrhea (DS), **Dysentery** (DS), **Blood infections*** (CS), **Cough** (CS), Stomachache (DS), Enhance urination (US), **Pneumonia** (RT), **Antidote** (CS), Induce sweating (GS); **Leprosy** (SO), **Epilepsy*** (NS), **Eye disorders** (SO), Pimples (SO), Hair tonic (SO)	Tranquilizing, Anticonvulsant, Anticancer Hepatoprotective, anti-tussive, Anti-diabetic (Raut & Gaikwad, 2006; Sivapalan, 2013)	63	6	33.92	73.02	0.3	0.32	Alkaloids, Flavonoids, Tannins, Glycosides, Furochromones, Glycerols, Monoterpenes, Sesquiterpenes, Sitosterol, Fatty oil, Linolenic, Myristic and stearic acids (Sivapalan, 2013)
Dalbergia sissoo Roxb. Ex DC. (Fabaceae) GY-ISL:766	Talhi (Treee)	Leaves, Root, Bark, Shoot/ Decoction, Paste, Juice, Powder	Gonorrhea* (RS), **Leprosy** (SO), Boils (SO), Vomiting (DS), Piles (DS), Jaundice (GS), **Ringworm** (SO), **Athlete's foot** (SO), **Nose bleed** (RT)	Anti-pyretic, Anthelmintic, (Bhattacharya *et al.*, 2014)	33	10	28.04	75.76	0.16	0.27	Isoflavone -O- glycoside, Mesoinisited, 7 - 0 – methyle tectorigenin and 4'-rhamnoglycoside, Isocaviumin, Tetorigeni dalbergin, Caviunins Tannins (Bhattacharya *et al.*, 2014)
Datura innoxia Mill. (Solanaceae) GY-ISL:767	Dhaatoro (Herb)	Leaves, Seeds, Fruit / Paste, Juice	Asthma* (CS), **Mouth infections** (DS), Skin problems (SO), **Gonorrhea** (RS), **Hydrophobia*** (NS), **Earache** (SO), **Bronchitis** (RT), **Tonsil problems** (GS), **Baldness** (SO), Fever (CS)	Antimicrobial (Eftekhar *et al.*, 2005)	63	5	39.18	98.41	0.3	0.16	Atropine, Scopolamine, Essential oils, Saponins, Flavonoids, Phenols, Cardiac glycosides (Ayuba *et al.*, 2011)
***Echinops echinatus* Roxb.** (Asteraceae) GY-ISL:768	Oont katara (Herb)	Whole Plant, Root, Leaves, Fruit, Seeds / Powder, Decoction, Paste, Juice	**Nerve tonic** (NS), **Cough** (RT), **Stomachache pain** (DS), **Fever** (CS), **Joint pain killer** (SS), **Scabies** (SO), **Sexual debility*** (RS), **Gastric problems** (DS), **Enhance urination** (US), **Liver disorder** (GS), **Bronchial disorders*** (RT), **Eye drops** (SO), **Urinary bladder diseases** (US)	Not Known	35	0	50.41	100	0.17	0.4	Not Known

Table 1. (Cont'd.).

Plant name/ (Family) / Voucher specimen no	Local name (life form)	Part used / modes of utilization	Diseases treated (with asterisk)[1*] and (written in bold fonts)[2*]	Reported biological activities	FC[3*]	PFC[*]	RI[5*]	FL[6*]	RFC[7*]	UV[*]	Reported Phyto-constituents
Euphorbia hirta L. (Euphorbiaceae) GY-ISL:769	Dodak, Kheer walh (Herb)	Leaves, Seed Flower/ Juice, Powder, Decoction	**Redness of eyes** (SO), **Eye diseases** (SO), **Hair tonic** (SO), Asthma (RT), Respiratory disorders* (RT), Cough (RT), **Measles*** (RT), **Athlete's foot** (SO), Premature ejaculation (RS), Diarrhea (DS)	Antimicrobial, Anti-asthmatic, Antimalarial, Glactogenic, Antifertility, Antiplatelet aggregation, Anticancer (Patil *et al*., 2015)	64	33	22.55	100	0.31	0.17	Euphorbianin, Camphol, Leucocyanidol, Quercitol Quercitrin, Polyphenols, Tannins, Triterpenes and Phytosterols (Patil *et al*., 2015)
***Fagonia bruguieri* DC.** (Zygophyllaceae) GY-ISL:770	Dhamao (Herb)	Whole plant / Powder, Decoction	Fever (CS), **Asthma** (RT), **Vomiting** (DS), **Dysentery** (DS), **Eye disorders** (SO), **Toothache** (DS), **Skin disorders*** (SO), **Snake bite** (CS), **Skin allergy** (SO)	Anti-inflammatory, Androgenic, Neuroprotective, Endocrinological, Analgesic, antitumor and Anticancer (Puri & Bhandari, 2015)	56	2	22.49	96.43	0.27	0.16	Sapsonins, Tannins, Unsaturated sterols, Triterpenoids, Alkaloids, Cardiac and Cyanogenic glycosides, Flavonoids, Coumarins, Chlorides and sulphates (Eman, 2013)
Lantana camara L. (Verbanaceae) GY-ISL:771	Phanch phali (Shrub)	Whole Plant Leaves, Flower / Decoction, Juice	**Induce sweating** (GS), Gastric problems (DS), Rheumatism (SS), Tetanus* (RT), Malaria* (CS)	Anti-hyperglycemic, Antimicrobial, Anti-motility, Hemolytic, Anti fertility (Kalita *et al*., 2012)	29	21	27.92	86.21	0.14	0.17	Mono- and di-sesquiterpenes, Iridoid glycosides, Triterpenes, Flavonoids, Furanonaphtho quinones, Phenyl ethanoid glycosides (Ghisalberti, 2000)
Luffa cylindrical (Linn.) Roem. (Cucurbitaceae) GY-ISL:775	Tori (Herb)	Fruit / Paste	**Stomach pain** (DS), Stomach ulcer* (DS), Constipation (DS), **Flu** (RT), Nose allergy (RT)	Antimicrobial, Anti-diabetic, Anti-inflammatory, Antiasthma, cardiotonic, Immuno-stimulatory (Partap *et al*., 2012)	14	7	11.26	85.71	0.07	0.36	Triterpenoid, Saponins, Apigenin, Luffins, Luffacylin (Aboh *et al*., 2012)
Malvastrum coromandelia num (L.) Garcke (Malvaceae) GY-ISL:776	Damhni plant (Herb)	Whole plant, Leaves, Flower/ Paste, Decoction	**Fever** (CS), **Induce sweating** (GS), **Sores and wounds** (SO), **Dysentery** (DS), **Respiratory tract*** (RT), **Diarrhea** (DS)	Anti-diabetic, Anti-hyperlipidemic, (Deore *et al*., 2011)	31	0	27.95	80.65	0.15	0.19	Alkaloids, Saponins, Phenols, Tannins, (Sanghai *et al*., 2013)
Mentha longifolia (L.) L. (Lamaiceae) GY-ISL:777	Phodno (Herb)	Whole plant, Leaves, Flower / Juice, Powder	Gastrointestinal problems (DS), Gastric problems (DS), Vomiting (DS), Dysentery (DS), **Asthma** (RT), Fever (CS), Chest diseases (RT), **Chronic diarrhea** (DS), **Contraceptive in females*** (RS), **Jaundice*** (GS)	Antimutagenic, Antimicrobail, Antioxidant (Orhan *et al*., 2012)	56	29	28.07	98.21	0.27	0.18	Luteolin, Menthol, Rutins, (Orhan *et al*., 2012)
Ocimum basilicum L. (Lamaiceae) GY-ISL:780	Niazbo (Herb)	Leaves, Seeds, Flower/ Oil, Decoction	Mouth sores (DS), Urinary diseases (US), Cough (RT), Indigestion (DS), Depression* (NS), Induce sweating (GS), Gastric problems (DS), Gonorrhea (RS), Low blood pressure (CS), Bronchitis (RT), Cold (RT), fever (CS), Diarrhea (DS), Ring worm (SO), Stomach ulcer (DS), Malarial fever (CS)	Anti-inflammatory, Anti-microbial, Antioxidant, Anti-ulcerogenic, Hepatoprotective, Hypoglycemic, Larvicidal Hypolipidemic, Immuno-modulator (Bilal *et al*., 2012)	67	36	39.33	100	0.32	0.22	Methyl cinnamate, Linalool, β-elemene, Phenylpropanoid (Kathirvel & Ravi, 2012)

Table 1. (Cont'd.).

Plant name/ (Family) / Voucher specimen no	Local name (life form)	Part used / modes of utilization	Diseases treated (with asterisk)[1*] and (written in bold fonts)[2*]	Reported biological activities	FC[3*]	PFC*	RI[5*]	FL[6*]	RFC[7*]	UV*	Reported Phyto-constituents
***Opuntia monacantha* (willd.) Haw.** (Cactaceae) GY-ISL:782	Thoor (Shrub)	Latex, Fruit / Paste	**Asthma** (RT), **Cough** (RT), **Hepatic congestion*** (GS), **Gonorrhea** (RS), **Diabetes*** (GS), **Paralysis** (NS)	Hepatoprotective, Antidiabetic, Antioxidant (Lim, 2012)	48	0	22.4	100	0.23	0.13	Flavonoids, Polyphenols (Lim, 2012)
***Physalis minima* auctt** (Solanaceae) GY-ISL:785	Popta (Herb)	Leaves, Fruit, Whole plant / Decoction, Juice	Jaundice (GS), **Anti-cancer*** (CS), Ear drop* (SO); **Enhance urination** (US), Indigestion (DS)	Anti-inflammatory, Antipyretic, Analgesic, Anti-leishmania (Khan *et al.*, 2009)	29	0	27.92	100	0.14	0.17	Vitamin E, Oleic acid, Hexadeconoic acid, Flavones, Physialin, Withanolides (Usaizan *et al.*, 2014)
Pongamia pinnata (Linn.) Pierr (Fabaceae) GY-ISL:786	Sukh chain (Tree)	Leaves, Seeds, Fruit, Young Branch/ Oil, Powder, Paste, Decoction	**Gastric problems** (DS), **Rheumatism** (SS), **Vermifuge** (DS), Toothache* (DS), Gum infection (DS)	Anti-hyperglycaemic and Anti-lipidperoxidative, Anti-ulcer Activity, Anti-hyperammonemic, Anti-plasmodial (Sangwan *et al.*, 2010)	29	6	11.26	100	0.14	0.17	Alkaloids, Demethoxy-kanugin, Gamatay, glabrin, Glabrosaponin, Kaempferol, Kankone, Kanugin, Karangin, Neoglabrin, Pinnatin, Pongamol, Pongapin, Auercitin, Saponin, β-sitosterol, Tannins (Chopade *et al.*, 2008)
***Prosopis cineraria* (Linn.) Druce** (Fabaceae) GY-ISL:788	Kandi (Tree)	Leaves, Stem, Fruit, Bark, Branch / Paste, Decoction, Juice	**Skeleton pain** (SS), **Wound** (SO), **Rheumatism*** (SS), **Brain tonic** (NS), **Eye inflammation** (SO)	Anti-hyperglycemic, Anti-hyperlipidemic, Antioxidant Hepatoprotective (Khatri *et al.*, 2011)	46	1	16.81	65.22	0.22	0.11	Methyl docosanoate, diisopropyl-9,10-dihydroxyicosane-1,20-dioate, Tricosan-1-ol and 7,24-tirucalladien-3-one. Diisopropyl-10,11-dihydroxyicosane-1,20-dioate, Methyl docosanoate, Tricosan-1-ol and 7,24-tirucalladien-3-one (Khatri *et al.*, 2011)
Psidium guajava L. (Myrtaceae) GY-ISL:789	Zaitoon (Shrub)	Fruit, Leaves, Bark / Powder, Decoction	Stomach problems (DS), **Appetizer** (DS), Cough (RT), Bronchitis (RT), Chronic whooping cough (RT), Diabetes* (GS), **Liver disorders*** (GS)	Antineoplastic, Anticancer, Anti-diarrheal, Cardiotonic, Hepatoprotective, Antitussive, Anti-genotoxic Anti-mutagenic, Anti-hyperglycemic (Gutiérrez *et al.*, 2008)	23	45	16.87	100	0.11	0.3	Polyphenols, Essential oils, Flavonoids, Saponins, Fixed oils (Gutiérrez *et al.*, 2008)
Ricinus communis L. (Euphorbiaceae) GY-ISL:791	Arand (Shrub)	Whole plant, Leaves, Seeds Bark / Oil, Decoction, Powder, Juice, Paste	Cough (RT), Paralysis (NS), Asthma (RT), **Increase milk production** (GS) Bronchitis* (RT), Gastric problems (DS), **Leprosy** (SO), Piles (DS), **Ringworm** (SO), **Amenorrhea** (RS), Dysentery (DS), Inflammatory diseases of the urinary organs (US), **Earache** (SO), **Nervous problems** (NS), **Sciatica*** (SS), **Sexual disorders** (RS), Constipation (DS)	Anti-diabetic, anti-histamic, Anti-nociceptive, anti-asthmatic, Antiulcer, Immunemodulatory, Anti-diabetic, Hepatoprotective, Anti-inflammatory, Antifertility, Antimicrobial, (Jena & Gupta, 2012; Scarpa & Guerci, 1982)	72	52	50.5	68.06	0.35	0.24	Steroids, Saponins, Alkaloids, Flavonoids, and Glycosides (Jena & Gupta, 2012)

Table 1. (Cont'd.).

Plant name/ (Family) / Voucher specimen no	Local name (life form)	Part used / modes of utilization	Diseases treated (with asterisk)[1*] and (written in bold fonts)[2*]	Reported biological activities	FC[3*]	PFC[*]	RI[5*]	FL[6*]	RFC[7*]	UV[*]	Reported Phyto-constituents
Salvia santolinifolia Boiss. (Lamiaceae) GY-ISL:792	Khoropo (Herb)	Seeds / Powder	**Diarrhea** (DS), **Piles*** (DS)	Antimicrobial, Antioxidant (Nadir *et al*., 2013)	26	0	5.61	80.77	0.13	0.08	Monoterpenes, Sesquiterpenes, Diterpenes, Fatty aldehydes (Nadir *et al*., 2013)
Senna occidentalis Vahl. (Fabaceae) GY-ISL:755	Ghora walh (Herb)	Leaves, Pod / Paste, Juice	Constipation* (DS), Skin disorders (SO), **Pimples** (SO), Malaria (CS), Diabetes (GS), Indigestion (DS)	Hepatoprotective, Antimalarial, Anti-mutagenic (Jafri *et al*., 1999; Yadav *et al*., 2010)	33	11	16.9	39.39	0.16	0.24	Aloeemodin, Emodin, Anthraquinones, Apigenin, Anthrones, Aurantiobtusin, Campesterol, Cassiollin, Chryso-obtusin, Chrysophanic acid, Chrysarobin, Chrysophanol, Chrysoeriol (Yadav *et al*., 2010)
Solanum surrattense Burm.f. (Solanaceae) GY-ISL:795	Kandirii (Herb)	Whole plant, Fruit, Seed, Leaves, Root / Powder, Juice, Ash, Decoction	Digestive problems (DS), Cough (RT), Asthma* (RT), Fever (CS), **Chest pain** (RT), **Sore throat** (RT), Piles (DS), Purification of blood* (CS), **Rheumatism** (SS), **Respiratory tract problems** (RT)	Anti-hyperlipidemic, Antimicrobial, Antifertility, Antipyretic, Anticancer, Anti-asthmatic, Cardiotonic Hepatoprotective (Parmar *et al*., 2010; Singh & Singh, 2010)	58	12	22.52	98.28	0.28	0.17	Steroidal and Glyco-alkaloids, Steroids, Saponins, Essential oils (Parmar *et al*., 2010; Singh & Singh, 2010)
Sonchus asper (L.) Hill (Asteraceae) GY-ISL:796	Dodh Bhatal (Herb)	Whole Plant, Root, Leaves / Decoction, Juice	**Wounds and boils** (SO), Burns (SO), **Enhance urination*** (US), Sedative (NS), Cough (RT), Bronchitis (RT), Asthma (RT)	Hepatorenal protective, Antioxidant, Anticancer, Cardioprotective (Khan *et al*., 2012)	39	14	22.43	61.54	0.19	0.18	Polyphenols, Lactones Sesquiterpene, Glycosides, Flavonoids, Ascorbic acid (Khan *et al*., 2012)
Tamarindus indica L. (Fabaceae) GY-ISL: 707	Imli (Tree)	Fruit, Root / Juice	Hepatitis (GS) and Jaundice* (GS)	Anti-diabetic, Anthelmintic, Hypolipidemic, anti-venomic, Antimalarial Hepatoprotective, Anti-asthmatic (De Caluwé *et al*., 2009; Havinga *et al*., 2010)	49	23	5.61	100	0.24	0.04	Polyphenolics, Cardiac glycosides (Bhadoriya *et al*., 2011)
***Tecomella undulata* (sm.) Seem.** (Bignoniaceae) GY-ISL:798	Roheero (Tree)	Young Stem, Flower / Decoction	**Vermifuge** (DS), **Constipation** (DS), Menstrual **problems** (RS), **Sterility in females*** (RS), **Wounds** (SO), **Tetanus*** (RT)	Anti-hyperglycemic, Anti-obesity, Hepatoprotective, Anti-inflammatory, Immunomodulatory, Anticancer, Anti-proliferative (Khatri *et al*., 2009; Srivastava & Choudhary; 2012)	45	0	16.84	97.78	0.22	0.13	Radermachol, Lapachol, Tecomaquinone-I, α-lapachone, β- lapachone, Stigmasterol, β-sitosterol, Oleanolic acid, Ursolic acid and Betulinic acid (Dhir & Shekhawat, 2012)

Table 1. (Cont'd.).

Plant name/ (Family) / Voucher specimen no	Local name (life form)	Part used / modes of utilization	Diseases treated (with asterisk)[1*] and (written in bold fonts)[2*]	Reported biological activities	FC[3*]	PFC[*]	RI[5*]	FL[6*]	RFC[7*]	UV[*]	Reported Phyto-constituents
***Tephrosia apollinea* subsp. *apollinea* (Delile) Hosni and El-Karemy.** (Fabaceae) GY-ISL:799	Sar Phonko (Herb)	Whole plant, Seeds, Leaves/ Decoction, Paste, Powder	**Ear drop** (SO), **Rheumatic pain** (SS), **Stomachache** (DS), **Diarrhea** (DS), **Asthma*** (RT), **Urinary disorders** (US), **Wounds** (SO)	Anticancer (Hassan *et al*., 2014), Antioxidant, Antimicrobial, Anticancer, Anti-plasmodial, Anti-inflammatory, Larvicidal (Touqeer *et al*., 2013)	24	1	27.98	62.5	0.12	0.29	Pseudosemiglabrin - glabratephrin, glabratephrinol Appollinine (Touqeer *et al*., 2013)
Thespesia populnea (L.) Sol. Correa (Malvaceae) GY-ISL: 801	Borh (Tree)	Root, Flower, Leaves / Juice, Paste	**Insect bites** (CS), **Gonorrhea** (RS), Ringworm (SO), **Migraine*** (NS), **Headache** (NS), Scabies (SO)	Anti-nociceptive, Anti-inflammatory, Antifertility, Antibacterial, Anti-diabetic Hepatoprotective (Dhanarasu *et al*., 2010)	40	3	22.4	100	0.19	0.15	Populnein, Quercetin-7-O rhamnoglucoside (Shirwaikar *et al*., 1995)
***Trianthema portulacastrum* L.** (Aizoaceae) GY-ISL:802	Itsit (Herb)	Whole plant, Root, Leaves / Paste, Powder	Jaundice* (SS), Liver disorders* (GS), **Enhance urination** (US), **Urinary bladder inflammation** (RS), **Cough** (RT), **Asthma** (RT), **Wounds** (SO), **Rheumatism** (SS), **Fever** (CS)	Hepatoprotective, Anti-ulcer, Anti-diabetic, Anti-cancer, Antimicrobial (Kumar *et al*., 2004; Geethalakshmi *et al*., 2010)	44	2	39.12	100	0.21	0.18	Steroids, Alkaloids, Terpenoids, Glycosides, Flavonoids, Phenols (Geethalakshmi *et al*., 2010; Shivhare *et al*., 2012)
Tribulus terrestris L. (Zygophyllaceae) GY-ISL:803	Gokhru (Herb)	Seeds, Leaves, Fruit, Root, Whole plant / Powder, Juice, Decoction	Kidney and urinary bladder stones* (US), **Skin diseases** (SO), **Asthma** (RT), **Leprosy** (SO), **Itching in urethra** (US) , Sexual weakness in male (RS), Spermatorrhoea (RS), Cooling agent (CS), Enhance urination (US), Renal diseases (US), Urethral discharges (RS), Oral inflammations (DS)	Antiseptic, Anti-inflammatory (Ukani *et al*., 1997; Akram *et al*., 2011)	59	17	39.24	96.61	0.29	0.2	Protodioscin, Terrestrosins A-E, Desgalactotigonin, Fegitonin, Quercetin, Desglucolanatigonin, Gitonin, Tigogenin, Furostanol glycosides, β-Sitosterol, Spirosta-3,5-diene, Stigmasterol, Diosgenin, Hecogenin, Ruscogenin, Kaempferol, Tribulusamides A and B (Ukani *et al*., 1997; Akram *et al*., 2011)
Withania somnifera Dunal (Solanaceae) GY-ISL:806	Asgand (Herb)	Leaves, Fruit, Root, Seeds, Bark / Powder Paste	Stomach problems (DS), **Arthritis** (SS), Rheumatism (SS), Asthma* (RT), **Uterine diseases** (RS), Sexual weakness in male* (RS)	Anti-tumor, Apoptogenic, Immunomodulatory, Anticonvulsant, Neuropharmacological, Anti-hyperglycaemic, Anti-aging (Uddin *et al*., 2012)	58	26	22.43	93.1	0.28	0.12	Alkaloids, Steroids, Volatile oil, Glycosides, Hentriacontane, Dulcitol, Withaniol, Withanolides, Chlorogenic acid, Flavonoids (Uddin *et al*., 2012)
Ziziphus mauritiana Lam. (Rhamnaceae) GY-ISL:808	Bair (Shrub)	Fruit, Leaves / Juice, Ash, Powder, Decoction	Diabetes (GS), Hair tonic (SO), Constipation (DS), **Pimples** (SO), **Snake bite** (CS), **Measles*** (CS), **Bronchial disorders** (RT), Digestive problems (DS), Blood purifier* (CS), Skin diseases (SO)	Anticancer, Haemolytic, Anxiolytic, Antimicrobial Hypoglycemic, anti-plasmodial, Anti-diabetic, nticonvulsant (Mishra *et al*., 2010; Goyal *et al*., 2012)	62	16	27.78	95.16	0.3	0.17	Alkaloids, Flavonoids, Terpenoids, Saponins, Triterpenoic acids (Goyal *et al*., 2012)

1*= Specific use mentioned by informants, 2*= Written in bold show novel uses as compared with 299 published papers, 3*FC= Frequency of Citation (Number of informants), 4* PFC = Previous Frequency of Citation (Number of citations in reported 299 published papers), 5*= RI= Relative Importance, 6* FL= Fidelity Level, 7* RFC = Relative Frequency of Citation, 8*UV= Use Value, 09* RT = Respiratory tract, DS = Digestive System, RS = Reproductive System, SO = Sensory Organs, CS = Circulatory System, NS= Nervous System, US = Urinary System, SS = Skeletal System, GS = Glandular System

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