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Ecology, Ethnobotany, and Conservation Status of Browse Vegetation from Cholistan Rangelands of Pakistan

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Abstract. The browse vegetation of the Cholistan rangelands is diminishing with the passage of time due to climatic extremities, overgrazing, and human exploitation. Therefore, this study was planned to collect the baseline data about ecology, ethnobotany, and conservation status of browses. A semi-structured questionnaire was designed to record information of plant species from nomadic peoples (85 males, 05 females) and by ecological observations during field visits. In this study, a total of 25 browse species belonging to 17 genera and 12 families were documented, however family status showed that Chenopodiaceae and Mimosaceae were most dominant families. In these rangelands three-soil microhabitats sandunal, interdunal and clayey saline were noted, and each have different species structure and composition. According to life span and life form, all identified species were found as perennials and phanerophytes, respectively. Leaf spectra of Raunkiaerian approach revealed that leptopylls dominated study area, which is an indicator of arid conditions. Phenological observations revealed two flowering seasons, the first season was from February to April and second was from September to November, both were associated to winter and monsoon rains, respectively. Further ethnobotanical observations have divided species into four categories based on their uses i.e., firewood, timber wood, forage and medicinal. The peoples of this area depend on local plants and different parts of plants (bark, leaves, shoots, roots) were used for different treatments. Out of total, 24 species were observed to have forage value that showed potential of this area as rangeland whereas based on grazing response, maximum number of species (40%) were noted as decreasers. According to conservation status, most of browse species have become threatened, followed by endangered, vulnerable, least concerned, and critically endangered, respectively. Results showed current status and potential of browses to apply quick conservation measures with suggestion of further floral investigation in Cholistan rangelands.

Key words: Overgrazing, Browse species, Baseline data, Perennials, Threatened

Introduction

Pakistan is a sub-tropical country that is geographically located in South Asia between longitudes 61º and 76º E and latitudes 24º and 37º N. The overall area of this country is 80 million hectares out of which more than 80% found in arid or semi-arid conditions. Pakistan is a diverse ecological system of the world as it holds wide-ranging environmentally unique habitats. It covers nearly all types of well-known ecosystems, e.g., snow-capped mountains, deserts, vast water bodies, evergreen, and deciduous forests, and diversity of rangelands (Majeed *et al.*, 2002).

Out of the total (80 million hectares) area of Pakistan, 49 million hectares have been classified as rangelands, which mostly have arid to semiarid environmental conditions. These rangelands encompass alpine pasture in the northern mountains to temperate and Mediterranean ranges in the western mountains and arid to semi-arid desert ranges in the Indus plains. The rangelands of Pakistan reveal a great variety of plant species composition, soil characteristics, productivity potential, and lastly their capability to support livestock and human beings (Ahmad *et al.*, 2012).

Overall, rangelands embrace about 50 % of the world's land surface and are vast areas of natural vegetation used to support livestock production. Generally, the rangelands occur in vegetation biomes such as grasslands, shrublands, savannas, and deserts and are mostly determined by dry environments (Gamoun, *et al*., 2016). These rangelands are characterized as very significant from the ecological point of view as they provide vegetation cover, protection to the soil, and sustainable production of feed for grazing animals. Sustainability of rangelands is necessary to combat desertification and preserving biodiversity, along with the participation of pastoral people and their knowledge (Briske, 2017).

In Pakistan, rangelands hold 30 million herds of grazing livestock that add 400 million US $ to Pakistan annual export incomes (Anonymous, 2006). Unfortunately, the arid rangelands of Pakistan are under the degradation process due to over grazing, extreme climatic conditions, deforestation, and several anthropogenic factors (Mirza *et al.,* 2006). The productivity potential of Pakistani rangelands is very low; though the nomadic peoples and graziers who depend on these rangelands are only getting the 40-50% forage requirements of their livestock. At present, these vast natural resources of the country are not managed on a scientific basis and only 10-15% of their actual potential is being realized (Ahmad and Islam, 2011).

The concept of desertification in rangelands does not refer to the spreading out of existing deserts, but to the process of land degradation in these natural ecosystems. The variable distribution of rainfall contributes significantly towards the deterioration of rangeland productivity in the dry areas (Gamoun, 2016). The rangelands of Cholistan desert were once flourishing, the dynamic is now mostly transforming into a desolated piece of lands. Sustainability of life in these rangelands rotates around the occurrence of annual precipitation, which mostly occurs during monsoon. In the summer season, weather conditions are very harsh; only some xeric plant species do survive but then undergo extreme grazing pressure. The constant increase in the human population pressure for livelihood and multiplying the number of livestock is adding stress towards the vegetation of these rangelands (Akhter and Arshad, 2006).

The study of plant life of desert areas has always fascinated the ecologists from all over the world (Ward, 2016). Plants create

the floristic treasure and are important part of life and potential curative for several disorders both in human and animals (Phondani *et al.*, 2016). Traditional ecological information is a vital knowledge held by geographically and socially defined communities with their day-to-day contacts with natural environment (Fernandez-Gimenez and Fillat, 2012). This progressing information is collected, practiced, and transferred from one generation to another, mainly via observation and imitation. Documentation of traditional information is very important since they are getting lost due to changes in lifestyle, and fast loss of natural habitats. Moreover, such studies highlighted numerous threatened plant species which have been declared as rare, endangered, or extinct in the wild (Kakinuma and Seiki, 2012).

The vegetation of the Cholistan rangelands is playing a very significant role for local community and for livestock feed especially browse species (shrub and tree) are one of the most important and nutritionally rich sources of feed for grazing and browsing animals in the Cholistan (Abdullah *et al.,* 2013a). Browses species have the advantage of sustaining their nutritive value all over the dry season when grasses and herbs decline in both quantity and quality. However, due to year-round stress, the browse species of these rangelands are under the severe threat and need detail assessment for quick remedy measures (Abdullah *et al.,* 2017a).

Despite the pressures on the browse vegetation of Cholistan rangelands, little effort was made to assess these rangelands in terms of their ecology and ethnobotany. No conservational measures have been made in this area because of the unavailability of enough data about the browse vegetation. Protection and rangelands management seems to be the only safe approach for rehabilitation of this desert habitat, ensuring the future survival of man and his livestock in such an extreme environment (Abdullah *et al.,* 2013b). To keep the justifiable use of the rangeland resources for the future, information about the present rangeland resources is very essential. Therefore, this study was being planned to collect baseline data about ecology, ethnobotany, and conservation status of browse vegetation of Cholistan rangelands to chalk out their conservation measures.

Material and Methods

Description of the study area

This study was carried in the Cholistan desert that is in the southern area of Punjab Pakistan (Fig. 1). Cholistan desert is a fragment of Great Indian Desert and ranges between latitudes 27º 42′ and 29º 45′ N and longitudes 69º 52′ and 75º 24′ E covering an area of about 2.6 million hectares (Arshad *et al.,* 2008). The total human population in the Cholistan desert is about 110,000 nomadic pastoralists. Mostly they live on the margin of the desert while the inner of the desert is thinly occupied. The economy of this region is largely pastoral, and people have been living such a nomadic lifestyle for centuries. The pastoralists owned smaller to large herds of camels, cattle, goats, and sheep. It is classified as an arid sandy desert where mean annual rainfall differs from less than 100 mm in the west to 200 mm in the east, commonly expected in monsoon season (July to September). Persistent drought periods are common after every 10 years (Akbar *et al.,* 1996). Rainfall is collected in locally made water pools called 'tobas'. Underground water is found at the depth of 30-50 m, which with some exceptions is brackish having salts from 9,000-24,000 mgL^{-1}. The mean temperature in summer (May-July) is 34-38ºC with the maximum reaching over 51.6ºC as shown in Fig. 2 (Arshad *et al.,* 2003). The soil of the Cholistan desert is commonly considered as

saline, alkaline, and gypsiferous composed of gneiss, schists, granites, and slates. Sand dunes occur commonly in the Cholistan and extend an altitude of about 30-100 m (Akbar and Arshad, 2000). The soil is classified as either saline or saline-sodic, with pH ranging from 8.2 to 8.4 and from 8.8 to 9.6, respectively (Arshad *et al.*, 2008). The vegetation of this arid desert comprises of xerophytes that are adjusted to very high temperature, low moisture, and high salinity with wide-ranging edaphic features. The sparse vegetation normally covers perennial shrubs with dispersed small trees. Numerous ephemeral and annual species appear after rainfall, complete their life cycle in a small duration and dry up after producing their seeds (Akhter and Arshad, 2006).

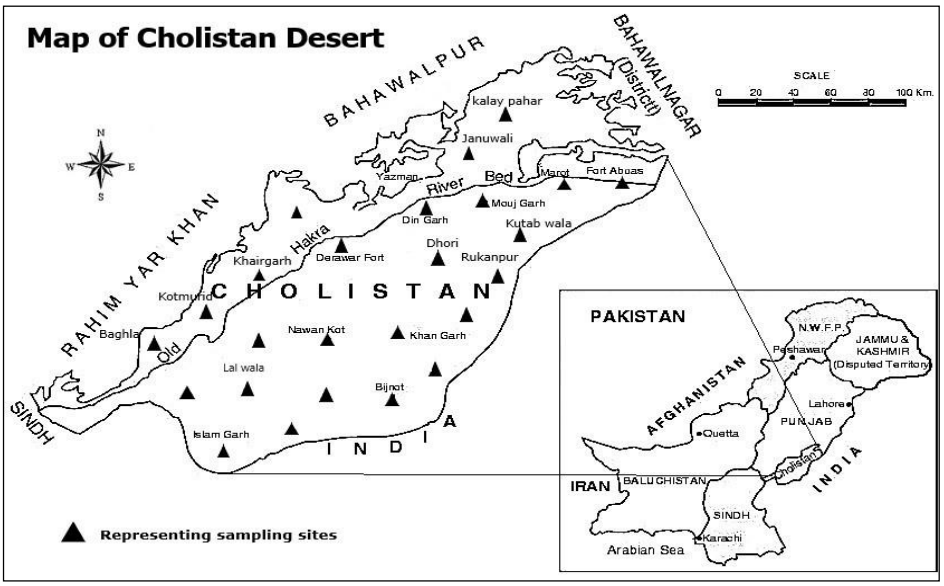

Fig. 1. Map showing the selection of study sites in Cholistan rangelands, Pakistan

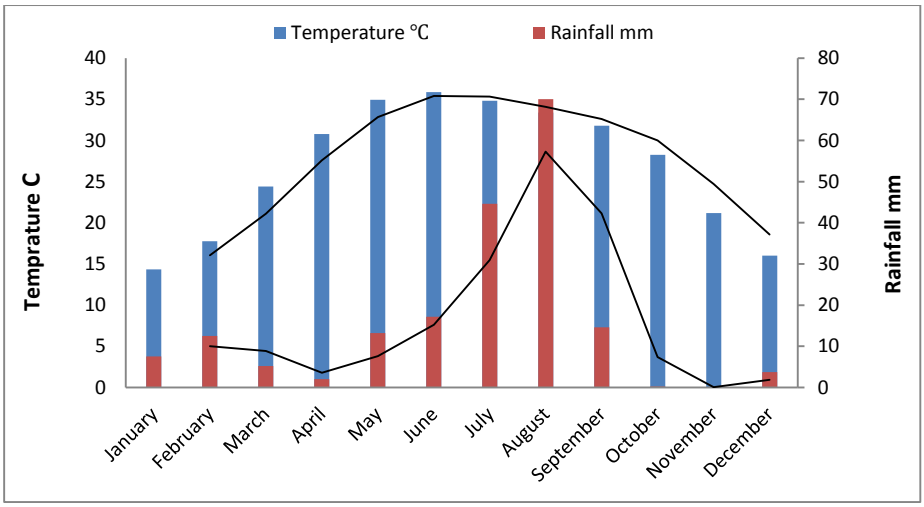

Fig. 2. A climate graph displays yearly temperature & precipitation in Cholistan (2010-2015)

Data Collection

Reconnaissance survey and ecological analysis

A reconnaissance survey was carried in January 2013 to select the sites, to have an overview of site condition, accessibility, plant composition and to decide the data collection methods (Fig. 3). According to plan, the whole research project was conducted for three successive years i.e., 2013 to 2015. The floristic survey was carried in different seasons to collect and identify the browse species of Cholistan rangelands. Complete specimens of each species were collected in triplicate, dried, preserved, and mounted on herbarium sheets by following the conventional process. The plants were identified with the assistance of Flora of Pakistan and existing literature (Ali and Nasir, 1990-1991; Ali and Qaiser, 1993-2007; Arshad and Rao, 1994; Qureshi, 2004). The identified specimens were checked and confirmed from the Cholistan Institute of Desert Studies, The Islamia University Bahawalpur. A complete floristic list along with botanical, families, genera, and vernacular names was compiled about browse species, which witnessed at any site. Information and observations about habit (climber, herb, subshrub, shrub, and tree) were documented on spot during plant collection. Plants were categorized into leaf size classes according to Rankiaer (1934) and Hussain (1989). Habitat of selected plants species were noted and characterized as sandunal, interdunal and clayey saline. The observations about phenological events of browses were noted at periodic intervals (fortnightly/monthly) during study period based on the method of Opler *et al*. (1980). For each plant species, four phenological events were observed, i.e.

- Seedling stage (vegetatively young and pre-flowering)
- Flowering stage (only flowers seen)
- Fruiting stage (mature where both flowering and fruiting can be seen)
- Dormant stage (life cycle completed, or fruiting completed)

Ethnobotanical classification

The identified browse species were categorized on the bases of their local economic uses to know their ethnobotanical importance. These economic uses of species were as forage, medicinal, timber, and fuel wood. A semi-structured questionnaire was designed to record the information about the economic and beneficial value of plant species by direct observations and from nomadic peoples (85 male and 05 female) during field visits in study area (Martin, 1995).

Range condition and conservation status

Range browse species were classified as increasers, decreasers and constant based on their grazing response that how these plants react when livestock graze them. The forage value of each browse species was also categorized into good, fair, poor and none by observing the preferences of grazing animals. Information was gathered from pastoralists and self-field observations on species at different range sites (Tainton, 1981). Plants were grouped into various conservations classes using the IUCN (2001) criteria such as Extinct (EX), Extinct in Wild (EW), Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Near Threatened (NT), Least Concern (LC), Data Deficient (DD), and Not Evaluated (NE).

Statistical analysis

The medicinal uses of plants were classified into various types by following the method of Cook (1995). Microsoft excel spreadsheet analysis was used to accomplish simple averages, percentiles, and mean values and

to make necessary graphs and tables (McCullough and Heiser, 2008).

Fig. 3. Author during data collection from the Cholistan rangelands

Results

Ecological assessment

In this baseline study, total 25 study sites were selected for data collection as well as to cover all habitat types and floral diversity (Table 1). Results revealed total 25 browse species belonging to 17 genera and 12 families were identified and documented from the arid rangelands of the Cholistan desert (Table 2).

Plant family status revealed that Chenopodiaceae and Mimosaceae were the most dominant families with 04 species each (16%) followed by Rhamnaceae with 03 species (12%), Amaranthaceae, Asclepiadaceae, Capparaceae, Papilionaceae, Tamaricaceae, with 2 species each (08%) and Compositae, Malvaceae, Polygonaceae, Salvadoraceae with 1 species each (04%) respectively.

For the ease of identification of plants in the field, local names of species were also noted from the study area as given in Table 2. The recorded browse species were composed of 6 species of trees (24%) and 19 species of shrubs (76%).

According to life span and life form, all the identified species were found as perennials and phanerophytes, respectively. Leaf spectra of the Raunkiaerian approach also revealed that leptopylls (56%) dominated the study area. They were followed by nanophylls (28%), micophylls (12%), and mesophylls (4%) respectively (Table 2).

In Cholistan rangelands three types of habitats were observed sandunal, interdunal and clayey saline. Maximum species were observed to be found on interdunal habitat (21 species) followed by clayey saline habitat with 19 species and 09 species were observed to be found on sandunal habitat (Fig. 5).

There was a great diversity in the phenological behaviour of browse species in the Cholistan rangelands. Overall, two phenological seasons were recorded, the first season was from February to April and the second was from September to November. May to August and December to January

were almost dormant seasons. Out of total species, 12 species (48%) were observed in the first season (Feb-Apr), in which 0 species were trees and 08 species were shrubs. In the second season, (Sep-Nov) 16 species (64%) were noted which consisted of 04 species of trees, 12 species of shrubs. Whereas 06 (24%) species were observed in both phenological seasons, which consist of 02 species of trees, 04 species of shrubs. There was also some species, which showed a great variation in their phenological stages as compared to others (Fig. 6).

The peak seasonal periods in which maximum species were observed in seedling form was September with 23 species followed by February with 12 species. Whereas maximum browse species were observed at flowering in October (12 species) followed by March (11 species). The peak time for fruiting was April and November with 12 species each. The last phenological stage was the dormant season and maximum browse species were observed to become dormant in May (11 species) and December (12 species). Generally, the dormant season was observed from May to August and December to January, but the activity of some species was also noted in these periods.

Table 1. Name, location, and topography of each study site in Cholistan rangelands

Sr. No.	Site Name	Latitudes	Longitudes	Elevation (m)	Topography
1	Fort Abas	N: 28º32.274´	E: 071º25.329´	119.18	Sandunal
2	Marot	N: 29º12.161´	E: 072º15.427´	121.31	Sandunal
3	Kalapahar	N: 29º10.430´	E: 072º05.569´	117.04	Clayey saline
4	Januwali	N: 29º05.056´	E: 072º09.933´	123.75	Interdunal sandy
5	Khirsir	N: 29º10.339´	E: 072º08.749´	119.18	Sandunal
6	Haider wali	N: 29º02.672´	E: 072º10.200´	116.43	Clayey saline
7	Mojgarh Fort	N: 29º01.059´	E: 072º08.106´	119.48	Sandunal
8	Kutab wala	N: 29º11.039´	E: 072º05.101´	110.34	Sandunal
9	Khangarh	N: 28º57.261´	E: 072º03.089´	112.47	Interdunal sandy
10	Khanser	N: 28º59.227´	E: 071º55.299´	107.29	Sandunal
11	Bijnot	N: 28º47.988´	E: 071º45.770´	103.63	Interdunal sandy
12	Dingarh Fort	N: 28º57.454´	E: 071º51.910´	111.25	Clayey saline
13	Dhori	N: 28º47.364´	E: 071º34.920´	114.30	Clayey saline
14	Rukanpur	N: 28º53.182´	E: 071º46.362´	113.08	Sandunal
15	Nidamwala Toba	N: 28º52.963´	E: 071º44.270´	108.20	Clayey saline
16	Nawankot	N: 28º47.939´	E: 071º45.770´	101.80	Interdunal sandy
17	Lalwala	N: 28º32.838´	E: 072º55.770´	098.75	Interdunal sandy
18	Lakhan	N: 28º52.232´	E: 071º42.731´	106.98	Clayey saline
19	Chananpir	N: 28º56.832´	E: 071º40.057´	107.59	Interdunal sandy
20	Baylawala	N: 29º23.466´	E: 071º39.563´	124.97	Interdunal sandy
21	Derawar fort	N: 29º23.465´	E: 071º39.560´	105.16	Interdunal sandy
22	Khair garh	N: 28º49.208´	E: 071º28.129´	101.80	Sandunal
23	Kotmurid	N: 28º39.864´	E: 071º15.632´	098.45	Clayey saline
24	Islamgarh Fort	N: 27º50.208´	E: 071º48.129´	101.80	Sandunal
25	Baghla	N: 28º46.325´	E: 071º34.638´	112.47	Interdunal sandy

Table 2. Summary of ecological characteristics of browse species in study area

Sr. No.	Plant characters	Class	No. of species	Percentage
1	Taxonomy	No. of Species	25	46
		No. of Genera	17	31
		No. of Family	12	22
2	Habit	Tree	6	24
		Shrub	19	76
3	Leaf size	Leptophyll	14	56
		Nanophyll	7	28
		Microphyll	3	12
		Mesophyll	1	4
4	Economic uses	Firewood	19	26
		Timber wood	6	8
		Forage	24	33
		Medicinal	23	32
5	Forage value	Good	7	28
		Fair	13	52
		Poor	4	16
		None	1	4
6	Grazing Response	Increaser	8	32
		Stable	7	28
		Decreaser	10	40
7	Conservation status	Least concern	4	16
		Near Threatened	8	32
		Vulnerable	5	20
		Endangered	6	24
		Critically Endangered	2	8

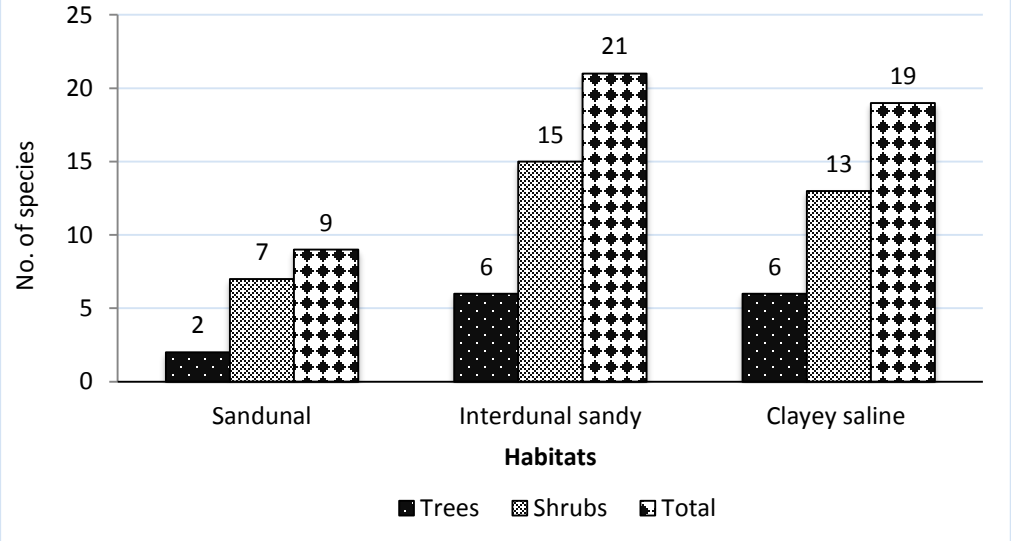

Fig. 4. Type of habitats and number of browse species inhabiting these habitats

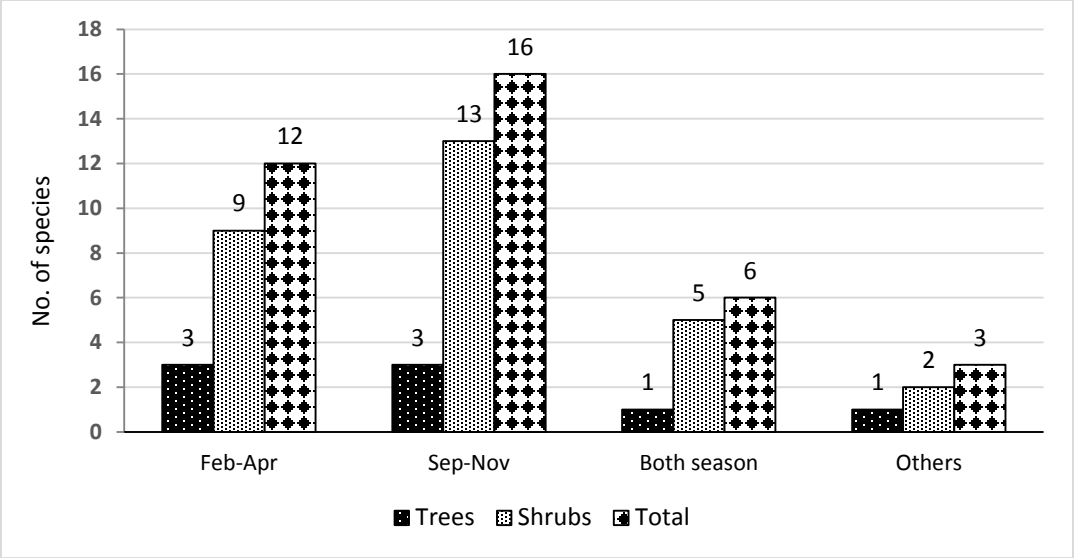

Fig. 5. Phenological behavior of browse species in Cholistan rangelands

Table 3. Ecological attributes of browse species in Cholistan rangelands

Sr. No.	Family	Botanical name	Habit	Leaf size#	Habitat@
1	Amaranthaceae	*Aerva javanica* (Burm. f.) Merill.	Shrub	Micro	S, I
2	Amaranthaceae	*Aerva pseudotomentosa* ssp. bovei. Clarke.	Shrub	Micro	S, I
3	Asclepiadaceae	*Calotropis procera* (Aiton.) Aiton.	Shrub	Meso	I, C
4	Asclepiadaceae	*Leptadenia pyrotecnica* (Forssakal.) Decne.	Shrub	Lepto	S, I
5	Capparaceae	*Capparis decidua* (Forsskal.) Edgew.	Shrub	Lepto	I, C
6	Capparaceae	*Capparis spinosa* Linn.	Shrub	Nano	I, C
7	Chenopodiaceae	*Haloxylon recurvum* Bunge. ex. Boiss.	Shrub	Lepto	C
8	Chenopodiaceae	*Haloxylon salicornicum* (Moq.) Bunge.	Shrub	Lepto	S, I
9	Chenopodiaceae	*Salsola baryosma* (Roem. et. Scult.) Dany.	Shrub	Lepto	S, I, C
10	Chenopodiaceae	*Suaeda fruticosa* (Linn.) Farsskal.	Shrub	Lepto	C
11	Compositae	*Pulicaria rajputanae* Blatt. and Hall.	Shrub	Nano	C
12	Malvaceae	*Abutilon muticum* (Del. ex. DC.) Sweet.	Shrub	Micro	I, C
13	Mimosaceae	*Acacia jacquemontii* Benth.	Shrub	Lepto	I, C
14	Mimosaceae	*Acacia nilotica* (Linn.) Del	Tree	Lepto	I, C
15	Mimosaceae	*Prosopis cineraria* (Linn.) Druce.	Tree	Lepto	S, I, C
16	Mimosaceae	*Prosopis juliflora* DC.	Shrub	Lepto	I, C
17	Papilionaceae	*Crotalaria burhia* Ham. Ex. Bth.	Shrub	Lepto	S, I
18	Papilionaceae	*Tephrosia uniflora* Pers.	Shrub	Nano	C
19	Polygonaceae	*Calligonum polygonoides* Linn.	Shrub	Lepto	S, I
20	Rhamnaceae	*Zizyphus mauritiana* Lam.	Tree	Nano	I, C
21	Rhamnaceae	*Zizyphus nummularia* (Burm. f.) Wifht &Arn.	Shrub	Nano	I, C
22	Rhamnaceae	*Zizyphus spina christi* (Linn.) Wild.	Tree	Nano	I, C
23	Salvadoraceae	*Salvadora oleoides* Decne.	Tree	Nano	I, C
24	Tamaricaceae	*Tamarix aphylla* (Linn.) Karst.	Tree	Lepto	S, I, C
25	Tamaricaceae	*Tamarix dioica* Roxb.	Shrub	Lepto	I, C

 # Leaf size Lepto-Leptophyll, Nano-Nanophyll, Micro-Microphyll, Meso- Mesophyll
@ Habitat S-Sandunal, I-Interdunal, C- Clayey saline

Ethnobotanical status

Out of total browse species in Cholistan rangelands, all the species were found to be useable directly and indirectly. These species were divided into four categories Firewood, Timber wood, Forage/Fodder and Medicinal based on their indigenous uses. 19 species that were being used as firewood, 06 species were as timber wood, 24 species were as forage/fodder and 23 species were as medicine as given in Table 2. The people of these areas depend on the local medicinal plants because no medicinal facilities are available in this area. It was also observed that people have no availability and affordability for pharmaceutical medicines. All the plants were used as medicine for different purposes except *Aerva pseudotomentosa* ssp. bovei. Clarke and *Pulicaria rajputanae* Blatt. and Hall. Different parts of plants were used for treatments such as bark, leaves, shoots, roots, and whole plants. The mode of use was both internal and external in the form of decoction latex and powder (Table 4).

Range condition and conservation status

Out of the total identified browse species, 24 species were observed to have forage value except *Leptadenia pyrotecnica* (Forssakal.) Decne. Based on forage value 7 species (28%) have good forage value, 13 species (52%) have fair forage value, 4 (16 %) species have poor forage value while 1 (4 %) species have no forage value. According to grazing response, 8 (32%) species were increasers, 7 species (28 %) were stable, and 10 species (40 %) were decreasers. According to the conservation status of IUCN maximum browse species were nearly threatened (32%) followed by endangered (24%), vulnerable (20%) least concerned (16 %), critically endangered (08%) respectively. *Salvadora oleoides* Decne. and *Tephrosia uniflora* Pers. have become critically endangered and need quick conservation measures (Table 4).

Table 4. Describing ethnobotanical uses, rangelands condition and conservation status of browse species in Cholistan rangelands

Sr. No.	Plant species	Economic uses@	Ethno medicinal uses			Range condition		Conser. Status$
			Part used	Mod of use#	Treatments	Forage value	Grazing response	
1	*Aerva javanica*	M, F	Leaves, oots	Decoction, Paste (E,I)	Wounds, Diuretic, Kidney stone, Toothache	Poor	Increaser	LC
2	*Aerva pseudotomentosa*	F	-	-	-	Poor	Increaser	LC
3	*Calotropis procera*	Fw, M, F	Whole plant	Latex, Decoction (E,I)	Cough, Fever, Muscular pain, Wounds, Leprosy Toothache,	Fair	Stable	NT
4	*Leptadenia pyrotecnica*	Fw, M	Shoots	Powder, Decoction (I)	Anti-cancer, Diarrhoea, Diuretic, Purgative	None	Increaser	NT
5	*Capparis decidua*	Fw, M, F	Whole plant	Decoction (E,I)	Asthma, Fever, Urine infections, Cardiac problems, Laxative,	Fair	Stable	VU
6	*Capparis spinosa*	M, F	Whole plant	Decoction (E,I)	Body pain, Toothache, Earache, Diuretic	Fair	Decreaser	EN
7	*Haloxylon recurvum*	Fw, M, F	Shoots	Decoction, Powder (E,I)	Ulcer problems, Insect bites	Fair	Stable	EN
8	*Haloxylon salicornicum*	Fw, M, F	Shoots	Paste, Powder (E)	Wounds, Insects bite	Poor	Increaser	NT
9	*Salsola baryosma*	Fw, M, F	Shoots	Decoction, (I)	Intestinal problems	Fair	Increaser	NT
10	*Suaeda fruticosa*	Fw, M, F	Whole plant	Decoction, Paste (E,I)	Eye infections, Wounds, Laxative, Menses disorders	Fair	Increaser	NT
11	*Pulicaria rajputanae*	F	-	-	-	Poor	Stable	VU
12	*Abutilon muticum*	M, F	Leaves, roots	Decoction (I)	Kidney problems	Fair	Decreaser	EN
13	*Acacia jacquemontii*	Fw, M, F	Whole plant	Decoction, Powder (E,I)	Measles, sexual problems, Fever, Toothache	Good	Decreaser	EN
14	*Acacia nilotica*	Fw,Tw, M, F	Whole Plant	Decoction, Powder (E,I)	Sexual problem, Eye Infection, Asthma, Joint pain	Good	Decreaser	NT
15	*Prosopis cineraria*	Fw,Tw, M, F	Whole Plant	Decoction, Powder (I)	Anemia, Dysentery, Pregnancy problems	Good	Decreaser	EN
16	*Prosopis juliflora*	Fw, M, F	Leaves, Bark	Decoction (E,I)	Throat infections, Asthma, Broken bones, Dermatitis	Fair	Increaser	LC
17	*Crotalaria burhia*	Fw, M, F	Whole plant	Decoction, Powder (E,I)	Leucoderma, Joint pain,	Fair	Increaser	LC
18	*Tephrosia uniflora*	M, F	Leaves	Powder (I)	Rheumatic pain	Fair	Decreaser	CE
19	*Calligonum polygonoides*	Fw, M, F	Whole plant	Decoction (E,I)	Heart burn, Sore throat, Eye Infection, Fever	Fair	Stable	NT
20	*Zizyphus mauritiana*	Fw,Tw, M, F	Whole plant	Decoction, Powder (E,I)	Anemia, Bronchitis, Scabies, Throat infection	Good	Decreaser	VU
21	*Zizyphus nummularia*	Fw, M, F	Leaves	Decoction, Paste (E,I)	Diabetes, Scabies, Wound	Good	Decreaser	EN
22	*Zizyphus spina christi*	Fw,Tw, M, F	Leaves	Decoction, Powder (E,I)	Skin infections, Wounds, Diarrhea, Anemia	Good	Decreaser	VU
23	*Salvadora oleoides*	Fw,Tw, M, F	Whole Plant	Decoction (E,I)	Appetizer, Purgative, Asthma, Fever, Blood purifier	Good	Decreaser	CE
24	*Tamarix aphylla*	Fw,Tw, M, F	Whole Plant	Decoction, Powder (E,I)	Skin diseases, Hepatitis, Jaundice	Fair	Stable	NT
25	*Tamarix dioica*	Fw, M, F	Bark	Decoction, Powder (E,I)	Ulcers, Piles	Fair	Stable	VU

@ Economic uses: M-Medicinal, Fw-Fire wood, Tw-Timber wood, F-Forage

#Mod of use: E-external, I-Internal

$ Conservation status: LC-Least Concern, NT-Nearly Threatened, VU-Vulnerable, EN-Endangered, CT-Critically Endangered

Discussion

Ecological assessment of browses

Pakistan has a large variety of potential range flora due to the great diversity of habitats and ecosystems (Yaseen *et al.,* 2015). The results have revealed that floristic composition was comprised of 25 browse species, which distributed among 12 families. Based on family status Chenopodiaceae, Mimosaceae and Rhamnaceae were considered as dominant families that have mainly contributed the browse flora of Cholistan rangelands. The identified browse species was characterized by arid climate commonly comprising of xerophytes that have adjusted to high temperature, less humidity, and wide variability of edaphic conditions (Arshad and Akbar, 2002).

The individual plant species of a specific community can be classified into different life forms due to their growth behaviour (Cheng *et al.,* 2011). All the identified browse species were categorized as perennials and phanerophytes. The dominancy of phanerophytes reveals the climax stage of vegetation however dominance of perennials is evident of arid conditions. Leaf size spectra showed that leptophyllous species were dominating this range area. In the study site, plants undergo hostile environmental conditions; therefore, they have adapted themselves to the prevailing conditions by reducing their leaf size, height, foliage, and growth duration. Overgrazing and deforestation in such a climate further increase the adverse effects of the arid environment (Harris, 2010). The observed relationship between small leaves and hot desert climate are adaptive features of retaining moisture in plants (Nasir and Sultan, 2002). Cholistan rangelands are hot, arid, and sandy where mostly annuals plant species come out with the onset of rain, complete their life cycle within a few days and disappear. Thus, it gives us a strong indication that most of the vegetation in the Cholistan is made up of perennial species that are generally shrub and trees.

According to vegetation diversity, the research area can be classified into three different habitats comprising of sandunal, interdunal sandy, and clayey saline. Sandunal habitat was covering medium to high, normally unstabilized shifting dunes and was highly sandy. Interdunal sandy habitat was containing small sandy hummocks of sandy loam soil. While the clayey saline habitat was encompassing plain hard crust of soil called dahar, impervious to water and has less vegetation. Results have revealed different types of browse species at three different habitats. It might be due to different soil features, ecophysiology of plants, site disturbances like human and grazing pressure. Within the Cholistan, several different soil types and dominant plant species have been reported (Arshad *et al.,* 2007). Based on results the most dominant browse species at sandunes were *Calligonum polygonoides* and *Haloxylon salicornicum*. At interdunal habitat *Aerva javanica, Salsola baryosma Leptadenia pyrotechnica* and *Crotalaria burhia,* species were common. Whereas at compact saline ‘dahars’ without any soil cover are dominated by *Suaeda fruticosa* and *Haloxylon recurvum.*

The results of this study have reported two phenological seasons in the study area, first from February to April and second from September to November. Both seasons were observed to be dependent on rainfalls which usually occur in monsoon (July to September) and in winter and spring (January through February) (Akbar and Arshad, 2000). Hence, two seasons-early spring and late summer-were categorized by high growth activities of many species. Also, maximum species were recorded in the second phenological season as compare to the first one because most of the rainfall

in the desert was received during monsoon. Some species were showing the dual behavior because they were observed in both phenological seasons. There were also some species, which were not following this pattern due to great variation in their phenological events, because they are not wholly dependent on rainfall.

The first phenological season (Feb-Apr) was directly related to winter rainfall, though winter rain is less than summer rainfall but lower evaporation during the winter increases the effectiveness of this rain. It was observed that with the availability of moisture in soil and low temperature in the desert, the seedlings start to appear, and maximum seedlings were noted in February. In May climatic conditions become very severe and species started to become dormant or dead. May to August was dormant period due to extreme temperature and the severe shortage of water and but few growth and reproductive activities of perennials were also observed in this period.

The second phenological season was triggered with the onset of monsoon rain that mostly occurs from July through September. In extreme climatic condition of Cholistan rangelands, monsoon rains provide enough water and lower overall temperature to some extent. These favorable conditions promote the germination, seedlings start to appear from the soil, and maximum seedlings were observed in September. In December, maximum plants started to become dormant/dead due to a shortage of water and a decrease in temperature. Furthermore, due to the continuous decrease in temperature, deficiency of water and short photoperiod in desert, most of the plant functions remain dormant from December to January.

The scarce and unpredictable nature of moisture in deserts is well known but the response of desert vegetation to this limiting resource is not well documented. The present study revealed that sporadically maximum moisture is used at specific times by particular groups of species and annual species are closely related to periods of abundant moisture. Based on results rainfall has been recommended as the main source of variation in the onset of flowering in communities with distinct dry weather. It has been observed that in tropics and desert environments, variations in precipitation are more important than temperature to control phenological patterns (Borchert *et al.*, 2004). Our findings agreed with Beatley (1974) and Kemp (1983) who have studied phenological behavior in Mojave and Chihuahuan desert, respectively.

Ethnobotanical classification:

Cholistan rangelands are one of the richest areas of the Pakistan especially for the plants of ethnobotanical importance. Here, the wild plants are used by nomadism for their necessities as well as for economic purposes (Abdullah *et al.*, 2017b). The present study deals with traditional uses of various browses in the Cholistan rangelands. For this purpose, 25 browse species belonging to 12 families were investigated and information was collected for their local uses related to firewood, timber wood, forage/fodder, and medicinal value. Results showed that the study area was rich in browse species of multiple usages. Maximum species were observed to have forage/fodder value that clearly indicates that this area can serve as rangeland.

Further, the uses of plants for the treatment of various diseases in man and livestock are very significant. These medicines perform an important role in the life of nomadic peoples due to easy accessibility. In Pakistan, major sources of medicinal plants are forest and rangelands. It has been observed that homeopathic and traditional medicines are cheaper and

usually more accepted by local peoples (Tounekti *et al.,* 2019). The maximum respondents stated that they had learned about medicinal plants from their parents and grandparents. The absence of systematic documentation for medicinal plants that occur in many parts of the world may contribute to the loss of this information (Herrick *et al.,* 2010). It was found that there is an increasing trend of exploitation of medicinal plants of Cholistan rangelands due to the increase in the human population, local hakims, and pharmaceutical industry. Subsequently, browse species were also exploited as fuel wood and timber wood in the Cholistan rangelands. Both uses were consisting of those perennial species, which were making the maximum vegetation cover, but their ruthless cutting and unchecked utilization are increasing pressure on this area. There was little published information about the uses of the flora of the Cholistan desert. Arshad *et al*. (2003) and Hameed *et al*. (2011) has reported the medicinal importance of plants in this area.

Range condition and conservation status

Cholistan rangelands were considered among the best pastoral lands but presently facing multiple stresses. Browse species of these rangelands have good forage value however decreasing due to high and continuous grazing during the whole year. The decreasers were highly palatable plants and were considered to decrease with the increase of grazing pressure. Grazing impact effects firstly desired plant species called decreasers, later less desired plants. Grazing reduced length of leaves, basal diameter, culm (stem) length, and culm numbers of plant species (Addison *et al.,* 2012). Then the rangelands are degraded by soil erosion, losing biodiversity, and breaking down nutrient cycle. This agrees Ayoub (1998) and Wesche *et al*. (2010) results, where they found that overgrazing is the extensive cause of soil degradation. After the removal of livestock and stresses, it results in the restoration of these rangelands. Certain conservation groups support keeping grazing pressure within certain limits for sustainable use of rangeland resources (Gamoun *et al.,* 2016).

The conservation status of browse species was assessed according to the IUCN criteria. The results have revealed that threatened browse flora is ethnobotanically valued and is utilized for various purposes such as forage, used as health care medicine, fuel-wood, and for timber wood. In this arid environment, there is always a deficiency of forage and livestock graze every green soft textured plant resulting in their reduction. All these major utilities have hampered their regeneration process to push them into endangered categories. The woody plants cut down for miscellaneous purposes, are facing conservational problems. The same data is meant to make the people aware of the conservation status of plant resources. Heywood and Iriondo (2003) stated that *ex-situ* conservation should be encouraged for the conservation of browse vegetation. Sayer *et al.* (2004) reported that large investments are being made in the establishment of tree plantation on the degraded area in Asia.

The species which have become threatened may facing the issue of conservation and a lack of sustainable methods to preserve this treasured diversity (Heywood, 2011). There was little published material about the flora of the Cholistan desert. Previously Arshad and Rao (1994) have done a preliminary survey to provide the base line about the flora of Cholistan Desert. Several floristic studies have been reported from in and out of the country. Some related work has been carried in the Indian desert that is on another side of the Cholistan Desert (Shetty and Singh, 1991). Few studies have been reported from other adjoining areas (Qureshi and Bhatti, 2010;

Durrani and Razaq, 2010; Qureshi *et al*., 2011).

Conclusion

This study was the first of its kind which provides a baseline inventory of ecological classification, diversity in ethnobotanical values, as well as the conservation status of browse vegetation in Cholistan rangelands. **S**ince the browse vegetation has continuously been under stress in terms of overgrazing, deforestation, fuel wood extraction and indiscriminate collection of valuable plants, therefore the number of ethnobotanically important species has become scarce. In other words, browse plants are the most oppressed and being misused due to ignorance and unawareness of the procedure of grazing and collection by the inhabitants of the Cholistan. If the same practice continues, the remaining plant population will likewise diminish, and the lush green Cholistan rangelands will become a story of the past. Therefore, establishment of natural reserves and wild plant nurseries are urgently recommended to retain natural habitats, while botanic gardens and seed banks are very important paradigms for *ex situ* conservation. However, further investigation on economic values, production and conservation practices should be carried out to utilize these plant resources to support sustainable ecosystem.

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