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Indigenous farmer's perception about fodder and foraging species of Semi-arid lowlands of Pakistan: A case study of District Kasur, Pakistan

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ABSTRACT: This paper analyzes the current use pattern, farmers' preferences, and conservation issues of fodders and forages growing in the agropastoral semi-arid lowlands of Kasur District, Pakistan. The data was collected through semi-structured interviews and participatory methodologies. Multiple data analyses (Relative frequency citation and Pairwise Comparison) and statistical tools (correlation and Tableau) were used for interpretations of ethnobotanical data. The current study reported 75 fodder/forage species belonging to 58 genera and 25 families. Poaceae (28%) was the most popular family followed by Fabaceae (20%). Most of the plants were herbaceous (40%) and were growing in the wild (85.3%). It was observed that livestock preferred shoot consumption (50%) in comparison to other parts. In addition, 37.3% of species were used as fresh feed, 44% of species were freely grazed and 18.7% were used as mixed feed. These plants were more palatable to goats (29%) followed by cows (23%), buffalos (20%), and sheep (15%). Moreover, 23 plants were considered to be high-value fodders and 08 species (*Dicliptera bipleuroides*, *Ehretia acuminate, Kochia indica*, *Cassia obtusifolia*, *Melilotus albus*, *Hibiscus rosa-sinensis*, *Poa pratensis* and *Lycium shawii*) were recorded as fodder/forage for the first time in this geographical regime. Results reported only 7% abundant and 3% rare species in the study area which reflected the overexploitation of these natural feed resources. This study provided baseline data for the development of feeding strategies and also highlighted a serious conservation concern of these fodder plants. Proper cultivation, farming and in-situ conservation would underpin the sustainability of these plant resources.

KEY WORDS: Agropastoral communities, conservation, fodder, forages, indigenous practices, livestock, semi arid.

INTRODUCTION

Raising livestock always plays a vital role in the economics and survival of agropastoral societies worldwide (DeMello, 2012; Savo, 2016). It has an inextricable link to rural human communities. These communities are associated with low-scale farming, agriculture, and limited livestock. The agropastoral communities derive 25–50% income from livestock andtheir products (Debele *et al*., 2016). Livestocks primary feed on either wild-growing or cultivated local fodder species (Herrero *et al*., 2013). Therefore, this sector demands sufficient grazing lands, potential agriculture, and favourable ecological systems for its sustainability (Benti *et al*., 2022).

Nowadays, this sector experiences different natural and anthropogenic threats such as encroachment of cultivable lands for urban infrastructure, drought, flood, and unsustainable utilization of wildly growing fodder and foraging species, etc. (Kubiszewski *et al*., 2020). The existing scientific information about alternative traditional fodder and forage is relatively scarce. Ample literature found on this subject from different parts of the world for instance China (Geng *et al*., 2017), Brazil (Nunes *et al*., 2015), Ethiopia (Bajru *et al*., 2014), South Africa (Chepape *et al*., 2014), India (Saini and Sood, 2018) and Mexico (Nahed *et al*., 1997). In Pakistan, various researchers also contributed to evaluating the wild flora utilization for livestock (Hussain *et al*., 2009; Badsha and Hussain, 2011; Khan and Hussain, 2012; Harun *et al*., 2017; Shaheen *et al*., 2020). Pakistan has been facing several environmental challenges due to its burgeoning population and climate change like heavy floods, salinity, water logging, water scarcity, and earthquakes unsustainable utilization of biological resources, etc. The indigenous flora particularly used in traditional practices as fodder, fuel woods, fibres, and herbal medicines experience unsustainable utilization. The country also supports a huge rural agro-pastoral population in the arid and semi-arid lowlands. They feed their livestock with certain plant taxa directly by grazing cattle or indirectly cutting as fodder for storage purposes for off-season storage. However, they hold ample ethnoecological knowledge regarding livestock rearing, fodder, and foraging species and conservationaspects. This knowledge underpins devising the effective management and conservation strategies of local biodiversity (Pandey, 2002). The arid and semi-arid lowlands are subjected to various anthropogenic activities such as cutting, uprooting, overgrazing declining the abundance and distribution of the fodder species.

The present research aimed to assess the taxonomic

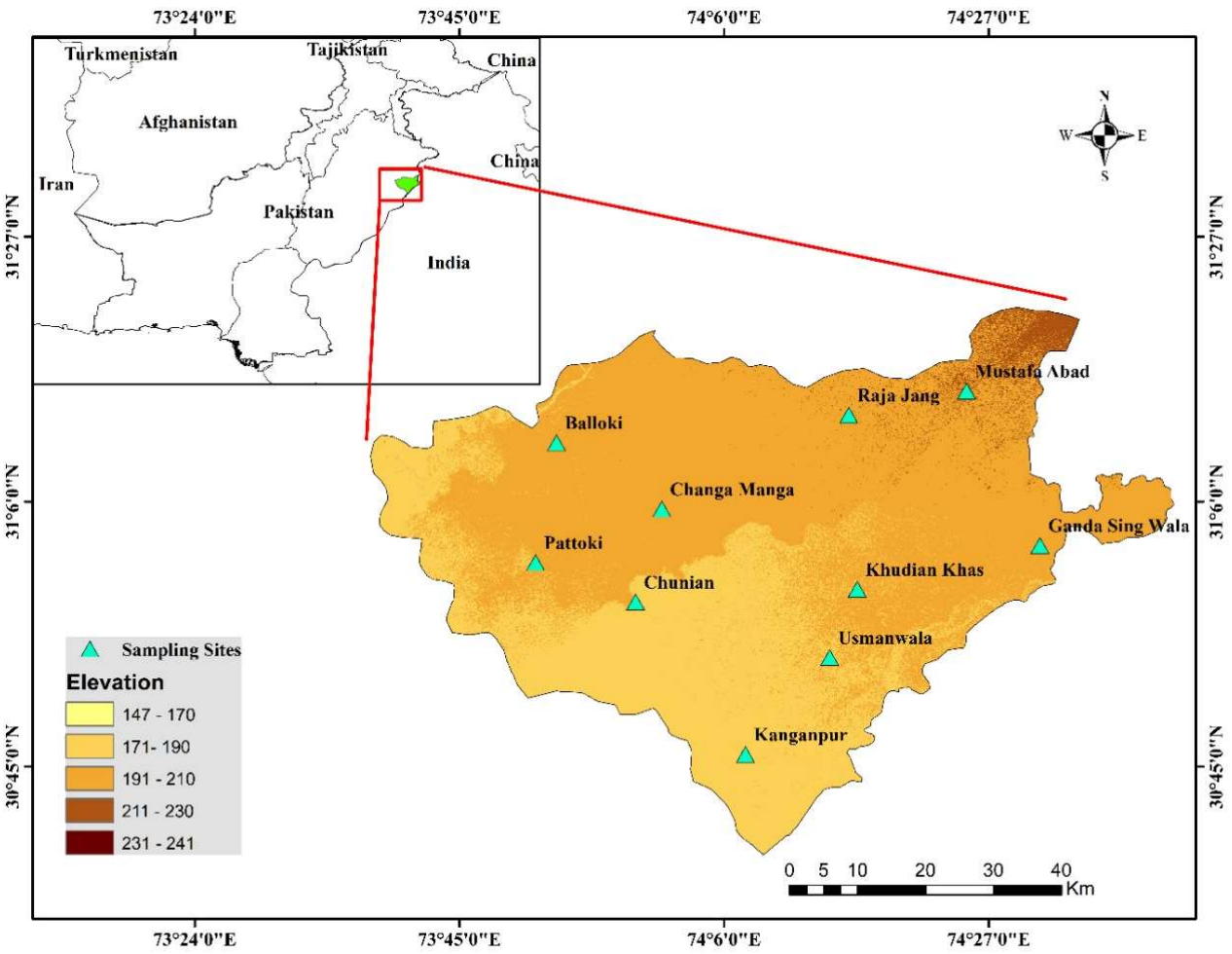

Fig. 1. Map of the study area, District Kasur; showing study sites i.e. Balloki, Changa Manga, Chunian, Ganda sing Wala, Kanganpur, Khudian Khas, Mustafa Abad, Pattoki, Raja Jang, Usmanwala.

diversity of traditionally used fodder/forage plants in Kasur District and identify potential conservation issues with the current grazing patterns. Our specific objectives include (1) to identify potentially used traditionally used fodder/forage taxa of the study area, (2) to document the customrary utilization strategies (feeding part, feeding methods, and livestock preferences) of fodders/forages (3) to estimate relative abundance and seasonal availability of the fodder/forage species i to find out the conservation issues, (4) to employ data visualization tool for logical outcomes among various studied parameters (5) and to find out novel fodder/forages and conservation issues the reported species.

MATERIALS AND METHODS

Study Area

District Kasur is situated at 31.12 N and 74.44 E with an altitudinal range of 150 to 200 meters above sea level in the Punjab Province Pakistan. It is located in Bari Doabs (land between Ravi & Satluj) and covers an area of 3995 km^2. It is bounded on the north by Lahore district, on the east and south-east by India, on the south-west by Okara district, and the north-west by Nankana Sahib District Tehsils namely Kasur, Chunian, Pattoki, and Kot Radha Kishan. It has 10 Municipal Committees and 125 Union Councils (Fig. 1) with a population of 3,454,996 people (Pakistan Beauru of Statistics, 2017) (https://www.pbs.gov.pk/content/final-results-census-2017).

Topographically, Kasur district is a semi-arid plain and basin area of Sutlej riverine District Kasur is famous for Changa Manga National Forest, Balloki Headworks, and Ganda Singh Border. Climate is characterized by summer hot and the temperature rises above 40^{o}C during the months of June and July. The area recieves average annual 500 mm rainfall (Anwar *et al*., 2012). Floristically, it falls in the Saharo Sindian region and hosts a significant number of plant species (Arshad *et al*., 2020). The vegetation includes xerophytic and thermophilic species in the open and arid area but riverine belts host several macrophytes. The agricultural lands host weeds and ruderal species for instance *Ageratum conyzoides*,

Amaranthus viridis, *Coronopus didymus*, *Chenopodium album*, *Convolvulus arvensis*, *Cypreus rotundus*, *Cynodon dactylon*, *Oxalis corniculata, Rumex dentatus, Melilotus parviflora and Eragrostis poaeoides* (Riaz *et al*., 2009). Moreover, considerable edible arboreal species such as *Zizyphus mauritiana*, *Mangifera indica*, *Syzygium cumini*, *Morus alba*, *M. nigra*, *Ficus palmate,* and *Cordia myxa* are also part of flora (Arshad *et al*., 2020).

Data collection

Field trips were conducted in the Kasur District in different seasons for two years i.e. March 2019 to October 2020. Based on the potential of pasture area, flora, and vegetation cover, ten sampling sites were selected such as Balloki, Changa Manga, Chunian, Ganda sing Wala, Kanganpur, Khudian Khas, Mustafa Abad, Pattoki, Raja Jang, Usmanwala. In these sites, the snowball sampling method was adapted to select respondents. Altogether, 68 people (male 78% and female 22%) were interviewed including shepherds, farmers, and livestock rearers. Semi-structured in-depth open ended interviews, and group discussions were employed (Martin, 2010; Cotton, 1996).

International Society of Ethnobiology (ISE) code of ethics (https://www.ethnobiology.net/what-we-do/core-programs/ise-ethics-program/code-of-ethics/), and rules and regulations developed by the ethical review committee of University of Okara were strictly observed throughout research activities. In addition, individuals consents were also taken before the interviews. The respondents were asked multiple questions including fodder species, user preference, growing season, source palatability, and mode of feeding.

Fodder species' collection and identification

The habitats of all documented taxa were visited with the help of local guides and showed plant samples. Plants were first photographed and collected during field surveys based on the recorded local names. Plants were identified with the help of Flora of Pakistan (Ali and Nasir, 1970); Flora of China (http://www.efloras.org/flora_page.aspx?flora_id=2) and Flora of Inda (https://sites.google.com/site/efloraofindia/). Botanical and Family names were attributed to the specimens and arranged alphabetically. The assigned nomenclature of each taxon was confirmed by The plant list (http://www.theplantlist.org) and World flora online (http://www.worldfloraonline.org). Identified plants were dried, poisoned, and mounted on standard herbarium sheets, and submitted to the University of Okara Botanical Herbarium, Pakistan.

Relative abundance of fodder plants

The following method was followed for the estimation of Relative Abundance (RA) (Table 1) (Kent, 1992).

Table 1. Abundance categories and scale of reported grasses.

Abundance scale	Abundance categories	Coverage of grass species
0	Rare (R)	<5%
1	Occasional (O)	5-20%
2	Frequent (F)	20 - 50%
3	Common (C)	50 - 90%
4	Abundant (A)	90 - 100%

$$Relative\ abundance\ of\ species = total\ percentage\ cover\ of\ species\ in\ all\ plots/number\ of\ plots\ estimated \times 100$$

Data Analysis

The local preference of foraging plants was calculated by using Relative Frequency of Citations (RFCs) (Vitalini *et al*., 2013).

$$RFC = FC/N$$

Here, FC = Number of informants who cited the fodder plant

N= Total number of informants who participated in the survey

RFCs value varies from 1 (when all the informants cited a particular fodder plant) to 0 (when nobody had cited a particular plant).

Along with the RFCs, the Pairwise Comparison (PC) method was also used. PC helped to construct an order of priority (with RFC) among reported fodder plant species (Martin, 2010; Anwar *et al*., 2012; Badsha and Hussain, 2011; Harun *et al*., 2017; Shaheen *et al*., 2020). Through this method, a comparative matchup chart was established between fodder taxa, and the vote of informants was counted against each fodder.

For the calculation of significance and familiarity of a family, Family Importance Value (FIV) was applied and adapted from (Kayani *et al*., 2014):

$$FIV = FC\ of\ family/N \times 100$$

Where,FC= Number of informants cited the particular family

N= Sum of informants participated in survey

Jaccard Index

Ethnobotanists compute the JI for thecontrast of renowned data with prior published data collected from neighboring areas (González-Tejero *et al*., 2008). JI is calculated using the following formula:

$$JI = c * 100\ /(a + b) - c$$

Statistical interpretation

For the interpretation of qualitative data, descriptive statistical analysis (IBM SPSS 25) was used. However, Tableau was used for the overall data visualization. Additionally, Pearson Correlation were also employed to interpret the relationships between certain parameters.

RESULTS

In this study, a total of 68 respondents were interviewed. All respondent were classified into three age groups i.e. 20–40 (36%), 41–60 (52%), and above 60 (10%). It was observed that the majority of informants were men (77%) while women were only (22%). Most informants belonged to age group of 40–60 with 52.94 %. The literacy rate of this area is not much higher. The current study also reflects these statistics, i.e. most of the interviewed people were illiterate, 33 (48%), whereas 15 (22%) had completed their primary education (5 years), 12 (17%) were of middle education (8 years), 5 (7%) informants completed their graduation qualification and 3 (4%) had post-graduate qualification level (Fig. 2). Profession wise, 31 (45%) informants were shepherds, 28 (41%) were farmers (earning additional income by livestock farming) and 9 (13%) informants were domestic livestock caretakers (Fig. 2).

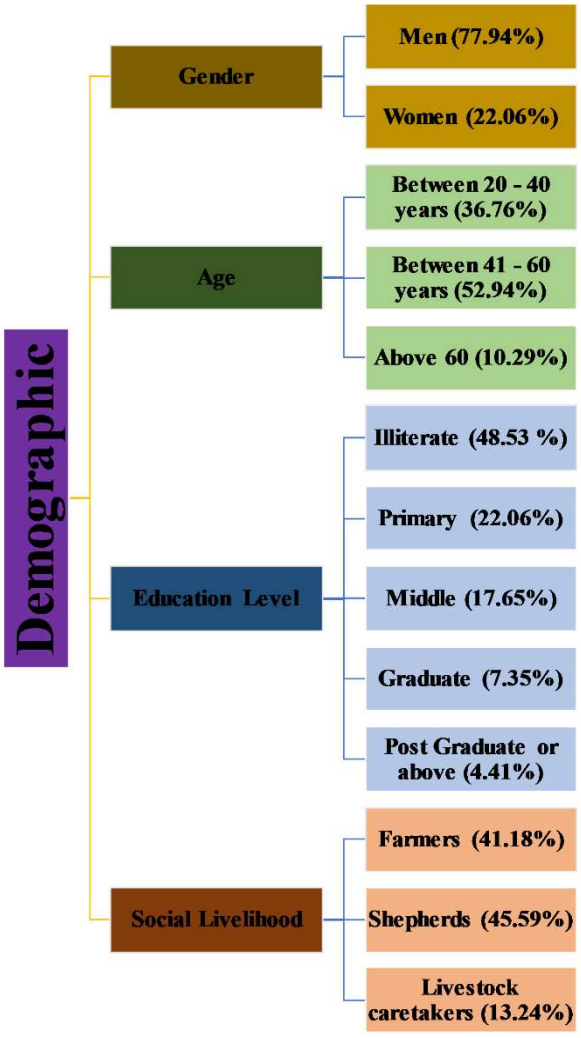

Fig. 2. Demographic attributes of local people from the study area; showing maximum and minimum percentages

Taxonomic diversity

The study encountered 75 fodder plant taxa belonging to 58 genera and 25 families (Table 2, Fig. S1). *Acacia* and *Prosopis* were the dominant genera, with 3 kinds of foraging species. Poaceae and Fabaceae were frequently used plant families with 21 and 15 species respectively. Similarly, Chenopodiaceae (05 plant species), Moraceae (04) and Asteraceae (03) were less popular families. The remaining families were bitypic (48%) and monotypic (52%) (Fig. 3A). A quantitative data analysis index, FIV (Family Importance Value) indicated that the highest number of informants recommended members of family Poaceae as alternative fodder species with 591.17 FIV, followed by Fabaceae with 357.35 FIV. Other notable families of higher FIV indices reported from the informants were Moraceae (141.17 FIV), Rhamnaceae (75 FIV), Chenopodiaceae (70.5 FIV), Brassicacaceae (61.76 FIV) Amaranthaceae (58.82 FIV). Most fodder species of the above-mentioned families were widely used as alternative fodder species (Fig. 3B).

Habit, part used, feeding method, and livestock preference

It was observed that the nature of plant fodder/forage species was predominantly herbs (40%), followed by grasses (28%), trees (28%), shrubs (07%), and sedge (Fig. 4A) Most of the species were available in wild (85.3%) while remaining were cultivated (14.7%). Furthermore, it was revealed that livestock preferred shoot consumption (50%), in comparison to other parts i.e. leaves (34%), flowers (05%), young branches (06%), and pods (05%) (Fig. 4B). The documented species were given to livestock by various feeding methods, either as fresh feed (FD), mixed feed, or free grazing in the fields. Thirty seven percentages (37%) of species were used as fresh feed (FD), 44% of species were freely grazed (FG) and 18.7% were used as mixed feed (MF) (Fig. 4C). The preferred palatability of fodder species by the livestock was observed in goats (29%), cows (23%), buffalos (20%), sheep (15%), horses (06%), donkeys (04%), and camels (03%) (Fig. 4D).

Relative abundance and seasonal effect on fodder availability

The relative abundance pie chart showed that most of the fodder/forage was catogerized as common or frequent in the study area i.e. 34% and 32% (Fig. 4E). However, only 7% of fodder/forage was reported as abundant in the study area which reflected the overexploitation of these natural animal food resources. Even 3% fodder/forage was also regarded as rare in the study area but still in use. Our study reported the maximum availability and diversity of fodder/forage species for livestock during the rainy season (spring and summer), while during the drought season (winter and autumn) minimum variations in fodder/forage species were observed (Fig. 4F).

Table 2. Inventory of fodder plants with botanical name, family name, common name, habit, parts used, livestock palatability, FC and RFC value

Family	Voucher Number	Species	Abundance	Common Name	Habit	Wild/ Cultivated	Part Used	Feeding Method	Livestock Grazer/ Brower	Seasonal Availability	FC	RFC	Previous Reports
Acanthaceae	00121	*Dicliptera bupleuroides* Nees	O	Sumbal	H	WI	ST	FD	GO	Au	13	0.19	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Aizoaceae	00066	*Trianthema portulacastrum* L.	C	It-Sit	H	WI	ST	FD	BU,GO	Su	19	0.28	1 2 3 4 ◘5 6 7 8 9 ◘10 11 ◘12 13 14 15 16 *17 18 19 20
Amaranthaceae	00071	*Amaranthus viridis* L.	F	Chulai	H	WI	L	FG	CO	Su	15	0.22	1 2 ◘3 4 ◘5 6 7 8 9 ◘10 11 ◘12 13 14 15 *16 *17 18 *19 20
	00092	*Digera muricata* (L.) Mart.	C	Tandala	H	WI	ST	FG	CO	Au	25	0.37	1 2 3 4 ◘5 6 7 8 9 10 11 ◘12 13 14 15 16 *17 18 19 20
Asteraceae	00122	*Sonchus arvensis* L.	O	Dhodak	H	WI	L	FD	BU,CO	Sp	13	0.19	1 2 3 4 5 6 7 8 9 10 11 ◘12 13 14 15 *16 17 18 19 20
	00112	*S. oleraceus* L.	O	Dhodak	H	WI	L	FD	BU,CO	Sp	9	0.13	1 2 ◘3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
	00123	*Taraxacum officinale Weber.*	F	Dudhak	H	WI	L	FD	GO	Sp	16	0.24	1 2 ◘3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 *19 20
Bombacaceae	00124	*Bombax ceiba* L.	O	Simbal	T	CU	FL	FD	CO	Sp	8	0.12	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 ◘17 18 *19 ◘20
Boraginaceae	00125	*Ehretia acuminata* R. Br.	F	Ghondi	T	CU	L	MF	GO,SH	Wn	21	0.31	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Brassicaceae	00099	*Coronopus didymus* (L.) Smith.	C	Thandi Boti	H	WI	ST	FG	BU,CO	Su	16	0.24	1 2 3 4 5 6 7 8 9 10 11 ◘12 13 14 15 *16 *17 18 19 20
	00126	*Sisymbrium irio* L.	A	Saro Boti	H	WI	ST	FD	BU,CO, GO	Sp	26	0.38	◘1 2 3 4 ◘5 6 7 8 9 10 11 *12 13 14 15 ◘16 17 18 19 20
Capparidaceae	00127	*Capparis decidua* (Forssk.) Edgew.	R	Karre	S	WI	FL,L	FG	GO,SH	Sp	17	0.25	◘1 2 3 4 5 6 7 8 9 10 11 *12 *13 14 ◘15 16 17 ◘18 19 20
	00128	*Cleome viscosa* L.	O	Hulhul	H	WI	ST	MF	GO	Sp	19	0.28	1 2 3 4 5 6 7 8 9 10 11 *12 13 14 15 16 *17 18 19 *20
Chenopodiaceae	00070	*Chenopodium murale* L.	C	Karund	H	WI	ST	FD	BU	Su	13	0.19	◘1 2 3 4 ◘5 6 7 8 9 *10 11 ◘12 13 14 15 ◘16 *17 18 19 20
	00065	*C. album* L.	A	Bathu	H	WI	ST	FG	GO	Su	11	0.16	◘1 2 3 4 ◘5 6 7 8 9 ◘10 11 ◘12 13 14 15 *16 *17 18 *19 20
	00097	*Kochia indica* Wight	O	Boi	H	WI	L	FG	Ca	Au	9	0.13	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
	00129	*Salsola foetida* L.	O	Lonak	S	WI	YB	FG	Ca	Au	7	0.1	◘1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
	00130	*Suaeda fruticosa* Forssk.	O	Lana, Bui	H	WI	YB	FG	Ca	Au	8	0.12	◘1 2 3 4 5 6 7 8 9 10 11 *12 13 14 ◘15 16 17 ◘18 19 20
Combretaceae	00131	*Terminalia arjuna* (Roxb. Ex DC) Wt. & An.	F	Arjun	T	CU	L	MF	GO	Wn	17	0.25	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 ◘20
Convolvulaceae	00132	*Convolvulus arvensis* L	F	Lehli	H	WI	ST	MF	BU,CO	Sp	18	0.26	◘1 2 ◘3 4 5 6 7 8 9 *10 11 ◘12 13 14 15 ◘16 *17 18 19 20
Cucurbitaceae	00051	*Cucumis melo* var. agrestis Naudin	F	Chiber	H	WI	ST	MF	BU	Au	8	0.12	1 2 3 4 5 6 7 8 9 ◘10 11 ◘12 13 14 15 16 *17 18 19 20
Cyperaceae	00059	*Cyperus rotundus* L.	C	Tala	SD	WI	ST	FG	BU,CO,GO,SH	Su	27	0.4	1 2 ◘3 4 5 6 7 8 9 10 11 ◘12 13 14 15 16 *17 18 19 20
Euphorbiaceae	00037	*Euphorbia hirta* L.	C	Dhodi Boti	H	WI	ST	FG	CO	Sp	18	0.26	1 2 3 4 5 6 7 8 9 *10 11 ◘12 13 14 15 ◘16 *17 18 19 20
	00133	*E. prostrata* Ait.	F	Dhodi Boti	H	WI	ST	FG	CO	Sp	7	0.1	1 2 3 4 5 6 7 8 9 *10 11 ◘12 *13 14 15 16 17 18 19 20
Fabaceae	00080	*Acacia farnesiana* (L.) W	O	Pahari Kiker	T	WI	FL,L,P	FG	GO,SH	Wn	16	0.24	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 *16 17 18 19 ◘20
	00134	*A. modesta* Wall	O	Phulai	T	WI	FL,L,P	FD	GO	Wn	13	0.19	1 ◘2 ◘3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 *19 *20
	00053	*A. nilotica* (L.) Delile.	F	Kekir	T	CU	L	FD	GO	Wn	16	0.24	◘1◘2 ◘3 4 5 6 7 8 9 10 11 12 13 ◘14 ◘15 ◘16 ◘17 ◘18 *19 *20
	00082	*Albizia lebbeck* (L.) Willd.	F	Sharen	T	CU	L	MF	CO,SH	Wn	9	0.13	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 *16 *17 18 19 *20
	00135	*Alhagi maurorum* Medic	C	Jawanh	S	WI	L	FG	CO,GO,SH	Su	21	0.31	1 2 3 4 5 6 7 8 9 10 11 *12 13 14 15 16 *17 18 19 20
	00136	*Cassia obtusifolia* L.	R	Chasku	H	WI	L	MF	BU,CO	Au	11	0.16	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
	00085	*Cassia occidentalis* L.	C	Chasku	H	WI	L	MF	BU,CO	Au	9	0.13	1 2 3 4 5 6 7 8 9 10 11 ◘12 13 14 15 *16 *17 18 19 20
	00137	*Lathyrus aphaca* L.	O	Mater Boti	H	WI	ST	FG	CO,GO	Sp	22	0.32	◘1 2 ◘3 4 5 6 7 8 9 10 11 ◘12 13 14 15 ◘16 17 18 19 20
	00138	*Medicago polymorpha* L.	C	Maina	H	WI	ST	FD	GO	Sp	34	0.5	1 2 3 4 5 6 7 8 9 10 11 ◘12 13 14 15 16 17 18 19 20
	00139	*Melilotus albus* Desr.	C	Senji	H	WI	ST	FD	CO,GO	Sp	17	0.25	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
	00140	*M. indica* (L.) All	C	Senji	H	WI	ST	FD	CO,GO	Sp	15	0.22	1 2 ◘3 4 5 6 7 8 9 10 11 12 13 14 15 ◘16 17 18 19 20
	00107	*Prosopis cineraria* (L.) Druce	F	Jhand	T	CU	L	MF	CO,GO	Su	15	0.22	1 2 3 4 5 6 7 8 9 10 11 12 13 ◘14 ◘15 16 17 ◘18 19 ◘20
	00141	*P. glandulosa* Torr.	F	Kekir, Mesquite	T	WI	YB,P	FG	CO	Su	15	0.22	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 ◘18 19 *20
	00142	*P. juliflora* (Sw.) DC.	C	Bo Wala Kikar	T	WI	YB,P	MF	CO	Su	13	0.19	1 2 3 4 5 6 7 8 9 10 11 12 13 14 ◘15 16 17 ◘18 19 ◘20
	00143	*Vicia sativa* L.	F	Jangli Matter	H	WI	ST	FG	GO,SH	Sp	17	0.25	1 2 3 4 5 6 7 8 9 10 11 ◘12 13 14 15 16 17 18 19 20
Fumariaceae	00144	*Fumaria indica* (Hausskn) Pugsley	F	Pit-Papra	H	WI	ST	FG	BU	Sp	11	0.16	1 2 3 4 5 6 7 8 9 10 11 ◘12 13 14 15 ◘16 *17 18 19 20
Malvaceae	00041	*Hibiscus rosa-sinensis* L.	O	Shoo Flower, Gulhaar	T	CU	FL,L	FD	GO	Wn	6	0.09	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
	00145	*Malvestrum coromendelianum* (L.) Garck.	C	Qatal	H	WI	YB	FG	CO	Au	13	0.19	1 2 3 4 5 6 7 8 9 10 11 ◘12 13 14 15 ◘16 17 18 19 20
Meliaceae	00167	*Melia azedarach* L.	F	Dhareek	T	WI	L	FD	GO,SH	Au	24	0.35	1 2 ◘3 4 5 6 7 8 9 *10 11 12 13 14 15 ◘16 ◘17 ◘18 *19 ◘20
Moraceae	00146	*Broussonetia papyrifera* (L.) L'Hér. ex Vent.	C	Pepal Marvi, Jangli Toot	T	WI	L	FD	C	Au	21	0.31	1 2 ◘3 4 5 6 7 8 9 *10 11 12 13 14 15 16 17 18 19 ◘20
	00067	*Ficus palmata* Forssk.	O	Pagwara	T	WI	L	FD	GO,SH	Au	9	0.13	1 2 ◘3 4 5 6 7 8 9 10 11 12 13 14 15 16 *17 18 19 *20
	00048	*Morus alba L.*	C	Toot	T	CU	L	FD	BU,CO,GO,SH	Su	33	0.49	◘1 ◘2 ◘3 4 5 6 7 8 9 *10 11 12 13 14 15 ◘16 17 ◘18 *19 ◘20

Table 2. Continued

Family	Voucher Number	Species	Abundance	Common Name	Habit	Wild/ Cultivated	Part Used	Feeding Method	Livestock Grazer/ Brower	Seasonal Availability	FC	RFC	Previous Reports
Moraceae	00147	*M. nigra* L.	C	Toot	T	CU	L	FD	BU,CO,GO,SH	Su	33	0.49	1 ◘2 ◘3 4 5 6 7 8 9 *10 11 12 13 14 15 16 *17 ◘18 *19 ◘20
Oxalidaceae	00102	*Oxalis corniculata* L.	A	Thandi Boti	H	WI	ST	FG	GO	Au	5	0.07	◘1 2 3 4 ◘5 6 7 8 9 *10 11 ◘12 13 14 15 ◘16 17 18 19 20
Poaceae	00148	*Avena fatua* L.	F	Jangli Javi	G	WI	ST	FD	BU,CO,DO,HO	Wn	24	0.35	1 2 ◘3 4 5 6 ◘7 8 9 10 ◘11 12 13 14 15 16 *17 18 19 20
	00149	*Brachiaria ramosa* (L.) Stapf.	F	Sawari	G	WI	ST	MF	BU,GO	Su	27	0.4	1 2 ◘3 4 ◘5 6 ◘7 ◘8 9 10 ◘11 12 13 14 15 16 17 18 19 20
	00150	*Brachiaria reptans* (Linn.) Gardner & Hubbard	F	Hausa	G	WI	ST	MF	BU,CO,DO,HO	Su	23	0.34	1 2 3 4 5 6 ◘7 ◘8 ◘9 10 11 ◘12 13 14 15 16 17 18 19 20
	00086	*Cenchrus biflorus* Roxb.	F	Bhurat	G	WI	ST	FD	BU	Sp	21	0.31	1 2 3 4 5 ◘6 7 ◘8 ◘9 10 ◘11 ◘12 13 14 15 16 17 18 19 20
	00057	*Cynodon dactylon* (L.) Pers.	A	Ghaa	G	WI	ST	FG	BU,CO,GO,SH	Sp	38	0.56	◘1 2 ◘3 4 ◘5 ◘6 ◘7 ◘8 ◘9 10 ◘11 ◘12 ◘13 14 15 ◘16 17 18 *19 20
	00091	*Dactyloctenium aegyptium* (L.) W.	C	Madhana	G	WI	ST	FG	GO,SH	Sp	14	0.21	1 2 3 4 ◘5 6 7 ◘8 ◘9 10 ◘11 ◘12 13 14 15 16 17 18 19 20
	00151	*Dichanthium annulatum* (Forssk) Stapf.	A	Palwan	G	WI	ST	FD	GO	Wn	22	0.32	1 2 ◘3 4 5 ◘6 7 ◘8 ◘9 10 ◘11 ◘12 13 14 15 16 17 18 19 20
	00152	*Digitaria ciliaris* L.	F	Shamokha	G	WI	ST	FG	BU,GO,SH	Su	17	0.25	1 2 3 4 5 6 7 ◘8 ◘9 10 ◘11 12 13 14 15 ◘16 17 18 19 20
	00153	*D. longiflora* (Retz.) Pers.	F	Indian Crab G	G	WI	ST	FG	BU,GO	Su	23	0.34	1 2 3 4 5 6 7 ◘8 9 10 ◘11 12 13 14 15 16 17 18 19 20
	00154	*Echinochloa colona* (L.) Link	C	Cockspur	G	WI	ST	FD	BU,CO,GO	Au	16	0.24	1 2 3 4 5 6 ◘7 ◘8 9 10 ◘11 12 13 14 15 16 17 18 19 20
	00093	*E. crus-galli* (L.) P.Beauv.	C	Sanwak	G	WI	ST	FD	CO,BU	Au	12	0.18	1 2 ◘3 4 5 6 7 ◘8 9 10 ◘11 12 13 14 15 16 17 18 19 20
	00155	*Eleusine indica* (L.) Gaertn.	O	Ghaa	G	WI	ST	FG	GO	Au	7	0.1	1 2 ◘3 4 5 ◘6 ◘7 ◘8 ◘9 10 ◘11 ◘12 13 14 15 ◘16 17 18 19 20
	00156	*Imperata cylindrica* (L.) Raeuschel	C	Dhab	G	WI	ST	FG	BU,HO	Sp	16	0.24	1 2 3 4 5 6 ◘7 ◘8 ◘9 10 ◘11 12 13 14 15 16 17 18 19 20
	00060	*Panicum antidotale* Retz.	C	Moti Gha	G	WI	ST	FG	BU,CO,DO,HO	Su	23	0.34	1 2 3 4 5 ◘6 7 ◘8 9 10 ◘11 ◘12 13 14 15 16 17 18 19 20
	00166	*Paspalidium punctatum* (Burm.) A	F	Nseila	G	WI	ST	FG	BU,CO	Su	15	0.22	1 2 3 4 5 6 7 8 9 10 ◘11 12 13 14 15 16 17 18 19 20
	00157	*Paspalum paspalodes* (Michx) Scribn.	F	Chipri Gha	G	WI	ST	FG	BU,CO	Su	14	0.21	1 2 3 4 5 ◘6 *7 8 9 10 ◘11 12 13 14 15 16 17 18 19 20
	00158	*Phalaris minor* Retz.	C	Dhumbi siti	G	WI	ST	FG	BU	Sp	18	0.26	1 2 3 4 5 6 7 ◘8 ◘9 10 ◘11 ◘12 13 14 15 16 17 18 19 20
	00078	*Poa annua* L.	C	Annual crabG	G	WI	ST	FG	GO,SH	Sp	23	0.34	1 2 ◘3 4 5 ◘6 ◘7 ◘8 ◘9 10 ◘11 ◘12 13 14 15 16 17 18 19 20
	00159	*P. pratensis* L.	C	Annual Crab G	G	WI	ST	FG	GO,SH	Sp	23	0.34	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
	00160	*Setaria intermedia* Roem & Schult.	O	Chirchira	G	WI	ST	FG	CO,HO	Au	15	0.22	1 2 3 4 5 6 ◘7 8 ◘9 10 ◘11 12 13 14 15 16 17 18 19 20
	00161	*S. verticillata* (L.) P. Beauv.	O	Ban Kangni	G	WI	ST	FG	CO,HO	Au	11	0.16	1 2 3 4 5 6 ◘7 ◘8 9 10 ◘11 12 13 14 15 16 17 18 19 20
Polygonaceae	00162	*Polygonum plebeium* R. Br.	F	Knotweed	H	WI	L	MF	Ca,GO,SH	Wn	7	0.1	1 2 3 4 5 6 7 8 9 10 11 ◘12 *13 14 15 16 *17 18 19 20
Rhamnaceae	00163	*Ziziphus mauritiana* Lamk.	C	Jangli Ber	T	CU	L	FD	Ca,GO,SH	Wn	26	0.38	◘1 2 3 4 ◘5 6 7 8 9 10 11 12 ◘13 ◘14 ◘15 16 17 ◘18 19 ◘20
	00068	*Z. nummularia* (Burm.f.) W. & Arn.	C	Mallah	S	WI	L	FD	Ca,GO,SH	Wn	25	0.37	1 2 3 4 5 6 7 8 9 10 11 12 13 14 ◘15 16 ◘17 ◘18 19 20
Salicaceae	00164	*Populus nigra* L.	F	Poplar	T	CU	L	MF	BU	Wn	18	0.26	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 *17 18 19 ◘20
Solanaceae	00165	*Lycium shawii* Roem. & Schult.	O	Kandiari	S	WI	L	FD	Ca,GO,SH	Su	7	0.1	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
	00045	*Solanum nigrum* L.	O	Maku	H	WI	L	FD	GO	Au	8	0.12	1 2 ◘3 4 5 6 7 8 9 10 11 ◘12 13 14 15 16 *17 ◘18 19 20

Legends:
All voucher speciemen are deposited in UOBH herbarium in University of Okara, Punjab, Okara, Pakistan.
Occurrence: A=Abundant, C=Common, F=Frequent, O=Occasional, R=Rare
Habit: G=Grass, H= Herb, SD= Sedge, S=Shrub, T=Tree
Cultivation Status: Cu=Cultivated, Wi=Wild
Part utilization: Fl=Flower, L=Leaves, St=Shoot, P=Pods, YB=Young branch
Feeding Method: FD=Fodder, FG=Forage, MF= Mixed Feed
Livestock Grazers: Bu= Buffalo, Co= Cow, Ca= Camel, Do= Donkey, Go=Goat, Ho=Horse, Sh=Sheep
Seasonal Availability: Au=Autumn, Sp=Spring, Su= Summer, Wn=Winter
Previous Reports: (◘) = plants with similar uses; (*) = plants with dissimilar uses; ( ) = plants not reported in a previous study; 1: (Badshah and Hussain 2011), 2: (Rahim *et al.*, 2011) 3: (Rahman *et al.*, 2022) , 4: (Hassan and Nawchoo 2020), 5: (Awan *et al.*, 2007), 6: (Gul *et al.*, 2014), 7: (Ahmad *et al.*, 2009), 8: (Harun *et al.*, 2017), 9: (Shaheen *et al.*, 2020), 10: (Iqbal *et al.*, 2021), 11: (Majeed *et al.*, 2020), 12: (Fatima *et al.*, 2019), 13: (Ajaib *et al.*, 2021), 14: (Rasool *et al.*, 2017), 15: (Abdullah *et al.*, 2021), 16: (Zahoor *et al.*, 2017), 17: (Altaf *et al.*, 2019), 18: (Shaheen *et al.*, 2017), 19: (Saddique *et al.*, 2021),20: (Arshad *et al.*, 2020)

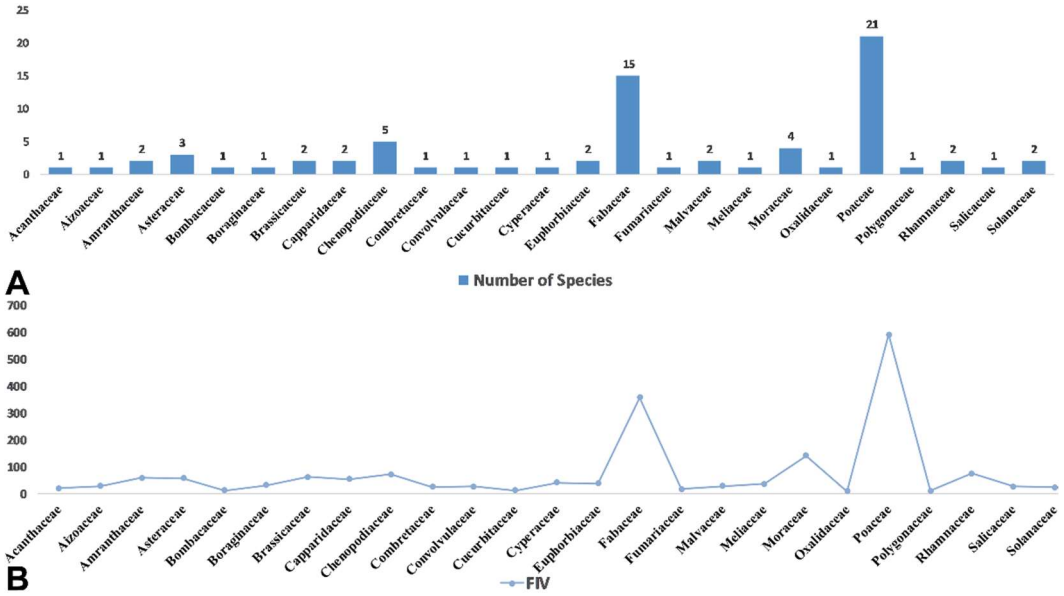

Fig. 3. A. Bar chart showing taxonomic diversity of fodder/forage species; **B.** Line chart showing FIV of reported fodder/forage species families

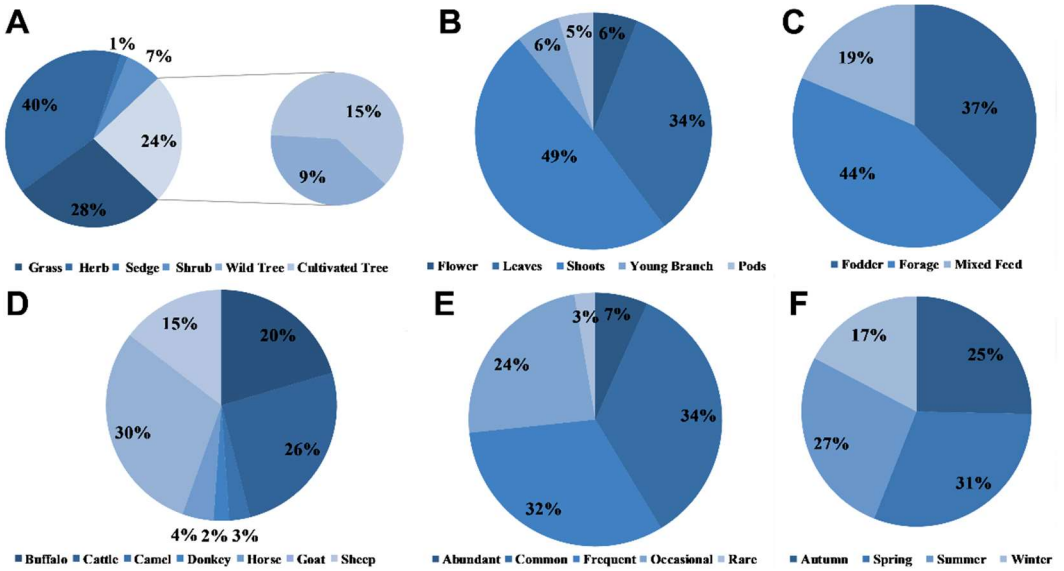

Fig. 4. **A**. Habit pattern among reported fodder/forage species; **B**. Preference of part utilization of fodder/ forage by the livestock; **C**. Preference of feeding strategy by the animal caretakers ; **D**. Preference palatability of fodder/forage species by the livestock; **E**. Relative abundance fodder/forage species in the study area; **F**. Seasonal availability of fodder/forage species in the study area

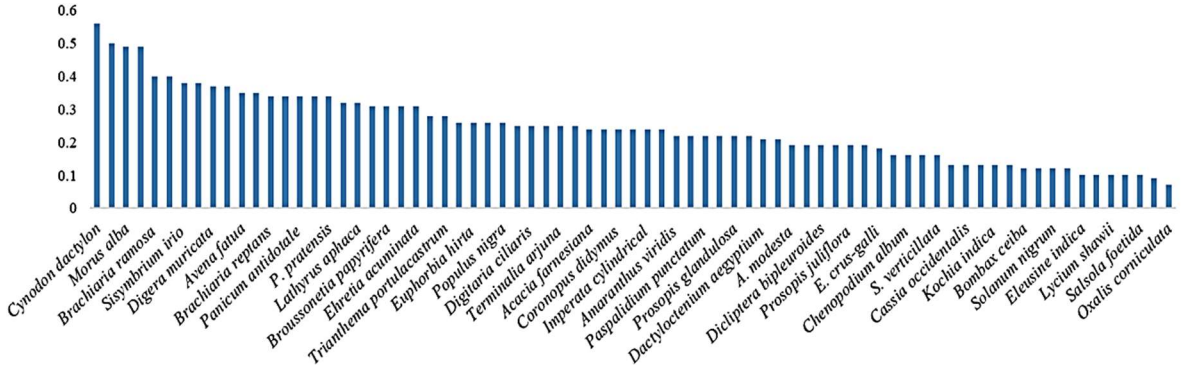

Fig. 5. Indigenous preferences of fodder species based on RFC.

Table 3. Pairwise comparison for fodder grasses having similar RFC.

Plant	Rank	Plant	Rank	Plant	Rank
A.(RFC =0.49)		**I.(RFC=0.28)**		**O.(RFC=0.19)**	
Morus alba	1	*Cleome viscosa*	1	*Sonchus arvensis*	1
Morus nigra	2	*Trianthema portulacastrum*	2	*Malvestrum coromendelianum*	2
B.(RFC =0.4)		**J.(RFC=0.26)**		*Chenopodium murale*	**3**
Cyperus rotundus	1	*Euphorbia hirta*	1	*Dicliptera bipleuroides*	4
Brachiaria ramosa	2	*Phalaris minor*	2	*Acacia modesta*	**5**
C.(RFC=0.38)		*Convolvulus arvensis*	3	*Prosopis juliflora*	6
Sisymbrium irio	1	*Populus nigra*	4	**P.(RFC=0.16)**	
Ziziphus mauritiana	2	**K.(RFC=0.25)**		*Fumaria indica*	1
D.(RFC=0.37)		*Vicia sativa*	1	*S. verticillata*	2
Ziziphus. nummularia	1	*Melilotus albus*	2	*Chenopodium album*	3
Digera muricata	2	*Digitaria ciliaris*	3	*Cassia obtusifolia*	4
E.(RFC=0.35)		*Capparis decidua*	4	**Q.(RFC=0.13)**	
Avena fatua	1	*Terminalia arjuna*	5	*Sonchus oleraceus*	1
Melia azedarach	2	**L.(RFC=0.24)**		*Kochia indica*	2
F.RFC=0.34)		*Taraxacum officinale*	**1**	*Cassia occidentalis*	3
Panicum antidotale	1	*Echinochloa colona*	2	*Albizia lebbeck*	4
Brachiaria reptans	2	*Imperata cylindrical*	3	*Ficus palmata.*	5
Digitaria longiflora	3	*Acacia nilotica*	4	**R.(RFC= 0.12)**	
Poa annua	4	*Coronopus didymus*	5	*Cucumis melo* var. agrestis	1
Poa pratensis	5	*Acacia farnesiana*	6	*Solanum nigrum*	2
G.(RFC=0.32)		**M.(RFC=0.22)**		*Bombax ceiba*	3
Dichanthium annulatum	1	*Paspalidium punctatum*	1	*Suaeda fruticosa*	4
Lathyrus aphaca	2	*Setaria intermedia*	2	**S. (RFC=0.1)**	
H.(RFCs=0.31)		*Mangifera indica*	3	*Eleusine indica*	1
Broussonetia papyrifera	1	*Amaranthus viridis*	4	*Salsola foetida*	2
Alhagi maurorum	2	*Prosopis cineraria*	5	*Polygonum plebeium*	3
Cenchrus biflorus	3	*Prosopis glandulosa*	6	*Lycium shawii*	4
Ehretia acuminata	4	**N.(RFC=0.21)**		*Euphorbia prostrata*	5
		Paspalum paspalodes	1		
		Dactyloctenium aegyptium	2		

Indigenous preferences of fodder species

The indigenous preferences for particular fodder were determined by using RFC and PC methods. RFC results showed that most of the species have average RFC ranging from 0.2 to 0.3 (Table 2). *Cynodon dactylon* (0.56) was designated as the most preferable alternative fodder plant for the animals in the study area. However, *Oxalis corniculata* reported with least RFC (0.0735) as cited by only five informants during the survey, which showed the animal's least dependence or interest in this plant (Fig. 5). However, many of the fodders within the same group possessed similar RFCs and their order of priority was determined by the application of the PC method (Table 3). Fodders (n=23) with RFCs ranging from 0.5 to 0.3 are considered to be High-value fodders (HVF) and appraised as best optional fodders.

Pairwise comparison ranking of fodder palatable to cow

For PC 10 out of 68 respondents were chosen based on their professional expertise and sufficient indigenous knowledge. Results showed *Cynodon dactylon* stands 1st followed by *Cyperus rotundus* and *Avena fatua* at 2nd and 3rd positions. *Alhagi maurorum* ranked at the last 12th position (Table 4).

Table 4. Pair wise ranking of fodder/forage palatable to cow.

Fodder/forage	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	Total	Rank
Cynodon dactylon	5	4	5	4	4	5	5	5	5	5	47	1st
Cyperus rotundus	4	4	5	5	5	4	4	5	4	4	44	2nd
Avena fatua	4	3	5	4	3	5	5	4	4	5	42	3rd
Panicum antidotale	2	4	2	4	4	5	4	5	5	4	39	4th
Sisymbrium irio	4	2	4	3	5	2	5	5	4	3	37	5th
Brachiaria raptens	4	2	4	3	3	2	5	5	4	2	34	6th
Morus alba	2	4	3	3	3	2	3	5	3	3	31	7th
Morus nigra	5	3	3	1	4	4	3	2	2	3	30	8th
Lathyrus aphaca	2	2	3	3	3	2	3	5	3	3	29	9th
Brossounetia papyrifera	4	2	2	3	1	1	2	3	4	5	27	10th
Digera muricata	4	2	1	3	2	1	2	3	3	3	24	11th
Alhagi maurorum	3	2	2	1	3	2	2	1	2	2	20	12th

Moreover, Pearson correlation was also applied to the voting results about 12 fodder/forage obtained by the 10 respondents.). Strongest correlation was observed between R9 and R4 (0.82; $p<0.05$), R3 and R7 (0.82; $p<0.05$), R8 and R4 (0.77 $p<0.05$), R2 and R6 (0.73 $p<0.05$), R8 and R9 (0.71 $p<0.05$). The positive correlation between respondents suggests that respondents report similar information about the plant, as

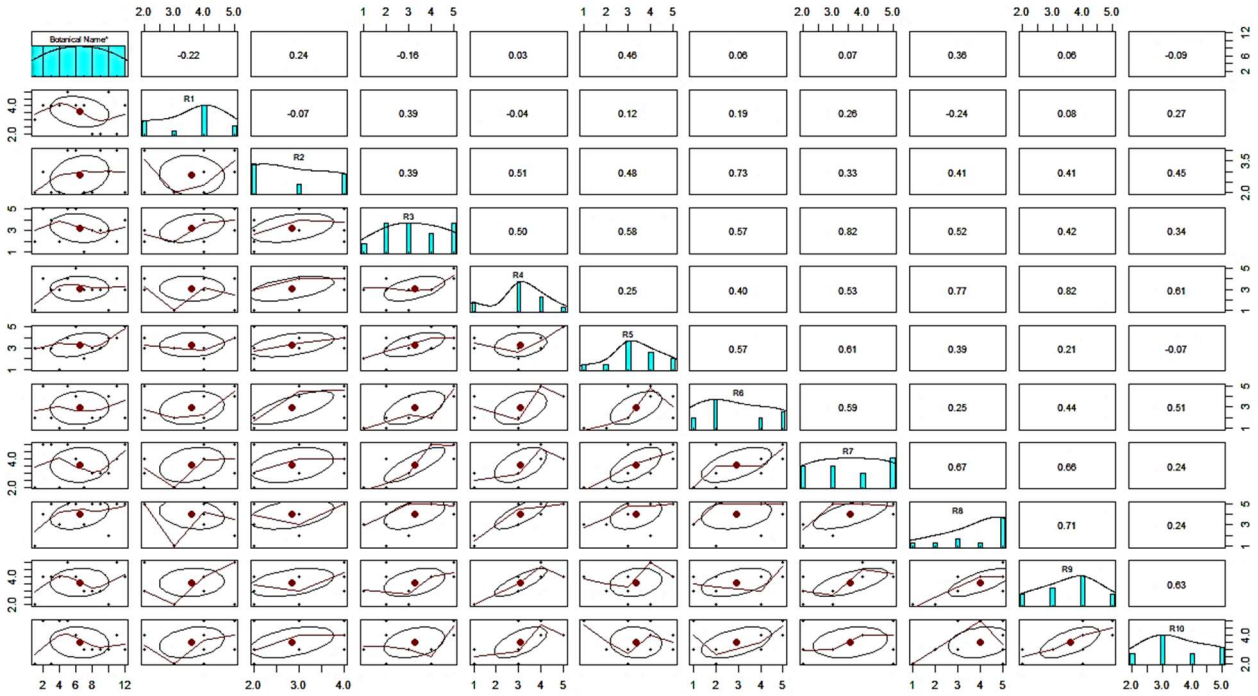

Fig. 6. Pearson correlation; showing the positive correlation among ethnobotanical knowledge of respondents

R9 and R4 both were farmers and were above 60 years, so they had similar knowledge. Similarly, R3 and R7 both were sphered (Fig. 6).

Data visualization through Tableau

The results of Data visualization (Tableau) helped to determine the relationship among different studied parameters. Dendrogram 1 interprets that in the study area cultivated fodder/forage are available in all seasons except autums. Moreover, all of them are used as fodder or mixed feed. The free grazing feeding strategy is not favored for cultivated fodder. In addition, these all were trees and usually common and frequent in the study area (Fig. 7 A–E). Dendrogram deduced that wild fodder/forage available in all seasons i.e. autumn, spring, summer, and winter. As wild fodder/forage is available for free therefore animal caretakers use them in all possible means to feed their animals. Therefore, all kinds of feeding strategies were in practice.

DISCUSSION

Demographic attributes of local community revealed that most of the informants were male and less number of females participate. A previous study by Harun (2017) also had similar kind of results from the province of Punjab and this could be attributed to the typical cultural restriction, as women were not readily allowed to work outside their residence. Furthermore, most informants belonged middle-aged (40–60 age group). This is due to the reason that young age respondents (20–40) were least interested in traditional kind of methods and the old age group (above 60) is declining day by day (Karim *et al*., 2021; Mazzocchi, 2006). These results urged the significance of documentation, and preservation of such information, alternatively the prestigious knowledge can be vanished. UN (United Nations) Article 8 of the Convention on Biological Diversity also enforces us to "respect, preserve and maintain knowledge, innovations and practices of indigenous and local communities embodying traditional lifestyles relevant for the conservation and sustainable use of biological diversity" (United Nations, 1992). The literacy rate in this area is not much higher. According to the last updates of the Pakistan Bureau of Statistics, only 36.2% of inhabitants of this area are literate (https://www.pbs.gov.pk/content/district-glance-kasur). It was also noticed that the people utilizing alternative wild fodder plants had a low-income background because of possessing fewer resources to feed their livestock with fodder crops. Therefore, the socioeconomic background of informants could be one of the reasons for the utilization of those wild fodder/forage resources (Parwada *et al*., 2022).

Taxonomic results showed that family Poaceae and Fabaceae were the most popular and dominantly used fodders families. This data was also supported by various ethnobotanical studies from different regions i.e., India (Singh *et al*., 2008), China (Geng *et al*., 2017; Kajidu *et al*., 2019), Africa (Bahru *et al*., 2017) and also in Pakistan from Punjab (Harun *et al*., 2017) and Thal desert of Pakistan (Shaheen *et al*., 2020). These fodders are mostly found in wild habitats and preferably herbaceous habits

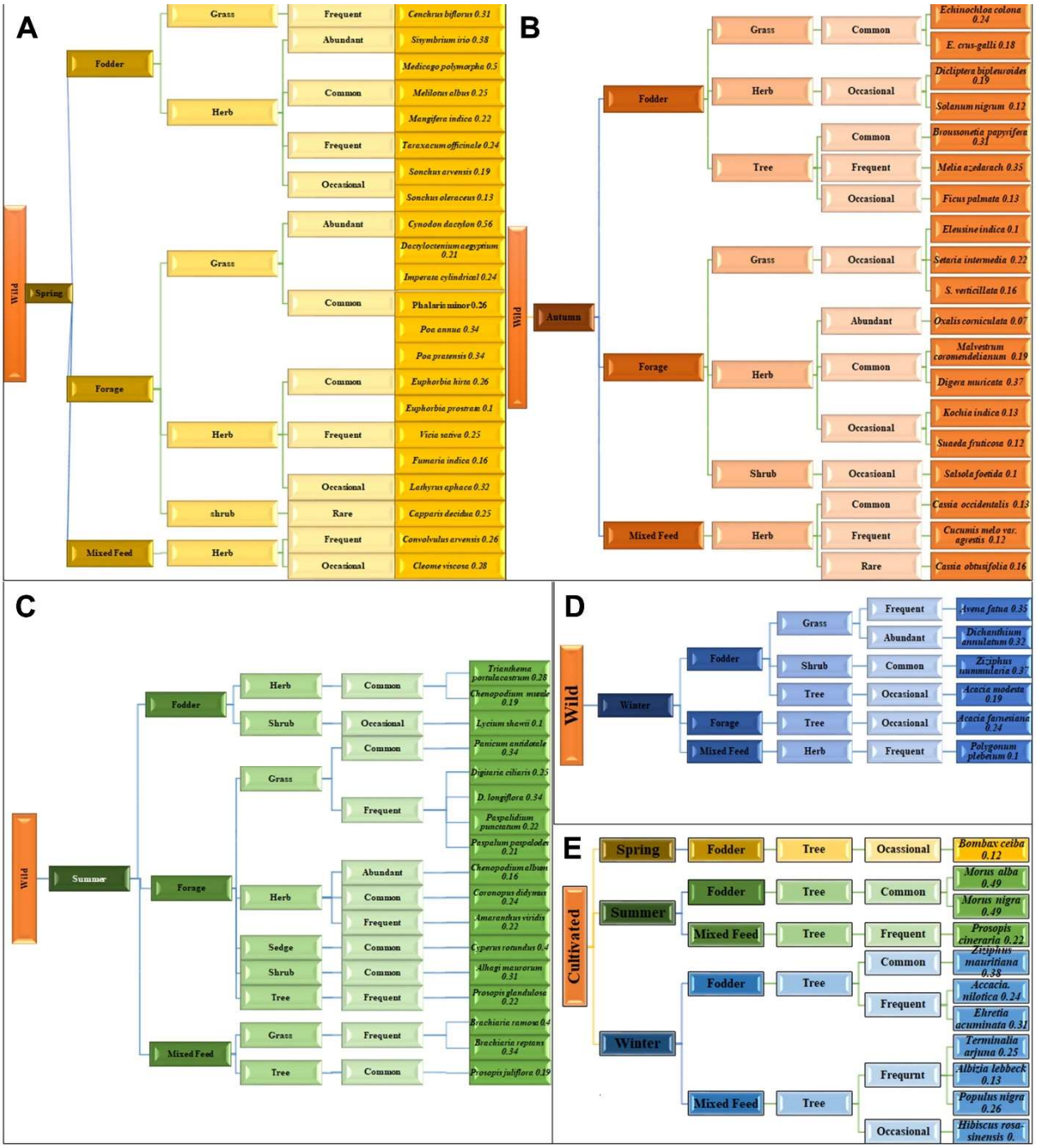

Fig. 7. Dendrogram showing the Data visualization (Tableau) results for: **A.** wild fodder/forage of spring seasons; **B.** wild fodder/forage of autumn seasons**; C.** wild fodder/forage of summer seasons; **D.** wild fodder/forage of winter seasons; **E.** cultivated fodder/forage of all seasons.

were used. Previous ethnobotanical studies also reported wild herbaceous habit as a palatable growth form for animals (Abbas *et al*., 2016; Abidullah *et al*., 2019; Malik *et al*., 2018; Altaf *et al*., 2019; Ashfaq *et al*., 2019; Abbas *et al*., 2021). Additionally, our study reported the maximum availability and diversity of fodder/forage species for livestock during the rainy season (spring and summer). Traditionally, legumes and grasses are the major components of diets of animal forage however in arid and semi-arid regions of the world, trees and shrubs fodders are the main ingredients of animal diets due to seasonal and spatial scarcity of pasture, shortage of grazing lands, and increasing livestock numbers (Bahru *et al*., 2014; Parwada *et al*., 2022). The availability of fodder/forage plants fluctuated according to seasonal variations (Hussain and Durrani, 2009).

Table 5. Novelty index (Jaccard Index).

Year	**Province**/Study Area	Np	NPSU	NPDU	TPCBA	PRAA	PRSA	PPSU	PPDU	JI	Reference
	KPK										
2011	Tank	38	13	0	13	25	62	34.21	0	13	Badshah *et al*., 2011
2011	Buner & Swat	29	4	0	4	25	71	13.79	0	4	Inam ur Rehman *et al*., 2011
2022	Buner	115	22	0	22	93	53	19.13	0	13.10	Rahman *et al*., 2022
2021	Haripur	80	0	10	10	70	65	0	12.5	6.90	Siddique *et al*., 2021
	AJK										
2020	Srinagar	9	0	0	0	9	75	18.03	0	0	Hassan and Nawchoo, 2020
2007	Muzaffarabad	61	11	0	11	50	64	25	0	8.8	Awan *et al*., 2007
	Sindh										
2014	Seer Creek to Jiwani	28	7	0	7	21	68	16.13	0	7.29	Gul *et al*., 2014
	Punjab										
2009	Jehlum	62	10	1	11	51	64	30.19	1.61	8.73	Ahmad *et al*., 2009
2017	Central Punjab	53	16	0	16	37	59	16.39	0	14.29	Harun *et al*., 2017
2020	Southern Punjab	61	10	0	10	51	65	3.36	0	7.94	Shaheen *et al*., 2020
2021	Sialkot	119	4	9	13	106	62	12.75	7.56	7.18	Iqbal *et al*., 2021
2020	Punjab	149	19	0	19	130	56	25.42	0	9.27	Majeed *et al*., 2020
2019	Bahawalpur	118	30	5	35	83	40	3.13	4.24	22.15	Fatima *et al*., 2019
2021	Jhelum	64	2	3	5	59	70	60	4.69	3.73	Ajaib *et al*., 2021
2017	Cholistan	5	3	0	3	2	72	28	0	3.90	Hussain *et al*., 2017
2021	Cholistan Rangelands	25	7	0	7	18	68	15.63	0	7.53	Abdullah *et al*., 2021
2017	Sheikhupura	96	15	7	22	74	53	4.12	7.29	14.77	Zahoor *et al*., 2017
2019	Gujranwala	97	4	21	25	72	50	9.30	21.65	17.01	Altaf *et al*., 2019
2017	Noorpur Thal	129	12	0	12	117	63	0	0	6.25	Shaheen *et al*., 2017
2020	Kasur	78	11	6	17	61	58	14.10	7.69	12.5	Waheed *et al*., 2020

Np:Total number of plants; NPSU: Total Number of Plants with Similar Uses; NPDU: Number of Plants with Dissimilar Uses; TPCBA: Total Plants Common in Both Areas; PRAA: Plants Reported in Aligned Area; PRSA: Plants Reported in Study Area; PPSU: Percentage of Plants with Similar Uses; PPDU: Percentage of Plants with Dissimilar Uses; JI: Jaccard Index.

Data analysis and statistical interpretations

Higher RFCs indicated greater familiarization of these species in the study area (Amjad *et al*., 2017). HVF is most preferable because of the herbaceous or grassy habit of most of the top-ranked species (convenient to eat and digest); ease in their wild availability and diversity in their palatability (cattle, buffalo, horse, sheep, goat, camel), and feeding methods (free grazing or as a feed). In addition, they are available throughout the year and also have a long shelf life in the dry season. We found similar reports in the previous ethnobotanical literature; (Khan and Hussain 2012; Harun *et al*., 2017) also recommended *Cynodon dactylon, Cenchrus ciliaris*, and *Dichanthium annulatum* as highly palatable fodders. In a recent study, (Shaheen *et al*., 2020) reported *Cynodon dactylon* as the most preferred fodder species in the Thal desert Punjab. Grasses were observed as the most preferred fodder/forage species for the livestock of the studied area. The most preferred trees plants for optional fodder usage were *Morus alba, Broussonetia papyrifera, Melia azedarach, Ziziphus mauritiana,* comparable to the study by Badshsah and Hussain (2011), while *Ziziphus mauritiana* available throughout the year and consumed by sheep and goats only. However, *Morus alba* and *Broussonetia papyrifera* were consumed by all kinds of livestock.

Most of these top-ranked foraging species were abundant, frequent, or common in the study area. This fact supports the 'hypothesis of appearance" which states that natives better know about those species which are comparatively well distributed in a particular area (de Lucena *et al*., 2012). Plants growing commonly in the area allow local people to have more experience of their properties and consequently have a greater probability of being introduced into the local culture.

Novelty (Jaccard Index)

The outcomes of the current study have been comparatively assessed with the already published ethnobotanical literature addressing fodder species. Documented list of 75 fodder plants in the studied area was cross verified in the 20 published articles of Pakistan (Table 5). This comparison supported finding out the diverse utilization and traditional knowledge indigenous about fodder species. This sort of difference and similarity is usually numerically measured in terms of Jaccard Index (JI) by the ethnobotanists (Farooq *et al*., 2019). In the current study, the JI values ranged from 22.15 to 0. The highest value has been reported by the Tehsil Yazman of Punjab i.e. 22.15 followed by Navapind and Shahpur Virkanin of Sheikupura District in Punjab i.e. 14.77 and Central Punjab i.e. 14.29; all three sites from province Punjab. The higher JI value reflects the similarity in vegetation types of both areas due to similar geographic or climatic conditions while lower JI value reflects the dissimilarity in vegetation types of areas

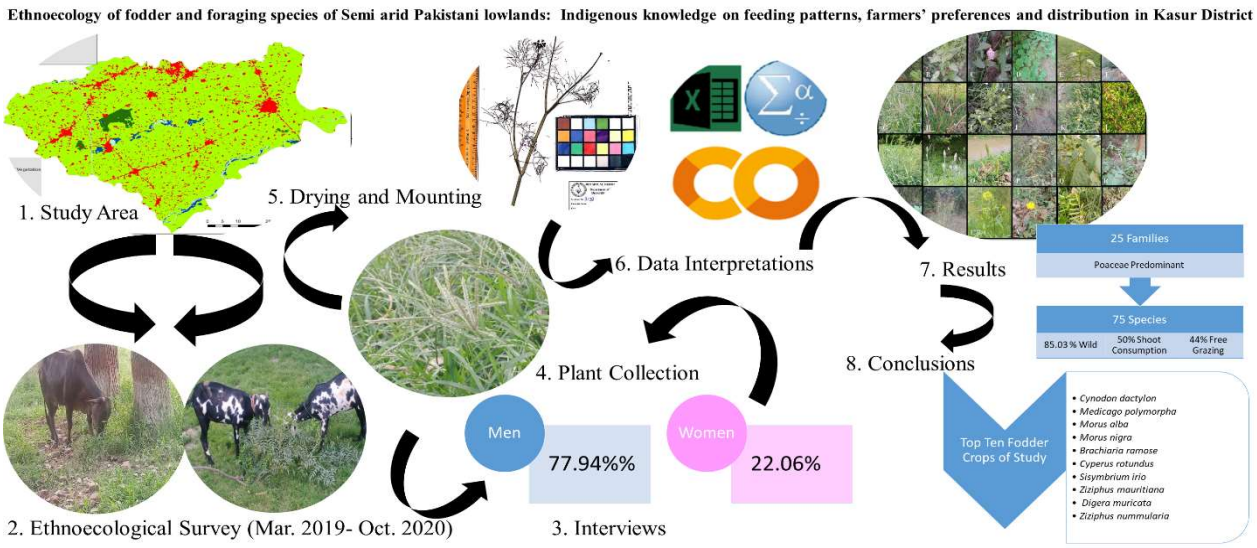

Fig. 8. Graphical abstract showing overall summary of the research.

because of different geographical and climatic conditions (Farooq *et al*., 2019). The minimum JI has been calculated in the study of Dal Lake of Jammu & Kashmir. i.e. 0 where no similar plant was reported with the current site because there is a big difference between the climate and geography, moreover only 9 plants inhabiting only near the lake were observed in the reported site while in current site the plants inhibiting the dry and warm climate were observed.

The present work reported 8 rarely documented plant taxa as fooder in the studied ethnobotanical literature of Pakistan i.e. *Dicliptera bipleuroides*, *Ehretia acuminate, Kochia indica*, *Cassia obtusifolia*, *Melilotus albus*, *Hibiscus rosa-sinensis*, *Poa pratensis* and *Lycium shawii*. However, 3 plants *Cleome viscosa*, *Albizia lebbeck*, and *Alhagi maurorum* have been reported in available literature but for the uses other than fodder; current study accounted their novel use as fodder for animals.

Conservation aspects

However, if we look at the relative abundance of these wild fodders/forages, it can be observed that usually they are common and frequent in their habitat. Only a few of them were abundant and even two (*Capparis decidua*, *Cassia obtusifolia*) were also reported as rare in the study area but still in use. It is a serious concern for conservation of natural fodder/forage resources for a particular area. These results showed that there is overexploitation of these natural resources in study area. It enforces for conservation of valuable natural resources (Bibi *et al*., 2022). It impacts on the climatic and ecological conditions of the region causing desertification, drought conditions, less transportation, and soil erosion (Li *et al*., 2000; Weber and Horst, 2011; Guo *et al*., 2022).

CONCLUSION

The Present survey disclosed that the indigenous people of District Kasur hold immense ethnoecological knowledge about fodder species regarding their diversity, distribution, and animal preferences (Fig. 8). *Cynodon dactylon*, *Medicago polymorpha*, *Morus alba*, *Morus nigra, Brachiaria ramose, Cyperus rotundus, Sisymbrium irio, Ziziphus mauritiana, Digera muricata* and *Z. nummularia* were the top ten fodder/forages used by the native of the study area. The local farming system could be improved by utilizing the indigenous knowledge of farmers. Moreover, the abundance of fodder species declines with the passage of time leading todesertification. The study was based on farmers' experiences and views about the utilization of alternative fodder/forage species so there is an urgent need for authentication of some of the upraised issues by using additional laboratory methods. Such traditional knowledge of people about fodder utilization would be significant for future planning and management of livestock along with fodder species utilization and conservation.

ETHICAL DECLARATIONS

The Code of Ethics of the International Society of Ethnobiology (ISE 2008) was strictly followed. Ethical consent had been taken from ethnical review committee of University of Okara, Pakistan reference number UOERC#44.

AUTHORS' CONTRIBUTIONS

FA designed and supervised the whole study, **MW, KF, MM** conducted field surveys and collected data, **NH**, **KF, SJ** contributed in data arrangement, presentation and analysis. **BAK** played role in statistical interpretation of data. **FA** and **MW** wrote the first draft of the manuscript; later **NH**, **KF and ZA** improvised its scientific input and language.

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Supplementary materials are available from Journal Website.