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ETHNOECOLOGICAL KNOWLEDGE OF WILD FODDER PLANT RESOURCES OF DISTRICT BUNER PAKISTAN

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Abstract

Livestock rearing often remain the sole means of livelihood in agro-pastoral communities harboring in rural mountainous settings. This study documents the characteristics, altitudinal distribution, seasonal availability, mode of utilization, preference rank, and palatability of fodder species used by indigenous agro-pastoralist communities of Buner, Pakistan. In total 85 informants (69 male, 16 female), aged between 25-90 years, including farmers, shepherds, local farm owners and veterinary practiotioners were interviewed, to obtain traditional knowledge for determining priority fodder species for sustainable livestock raising. In total 115 fodder species, belonging to 34 families were reported from the study area. Poaceae, Fabaceae and Rosaceae together shared 64% of the fodder species, contributed 39, 17 and 07 species, respectively. Most of the fodder plants (43%) are available in summer season, the peak months being July and August, while 30% fodder plants grow in spring season. In 64% cases whole plants were palatable while in 24% cases leafy shoots and in 12% species only the leaves were palatable. 44% species were of high priority, 32% medium priority and 24% were low priority species for livestock as identified by informants. Further 71% species were preferred by cattle only in fresh condition while 28% in both fresh and dry conditions. Based on pairwise comparison (PC), top 05 fodder species included *Avena fatua* ranked 1st with 25 points, followed by *Echinochloa crus-galli* (2nd, 24 points), *Brachiaria ramosa* (3rd, 23 points), *Phaceleurus speciosus* and *Melia azedarach* 4th and 5th respectively. The indigenous livestock rearing communities possess valuable traditional knowledge with substantial implications for prioritizing wild fodder/forage species, for sustainable livestock raising by rural pastoralists and domestic livestock owners.

Key words: Fodder species, Livestock, Buner Pakistan, Traditional fodder knowledge.

Introduction

Indigenous communities residing in rural mountainous settings depend for their livelihoods, often exclusively on agroforestry and cattle raising (Garrity, 2004; Shinwari *et al*., 2006; McDermott *et al*., 2010). The communities not only treat themselves with wild plants (Ahmed *et al*., 2020; Ali *et al*., 2018) that are verified by the scientists but also for their animal grazing and treatments (Tariq *et al*., 2016 & Tareen *et al*., 2016). Keeping livestock, is often the only means of livelihood for poor pastoralists and mountain dwellers (Thornton & Herrero, 2008). Due to human population expansion and associated factors, the area under crop cultivation is constantly increasing and pastoral land is decreasing at a rate of 2% per decade (Gill, 1998). This retreat in fodder land is affecting the availability and quality of fodder for livestock rearing (Cassidy *et al*., 2013; Delgado *et al*., 2001). As a result, the rural communities confront severe issues of fodder shortage and poor-quality fodder. This in turn severely affect the livestock sector and poor agro-pastoralist. The term fodder in agriculture is applied to plants consumed wholly or in parts by animals (livestock) as their feeds. Fodder may include whole plant such as grasses, herbs or their young sprouts, shoots, tendons, twigs, leaves, inflorescence, and fruits used to feed livestock (Bahru *et al*., 2014; Ivory, 1990). Indigenous livestock keeping communities possess valuable traditional knowledge about the characteristics of wild fodder/forage species. This knowledge represents the result of centuries old tradition of rearing livestock (Geng *et al*., 2017; Harun *et al*., 2017; Hussain *et al*., 2020). Shrubs and trees are used as fodder by animals in xerophytic conditions when shortage of feed increases in winter, but grasses and legumes are the major component of animal's diet during shortage of grazing land (Devendra, 1990). Various species of grasses are preferred by buffalos, cows, donkeys, and sheep, while goat and camels prefer shrubs and trees for health and nutrition (Badshah and Hussain, 2011; Osemeobo, 1996; Wilson *et al*., 1995). Goat and sheep usually rely on same type of feed under conditions of fodder scarcity (Gillen & Sims, 2004). Plant property that stimulates sensory impulse of grazing livestock to enjoy various plants or its parts is typically known as palatability (Hussain & Durrani, 2009; Adnan *et al*., 2015) and preference is the selection of a plant species by the animals. Palatability of fodder species is affected by some animal associated factors such as species of animal, hunger and general health of animal, seasonal availability, growth stage and morphology along with intraspecific competition and accessibility to plants (Grunwaldt *et al*., 1994; Nyamangara & Ndlovu, 1995).

Pakistan is geographically and climatically diverse country with a variety of ecological habitats (Shinwari, 2010). In Pakistan livestock sector contribute about 56.3% to agricultural economy and 11% to the overall agriculture grass domestic product (AGDP) (Rehman *et al*., 2017). Pakistan produces a huge quantity of milk and ranks fourth in the world in milk production. Natural resources are adequately available to develop this industry in Pakistan as it plays a pivotal role in reducing poverty. During the year 2014-15, 4.1% growth rate was recorded in livestock sector (Rehman *et al*., 2017). In Pakistan, the production of fodder varies according to ecological zones and the time of year. *Melia azedarach, Aesculus indica, Grewia oppositifolia,*

Morus nigra and Robinia pseudoacacia are available as tree fodder in mountainous areas (Leede *et al*., 1999; Inam-ur-Rahim *et al*., 2011).

Traditional knowledge of fodder/forage species is of immense importance under conditions of global climate change, agriculture expansion and retreat of grazing land. This valuable knowledge has greater implications in solving problems of fodder shortage, providing alternative fodder, and protecting the livelihood of pastoralists, farmers, and livestock farm-owners (Nunes *et al*., 2015; Shinwari *et al*., 2012). Fodder is a cheap source for dairy and meat industries and products. More fodder production and its collection are unavoidable for its proteins being major component of dairy produce. Availability of feeds to animals in sufficient amount is vital for livestock rearing. It is observed that acceptable amount of feed will not be available with the increase of human and population and shrinkage of fodder producing land thereof (Grover & Kumar 2012). Therefore, this study was carried out to identify, enlist, and characterize the fodder species found in the study area; to determine the preferred and valuable fodder species; and to document the indigenous fodder associated knowledge of the local communities.

Material and Methods

Study area (Buner district): Buner district lies in the Hindukush mountain ranges in north-west of Pakistan's Khyber Pakhtunkhwa province between 34°11′ to 34°43′ N latitude and 72°13′ to 72°45′ E longitude (Fig. 1). The district comprises a mountainous valley, having an area of 1865 km^2, inhabited by 0.897 million human populaces, increasing annually at a rate of 3.05%, with population density of 517.2/km (Anon., 2017). The district comprises of four sub-divisions namely Daggar, Gagra, Mandanr and Khadukhel. Altitude of the area varies from 400 m at Totalai in south to 3500 m, at Dosaray peak in the north at Swat border. The area is inhabited predominantly by various subtribes of the Yousafzai and Mandanr tribes of Pakhtuns, with a significant portion of Gujjars and Syeds (Arab descendants) as well. The native language of the area is Pashto, being understood by about 95% of the inhabitants, while 5% people are bilingual with Gujjri being their mother tongue, however they are fluent in Pashto as well.

The climate of the area is subtropical to montane type having warm to hot summers and cool winters. According to Koppen climate classification the area has humid continental climate (DWB) in the south plains and temperate continental climate (Dsb) in the North Temperate Zone. The mean monthly rainfall is 235 mm in summer and 116 mm in winter and mean annual rainfall of 1068 mm. The summers are mild, and the winters are cool, with snowfall at high elevations. In June, the mean high temperatures are 32°C, while in January mean lowest temperatures are below freezing point. Average annual temperature is 19°C. Relative humidity is 60-65%. Barandu being the lonely river, flows in the central region of Buner and is a main source of irrigation, although severely degraded by the outflow from hundreds of marble factories. The people mostly live-in rural settlements and 45.38% people live below the poverty line. They mainly depend on agriculture, livestock, fuel wood, timber, government services and overseas employment for livelihood.

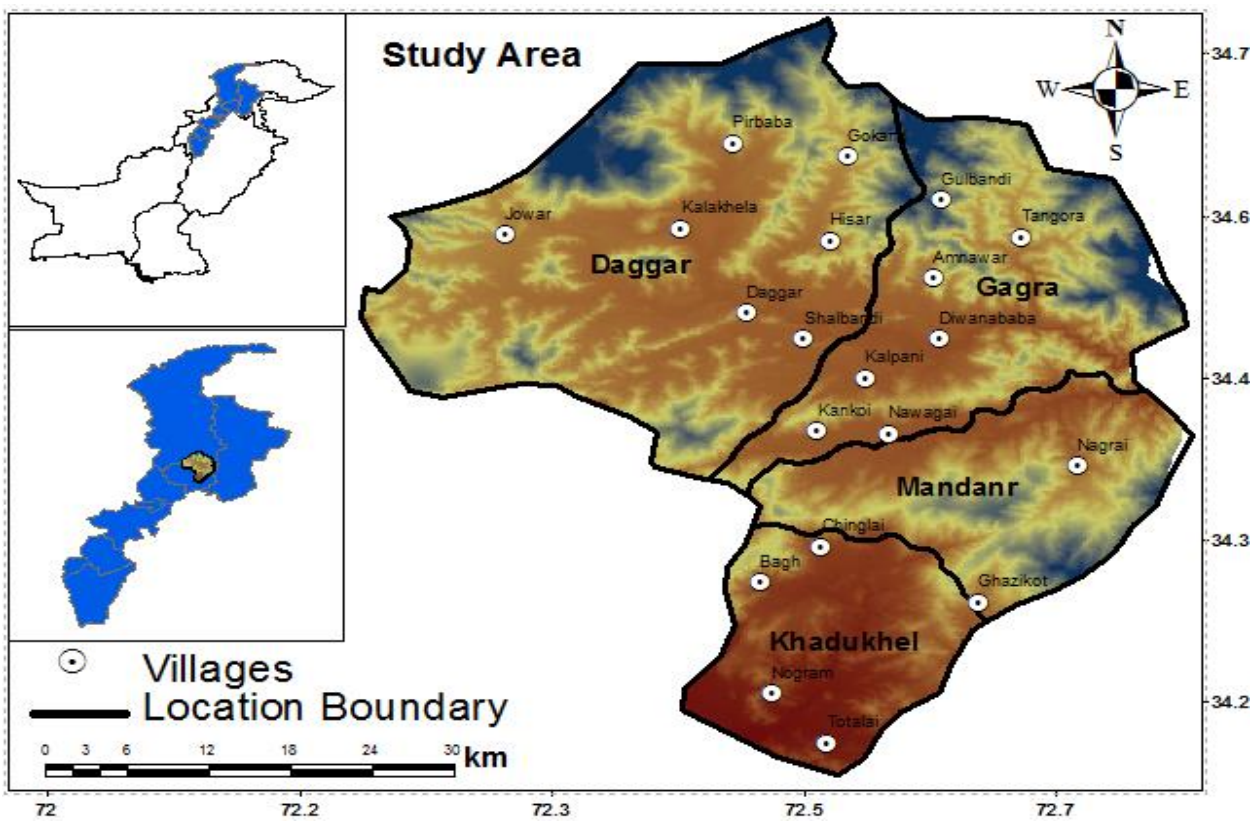

Fig. 1. Map of district Buner Pakistan, showing locations of sampling sites.

Field survey and acquisition of fodder traditional knowledge: The study was conducted from July 2017 to December 2019. The interviews were mostly conducted by the first author (SUR) being a resident of the area and sometimes accompanied by the second author (ZU). Hence it was easier to identify the key informants through a snowball sampling method (Bernard, 2011). Ethical guidelines of the International Society of Ethnobiology (Anon., 2006) were followed during this study. All interviews were conducted in the local Pashto language. We used semi-structured interviews and pasture walk coupled with personal observation to collect maximum information on all aspects of fodder species from the informants. We gathered ethnobotanical information pertinent to wild fodder species, or in few cases naturalized fodder species, and cultivated species were omitted. Traditional fodder knowledge (TFK) was documented from 85 key informants (69 male and 16 female), including farmers, livestock form owners, shepherds, herdsmen, and veterinary practitioners. Informants were interviewed on diverse characteristics of fodder species, including name in local language, palatable part, seasons of availability, mode of consumption (dry/fresh), preference by animals, relative abundance, and pairwise comparison. Sociodemographic information of informants (age, sex, ethnic group, education level, profession, number, and type of livestock animal were also documented. The relative abundance and availability of fodder species were determined by visual observations and asking from informants. The fodder species were then classified into four abundance categories i-e abundant, common, frequent, and rare.

Specimens of fodder taxa were collected, dried and the voucher specimens were submitted to Swat University herbarium "SWAT". The specimens were identified by the 2nd author (ZU) using Flora of Pakistan http://legacy.tropicos.org/Project/Pakistan. Nomenclature of species names follow (Anon., 2020) "Worlds flora online database" http://www.worldfloraonline.org/. The names of plant families are in accordance with APG-IV classification (Chase *et al*., 2016).

Data analysis

Ethnobotanical data on fodder species were entered in Excel spreadsheets, organized and analyzed. Frequency of citations (FC) was used for prioritizing and determining most preferred fodder species. Relative frequency of citation (RFC) was calculated using formula:

RFC= FC/N (Tardio & Pardo-de-Santayana, 2008)

where FC is the number of citations for a particular fodder species and N represent total number of informants included in the survey.

For the pairwise comparison (PC), top 15 fodder species based on highest FC scores were selected and 15 key informants were asked to select their 1st choice among each pair of fodder species. Two marks were allotted to a species when an informant preferred it over its counter species, while one mark was allotted to each species in case both were equally preferred by the informant (Harun *et al*., 2017, Shaheen *et al*., 2020). In this way preference ranks were established for top priority species (Table 3).

Results and Discussion

Demographic information of the respondents: Traditional knowledge of fodder/forage plants was gathered from 85 informants, including 69 male and 16 female informants (Table 1). Ages of informants ranged from 25 years to 90 years, with 67% aged above 50 years. Most informants (40%) were illiterate and never attended school, these included mostly shepherd women involved in goat and sheep rearing in alpine meadows and belonged to mobile landless pastoralists. 32% informants had completed 10 grade or higher education. Informants included people associated with domestic livestock keeping (20), farmers and shepherds (38 male) and shepherd female (16), veterinary practitioners (06) and animal dairy farm owners (05) (Table 1). It was observed that in Buner district due to cultural and religious restrictions women had less involvement in outdoor livestock rearing activities and hence had relatively low traditional fodder knowledge (TFK). This result was in congruence with Harun *et al.*, (2017), however, Shaheen *et al*., (2020) observed no gender bias in their study regarding TFK. Similarly, it was found that old, aged people had more fodder related knowledge due to their long experience of livestock rearing. Similar findings were reported by Ouachinou *et al.*, (2018) in Benin Africa and Nunes *et al.*, (2015) in Brazil.

Table 1. Demographic Characteristics of the informants.

Variable	Category	Number of informants (N=85)	Percentage
Sex	Male	69	81.18
	Female	16	18.82
Age groups	25-40	14	16.47
	41-50	14	16.47
	51-60	29	34.12
	61-70	9	10.59
	71 <	19	22.35
Education level	Illiterate	34	40.00
	Primary	24	28.24
	Matriculation	13	15.29
	Intermediate	4	4.71
	Bachelor	4	4.71
	Master	6	7.06
Profession	Farmers and Shepherds (Male)	38	44.71
	Hakims & veterinary technicians	6	7.06
	Domestic livestock owners	20	23.53
	Shepherds Female	16	18.82
	Farm owners	5	5.88

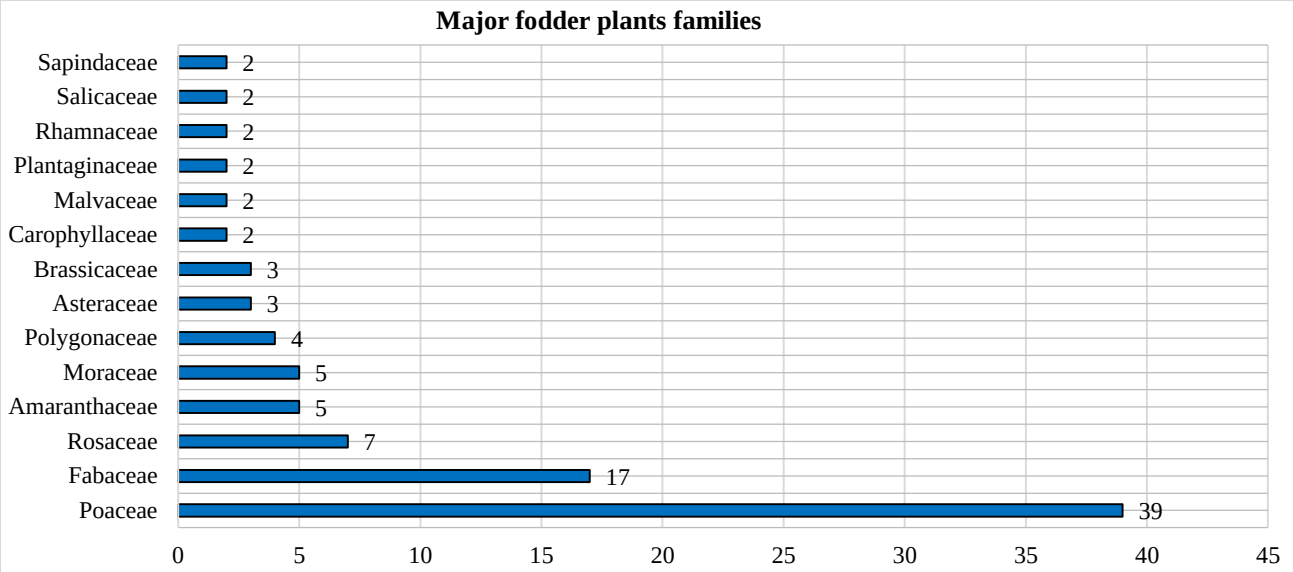

Fig. 2. Families with most number of fodder plant species.

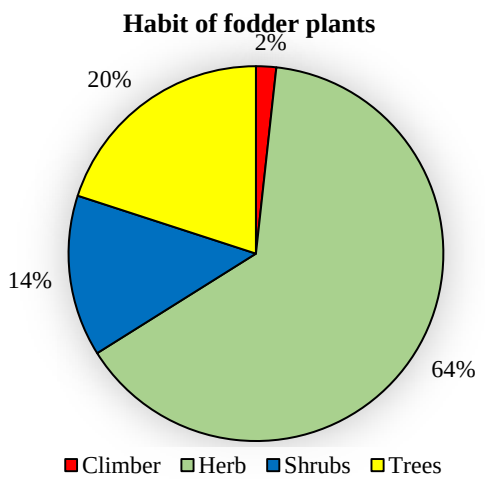

Fig. 3. Habit wise classification of fodder plant species.

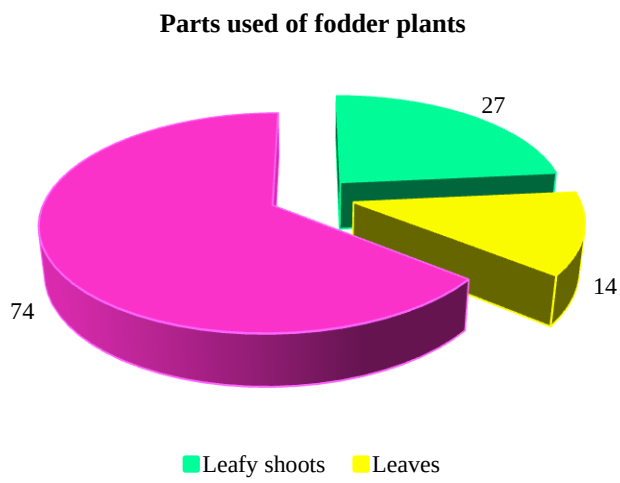

Fig. 4. Proportion of different parts of fodder utilized.

Taxonomic diversity and habit of fodder species: This study revealed 115 fodder plant species, belonging to 91 genera and 34 families (Table 2). Poaceae (grasses) was the leading family with 39 species, followed by Fabaceae (17 spp) and Rosaceae (07 spp). Amaranthaceae and Moraceae (05 spp each), and Polygonaceae (04 spp) (Fig. 2). Together these 5 families accounted for 64% of the fodder species for local livestock. Rest of the families had 3 or less species per family. Genera with the greatest number of species were *Amaranthus* and *Rubus*, each had 3 species. Other rich genera were *Alopecurus*, *Avena*, *Acacia*, *Cajanus*, *Chenopodium*, *Chrysopogon*, *Ficus*, *Morus*, *Lathyrus*, *Poa*, *Setaria* and *Salix*, each represented by 2 species (Table 2). Based on habit most fodder species (74, 64%) were herbaceous, these mostly included grasses, while 23 species were trees (20%), 16 were shrubs (14%), and only two were climbers (1.74%) (Table 2, Fig. 3). Although many diverse kinds of herbs, shrubs and trees were available, however livestock mostly preferred grasses for feeding, as (Bahru *et al*., 2014) also reported that 52% of all fodder/forage species were grasses. Ouachinou *et al*., (2018) also reported Fabaceae and Poaceae as dominant families that contributed 76 and 57 species respectively. While 52 species of Poaceae were reported by Shaheen *et al*., (2019) from Thal region Pakistan and 53 grasses by (Harun *et al*., 2017). Geng *et al*., (2017) also reported that shrubby fodder mostly belonged to Rosaceae and herbaceous fodder was dominated by Poaceae.

Altitudinal distribution of fodder species: Different fodder species prefer different habitats and altitudes. Based on altitude 35% fodder species were found distributed from the plains 300m to 1500m elevations in the so-called plains and foothills. These represent subtropical climates and relatively dry zone, with low rainfall ratios, but becoming moist in the upper elevations. 21% species were found in subtropical-cum-temperate region, having altitudes reaching to 2000m above sea level. This included mostly mountainous oak forest areas, with mixed olive forests. 16% species belonged to moist temperate blue-pine and fir-spruce zone (altitude 2000-3000), while 12% fodder species belonged to alpine and subalpine meadows. Most important and frequently cited alpine fodder included *Poa alpina*, *Pennisetum lanatum*, *Aloecurus himalaicus* and

Dactylis glomerata. These are dominant components of alpine meadows being grazed by flocks of sheep and goats, and cut for hay, that is stacked for winters. Below 1000m the habitats are dry, and rainfall is less in lower Buner, 17% species of dry subtropical climate are found here (Table 2).

Seasonal availability: The formers identified three seasons based on fodder availability i.e., summer (pashakal), spring (sparlay) and winters (jamay), the latter included autumn. Most of the fodder plants (43%) are available in summer season, the peak months being July and August. Plenty of rainfall in monsoon season, with high relative humidity and warm temperature favours the growth of many annual and perennial herbs and grasses. *Brachiaria ramosa* grows abundantly as weed in summer crops and disturb places and provide excellent fodder for cattle. Another very important fodder of the season is *Echinochloa crus-galli* that is very common as a weed of rice fields and surrounding wetlands. This is an excellent fodder, both nutritive and digestive, and can significantly increase milk production. Heuze *et al.*, (2020) has also discussed the fodder potential of this grass. Spring is the second most productive season with 30% fodder plants. Additionally, 14% of the summer species, usually trees and shrubs may be available as fodder till mid of winters. 12% species primarily growing in the spring season enters in summer season with increasing altitude. Only 2 species are at peak in winters and then entering in spring season (Table 2; Fig. 7).

Two seasons of fodder scarcity were identified, June to mid of July and winters from mid-November to end of February. Our results agreed with (Inam-ur-Rahim *et al*., 2011), who also reported similar fodder shortage seasons, however in their study area had six different seasons. We observed that trees like *Aesculus indica*, *Morus nigra*, *Grewia* and *Quercus*, along with dry hay provided fodder in dry season and winters. Similar practices have also been observed in China (Geng *et al*., 2017) and Nepal (Panday, 1982). In the lower dry hills *Carrisa carandas* is grazed by goats and camels during winter.

Plant parts used: In most of the (64%) cases, whole plant (above ground parts) was palatable as cited by informants. In 24% plants the palatable part were leafy shoots, while in 12% plants (mostly shrubs and trees) only the leaves were eaten by cattle (Fig. 4). Harun *et al*., (2017) also reported that 45% species in their study were consumed by the ruminants. We found that due to tender aerial parts, majority of herbaceous flora is consumed. In some herbs and grasses, the aerial parts become tough with maturity, and under such conditions the animals graze on their aerial tender tops only e.g *Saccharum spontaneum, Aristida cynantha* and *Themeda anathera.*

Preference rank of species: Based on preference of certain fodder plants by the grazing livestock over other plants, three priority ranks were identified by the informants. Out of 115 fodder plants, 44% species were high priority desirable species for animals, while 32% species had medium priority for the feeding animals. The low priority fodder plants constituted 28 species (24%) (Fig. 6).

Pair-wise comparison (PC): For the pairwise comparison (PC), top 15 fodder species with highest frequency of citations were selected, and 15 key informants voted between each pair of species. *Avena fatua* ranked 1st with 25 points, followed by *Echinochloa crus-galli* (2nd, 24 points), *Brachiaria ramosa* (3rd, 23 points), *Phaceleurus speciosus, Melia azedarach, Avena sterilis, Setaria pumila, Morus nigra, Medicago polymorpha*, and *Alopecurus myosuroides* ranked 4th to 10th respectively (Table 3). Similar studies to select priority fodder species were also done in other parts of Pakistan, like Harun *et al.*, (2017) in Central Punjab and Shaheen *et al.*, (2020) in Thal desert.

Preference of a fodder by kind of animals: In total, 115 fodder species, 92 species are grazed and browsed by goats, followed by cows that feed on 88 species, and buffalos on 70 species. Sheep usually graze on grasses and herbs 58 species, donkeys were found eating 27 of the reported species and camel feed on 38 species (Table 2, Fig. 8). It was found that cow, buffalo, sheep and goats share most of the fodder species (13), cow and buffalos share 10 species, goat and sheep share 9 species, while camel and goat share 7 species and camel, sheep and goat share 7 species. Similar results were reported by Harun *et al*., (2017) and found that cow grazed on 35% and buffalo, cow, sheep and goat shared 75% of the grasses in their study.

Table 3. Pairwise Comparison (PC) ranking of top priority fodder species identified by the informants.

S#	Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Points scored	Rank
1.	*Avena fatua*	-	0	1	2	2	2	2	2	2	2	2	2	2	2	2	25	1st
2.	*Brachiaria ramosa*	2	-	1	2	2	2	2	2	2	1	2	2	2	1	2	23	3rd
3.	*Echinochloa crus-galli*	1	1	-	2	2	2	2	2	2	1	2	2	2	2	2	24	2nd
4.	*Morus nigra*	0	0	0	-	1	2	1	2	1	0	1	1	2	0	1	12	8th
5.	*Ailanthus altissima*	0	0	0	1	-	1	1	1	1	0	2	1	1	0	1	10	10th
6.	*Setaria pumila*	0	0	0	0	1	-	1	2	2	1	2	1	2	1	2	15	6th
7.	*Medicago polymorpha*	0	0	0	1	1	1	-	2	2	1	1	0	1	0	1	11	9th
8.	*Bromus pectinatus*	0	0	0	0	1	0	0	-	1	1	0	0	1	0	1	5	15th
9.	*Aesculus indica*	0	0	0	1	1	0	0	1	-	1	1	0	1	0	1	7	13th
10.	*Avena sterilis*	0	1	1	2	2	1	1	1	1	-	1	1	1	1	1	15	6th
11.	*Cymbopogon jwarancusa*	0	0	0	1	0	0	1	2	1	1	-	0	1	2	1	10	10th
12.	*Melia azedarach*	0	0	0	1	1	1	2	2	2	1	2	-	2	1	1	16	5th
13.	*Lolium temulentum*	0	0	0	0	1	0	1	1	1	1	1	0	-	0	0	6	14th
14.	*Phacelurus speciosus*	0	1	0	2	2	1	2	2	2	1	0	1	2	-	2	18	4th
15.	*Alopecurus myosuroides*	0	0	0	1	1	0	1	1	1	1	1	1	2	0	-	10	10th

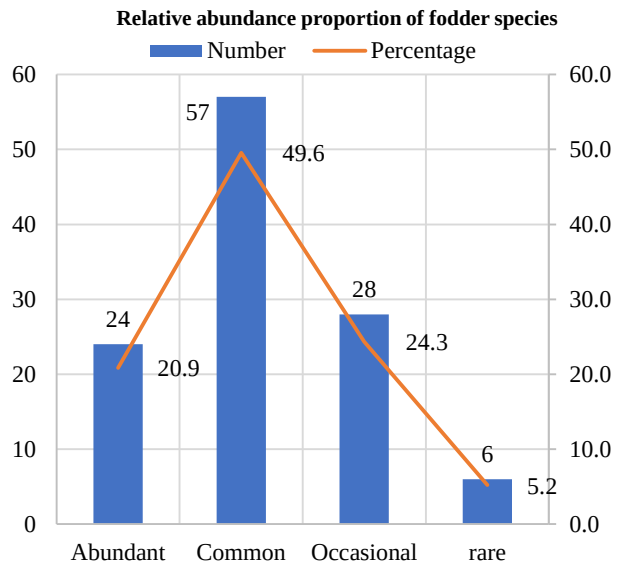

Fig. 5. Abundance scale of fodder species.

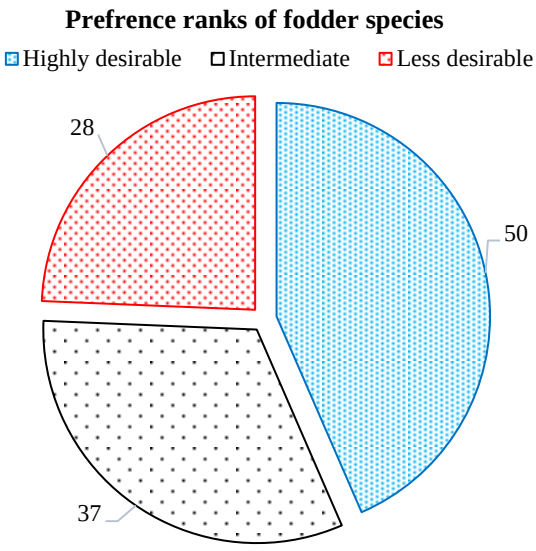

Fig. 6. Preference rank of the fodder species.

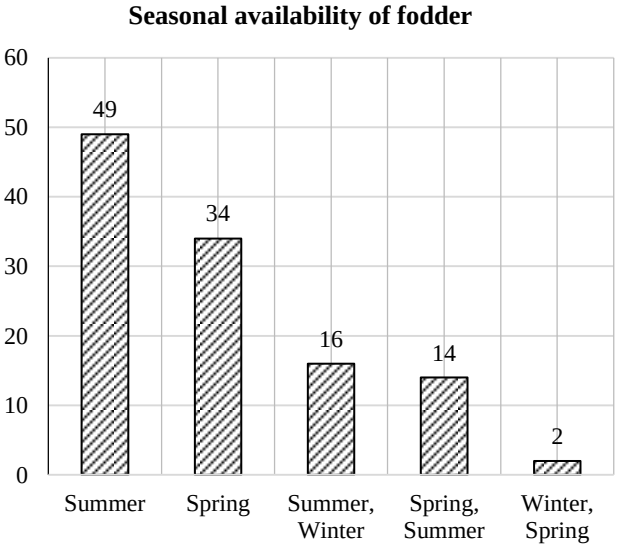

Fig. 7. Seasonal availability of fodder plants in Buner.

Mode of utilization of fodder plants: Depending upon the mode of utilization of fodder by the grazing livestock, majority (71%) fodder plants are used in fresh conditions, whereas 28% are used in both fresh and dry condition, and only one species is utilized only in dry condition.

Abundance scale: The distribution and abundance of fodder species was not uniform in the area. Some species were abundant weeds, others were very specific and confined only to certain places. On the basis of abundance out of 115 species 50% species were common in the area, 24% were occasional, 30% were abundant and 6% were rare (Table 2). Most of the abundant and common species were also among the most cited and preferred species, because their abundance and availability make them a good choice for the livestock keeper. Some of the most abundant fodder plants were *Brachiaria ramosa, Avena fatua, Melia azedarach, Morus nigra, Setaria pumila, Echinochloa crus-galli, Robinia pseudoacacia, Sorghum halepense* and *Poa annua.* The rare species cited were *Vicia monantha* and *Lathyrus cicero* (Fig. 5).

Relative frequency of citation (RFC): Based on RFC values *Avena fatua, Brachiaria ramosa, Echinochloa crus-galli, Morus nigra, Ailanthus altissima,* were top five fodder plants with RFC values of 0.85, 0.82, 0.76, 0.76 and 0.71, respectively. The greater citation reports of these species were due to their high frequency and abundance. The grasses are weedy in nature and abundant in and around agriculture fields in spring and summer. While *M. nigra* and *A. altissima* are often planted around homes, gardens, around agriculture fields and on slopes in foothills, both as fuelwood and for goat's fodder. Inam-ur-Rahim *et al.*, (2011) and Shinwari & Gilani (2003) have also reported these trees in similar habitat. Fortyfour fodder plants have RFC values more than 0.3 or 30% which shows that informants have rich knowledge about utilization of diverse number of fodder species (Table 2).

Conclusion

Indigenous people associated with livestock rearing have rich knowledge about the characteristics and preference of fodder species for different kinds of animals. This rich and at the same time threatened knowledge is very valuable in the development of strategies for sustainable fodder/forage resources in rural mountainous settings. This research has identified some high priority grasses and trees like *Avena fatua, Echinochola cruss-galli, Brachiaria ramosa, Morus nigra, Melia azedarach* and *Aesculus indica* that can be grown on rangeland, waste places, forests slopes, around gardens and agriculture fields to subside the shortage and poor quality of fodder, particularly in dry periods and winters. The indigenous livestock rearing communities possess valuable traditional knowledge with substantial implications for prioritizing wild fodder/forage species, for sustainable livestock raising by rural pastoralists and domestic livestock owners.

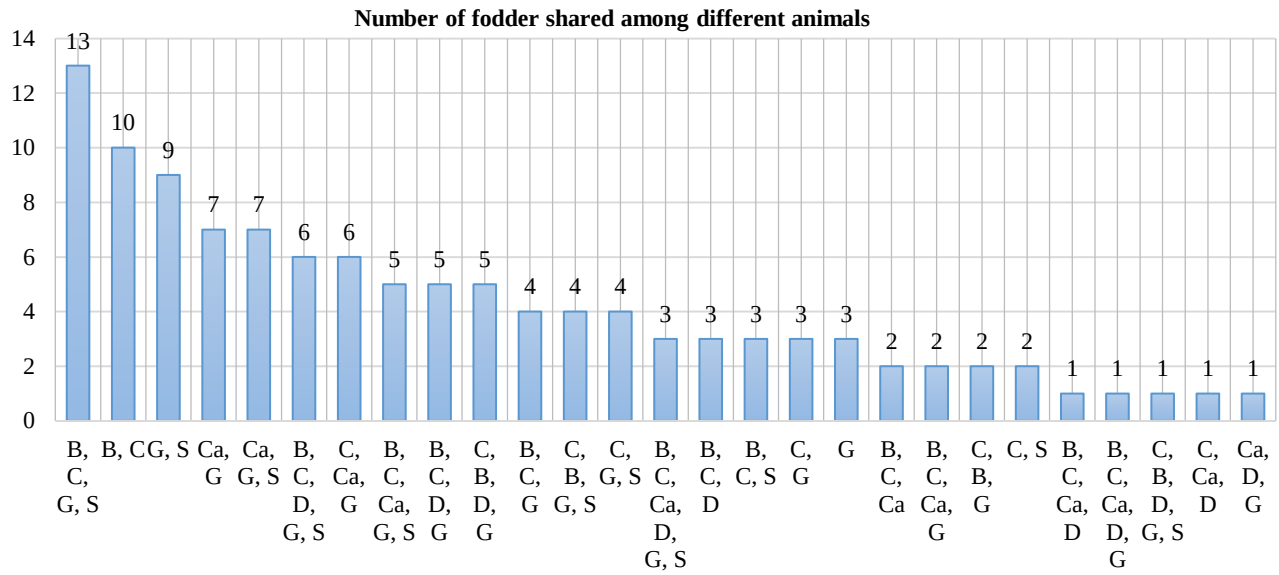

Fig. 8. Fodder species palatable to different livestock animals.

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