Palatability status and animals' preferences of forage plants in Pashat Valley, Pak-Afghan border, District Bajaur, Pakistan

Aminul Haq and Lal Badshah

Correspondence

Aminul Haq[1,2*] and Lal Badshah[1]

[1]Phytoecology Lab. Department of Botany, University of Peshawar, Pakistan
[2]Department of Botany, Govt. Post Graduate College Khar, District Bajaur, Pakistan

[*]Corresponding Author: aminulhaq.bot@gmail.com

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Research

Abstract

Background: The phytodiversity of a given region provide a variety of services to human and their livestock such as food, feed and medicines. The livestock's preference and nutritional requirement are quantified by the plants' palatability. The present study is the first attempt to record the palatable status of plant resources in the area.

Objectives: The objective of this study was to assess the palatability of the flora and the preference of grazing and browsing animals in the Pashat Valley Bajaur, Khyber Pakhtunkhwa, Pakistan.

Methods: An investigation survey with frequent visits to the research area in different seasons was conducted to record the palatability status of plant resources through visual observations of grazing animals.

Results: The flora of Pashat Valley consists of 385 species belonging to 292 genera and 100 families. Based on habit, there were 289 species of herbs, 54 shrubs, 38 trees and 4 lianas. Of the recorded species, 98 species were non-palatable, 95 species were moderately palatable, 78 species were highly palatable, 60 species were less palatable and 54 species were rarely palatable. The animals preferred 187 plant species in fresh form while 92 species in both fresh and dry forms. Goats and sheep were found the prefer the majority of plant species. The seasonal availability reveals that most of the species grew in the spring (40.65 %) and summer (34.48%) seasons in the area.

Conclusion: It was concluded that the area has a diverse flora with a rich source of palatable plants. Several variables influence the palatability such as plant morphology, phenology and chemical nature of plants. The documented data explore the palatability status which will act as the foundation for subsequent research into the nutritional components of the palatable plants that will be used as animal feed by the locals to satisfy their nutritional requirements.

Keywords: Palatability, animals' preference, grazing, browsing

Background

Every grazing animal chooses its food from a diverse range of plants that depend on the animal-plant relationship in their natural habitat (Fraser *et al*. 2022). This relationship is often termed palatability and animal preference. Palatability is the delight with which plants or their parts are consumed as determined by the stimulation of sensory impulses of graining

animals (Kochare *et al*. 2018). It is very difficult to define palatability in terms of biological processes because it involves the selection of food. Botanists define palatability as the availability of a plant species, its chemical composition and structure on rangeland or in a pasture while zoologists describe it as the degree to which animals like a forage, based on its flavor (Burritt 2011). National Research Council's guidelines (2006) defined palatability as the physical and chemical features of food that promote or suppress feeding behaviors in the pre-absorptive or post-absorptive period. As commonly used, the term implies acceptability but not necessarily desirability. Thus, palatable foodstuff may be essentially neutral concerning preference, being neither attractive nor repellent to the taste (Molyneux and Ralphs 1992). Palatable plants are susceptible to grazing, trampling, irregular and unreliable rainfall, short growing seasons and eroded exposed steep soil (Amjad *et al*. 2014). As a result of overgrazing, palatable species have been reduced and replaced by non-palatable ones (Cipriotti *et al*. 2019).

Animal factors like the differential preference for forage species, hunger, health, period and stage of pregnancy affected the palatability (Khan and Hussain 2012). At the same time, plant factors such as seasonal availability of plants, stage of growth, maturity, phenology, chemical nature and morphology also influence palatability (Amjad *et al.* 2014). Preference is described as " what animals choose given the simplest physical limitations" (Parsons *et al*. 1994), whereas selection is defined as "preference altered by environmental factors" (Hodgson 1979). In other words, preference is the animal's desire for what an animal has to eat and selection is eating due to certain restrictions (Rutter 2006). Different animals choose various plant species and their parts as food (Hussain and Durrani 2009).

Range management strategies are influenced by a variety of elements, including plant preference value, range health and capacity, estimation of available forage, conservation of palatable species and their long-term utilization (Ahmadi *et al*. 2013). Generally, cattle select their food from specific plant species and they do not graze readily available forage (Baghestani *et al*. 2001). The current study aimed to determine the palatability and animal preferences of Pashat Valley, the Pak-Afghan border, Bajaur, which had never been evaluated previously. The expected outcomes of the study will help the ecologist in recommending strategies for the development of this region and other parts of the country.

Materials and Methods

Study Area

The Pashat Valley is located in the North-West of the tribal district Bajaur at 34°51'55.69 N latitude and 71°31'28.30 E longitude. The elevation of the valley ranges from 1065 to 3257 m (Figure 1). The valley consists of lush green high mountains that form the border with the Kunar province of Afghanistan. There is a famous spring in the valley, the Gabar Spring (Gabar Chena in the local language) which attracts tourists in the summer season. This area has diverse types of vegetation. The irrigated agriculture lands are confined to the bottom and adjoining gentle slopes of the valley. The most popular cultivated crops in the area are paddy (Rice). The average annual rainfall is about 500 mm, with 375 mm falling mostly in the months of July and August in the form of Monsoon rains. Geographically, the research area is located in the Hindukush mountain range, which shows significant variation and uncertainty in the pattern of monsoon rains from year to year. The mean temperature during winter ranged from 5 ℃ to 10 ℃. Usually in the winter, mountain tops are capped with snow while the mean summer temperature varies from 26 ℃ to 40 ℃ (Haq and Badshah 2021).

Survey of the area and monitor sites

An investigation survey was conducted from March 2018 to October 2020 in the different sites of the valley. The specific site position was determined with the help of GPS (Global Positioning System) and the geographic coordinates for latitude, longitude and altitude were taken from each site (Table 1).

Data collection

The research area was frequently visited to collect data on palatability through observing grazing and browsing animals and conducting interviews with sheepherders and villagers. For identification of palatable plant species, all the species of the area were collected, identified with the flora of Pakistan (Ali and Qaiser 1995-2018) and then verified with the Plants of World Online (https://powo.science.kew.org/). The information from the local inhabitants was collected through questionnaires. The collected information was confirmed with available published literature (Hussain and Durrani 2009; Amjad *et al.* 2014; Abdullah *et al.* 2017; Geng *et al.* 2017; Haq and Badshah 2021; Hussain *et al.* 2023). The specimens were then submitted to the Herbarium of Botany PUP, University of Peshawar.

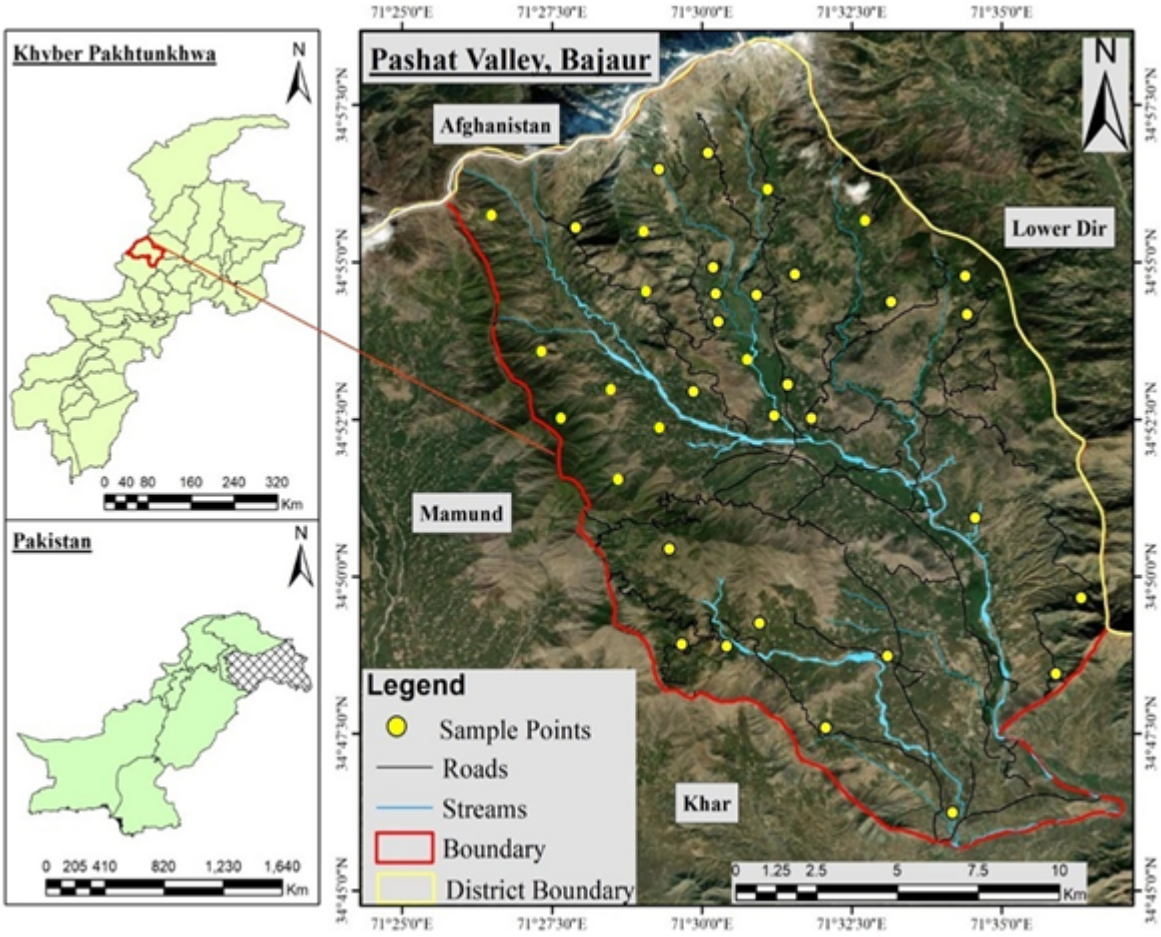

Figure 1. Map of the area

Table 1. Location of survey sites Pashat Valley, Bajaur

Mean Rainfall **Annual Rain fall= 500mm** **Moonson Rainfall= 375mm**		**Mean Annual Temperature** **Winter= 5℃ -10℃** **Summer= 26℃ -40℃**	
Site Name	**Altitude (Ft)**	**Latitude**	**Longitude**
Bagandel	6240	34˚56'25"	71˚31'23"
Tarano	6234	34˚55'34"	71˚33'02"
Batwar	6156	34˚56'20"	71˚29'40"
Gabar	4775	34˚54'41"	71˚29'32"
Saro Wano	5460	34˚55'30"	71˚25'45"
Mala Said	4611	34˚51'29"	71˚28'59"

Palatability

The collected plants were classified into the palatability classes (Hussain and Durrani 2009) which are given below.

- Highly palatable (HP): Plants that are mostly preferred by the grazing animals.
- Moderately palatable (MP): Plants that are moderately grazed by animals.
- Rarely palatable (RP): Plants that are grazed by animals when no choice is available.
- Less palatable (LP): Plants that are less grazed by the animal as the first choice.
- Non-palatable (NP): Plants that are not grazed by animals at any stage of growth.

Parts of plants consumed and their condition

Based on animal preference, the palatable plant species were then further classified into consumed parts (Whole plant, Aerial part and leaves). The consumed parts are further classified based on their condition into fresh, dry, or both.

Seasonal availability of plants

For determination of seasonal availability and abundance of the plants were recorded in the field survey (Hussain and Durani 2009, Badshah *et al*. 2016; Haq and Badshah 2021).

Data management and analysis

The collected data of the field survey were further analyzed using descriptive statistics, summarized and presented in tables and figures using Microsoft Excel 2016.

Results and Discussion

Phytodiversity and palatability status

The phytodiversity of Pashat Valley is comprised of 385 species belonging to 292 genera and 100 families. Among the total species, 289 were herbs, 54 shrubs, 38 trees and 04 lianas. Based on palatability status, plants were classified into five classes i.e. highly palatable, moderately palatable, less palatable, rarely palatable and non-palatable. The results revealed that out of 385 species, 98 species (25.52%) were non-palatable (Table 2). The common non-palatable species were *Chenopodium botrys*, *Euphorbia helioscopia*, *Parthenium hysterophorus*, *Persicaria hydropiper*, *Daphne mucronata*, *Dodonaea viscosa, Justicia adhatoda*, *Nerium oleander, Ricinus communis* and *Sarcococca saligna*, *Alnus nitida, Pinus roxburghii* and *Pinus wallichiana*. In these non-palatable species, the *Arisaema flavum* is one of the poisonous herbaceous plants that kill livestock when ingested while *Urtica dioica* irritates the body of cattle and humans when touched. Castor oil, which is extracted from the seeds of the *Ricinus communis* plant, is used to treat edema and as a laxative (Bahadur *et al.* 2020). However, the odour of the fresh leaves might make people cough and sneeze. Some of the non-palatable plants such as *Euphorbia helioscopia, Ricinus communis* and *Nerium oleander* are considered poisonous and toxic to humans and livestock but contain bioactive chemicals that can be exploited as a source of medicine (Naveed *et al.* 2018; Rasool *et al.* 2022). Morphological characteristics of plant parts, growth stages and chemical composition influenced acceptability which may stimulate or inhibit animals from grazing. The non-palatable plants contain chemical compounds such as alkaloids, phenolics and tannins that are toxic, bitter, or simply unpleasant to herbivores preventing them from grazing (Molyneux and Ralphs 1992). Some plants are unattractive to herbivores because of their physical features, such as thorns, spines, awans, leaf hair, or waxes which deter them from grazing and browsing (Lyons and Hanselka 2001). While other non-palatable species have low nutritional value or lack essential elements that herbivores need (Provenza *et al.* 2007).

Plant palatability is linked to the chemical composition of plant parts, as well as morphology, phenology, availability, plant growth stages and degree of maturity (Hussain and Durrani 2009; Yin *et al*. 2017). The presence of bioactive compounds in the plants is also linked with their therapeutic significance which is used for the treatment of human and livestock diseases (Abdullah *et al*. 2017; Jan *et al.* 2021; Haq *et al*. 2022; Hussain *et al.* 2023; Singh *et al.* 2023). The active compounds differ among plant parts and as a result, the same plant parts can be used for multiple purposes (Jan *et al.* 2021; Mir *et al.* 2022).

Table 2. Non-Palatable flora of Pashat Valley, Bajaur

Family/ Botanical name	**Habit**	**Parts used**	**Palatability class**	**Plant condition**	**Animal preference**
Pteridophytes					
1. Pteridaceae					
Cheilanthes pteridioides (Reichard) C. Chr.	Hb	-	Np	-	-
2. Selaginelleaceae					
Selaginella sanguinolenta (L.) Spring.	Hb	-	Np	-	-
Gymnosperms					
3. Pinaceae					
Pinus roxburghii Sargent	T	-	Np	-	-
Pinus wallichiana A.B. Jackson.	T	-	Np	-	-
Angiosperms					
4. Amayllidaceae					
Narcissus tazzetta L.	Hb	-	Np	-	-
5. Cyperaceae					
Erioscirpus comosus (Wall.) Palla	Hb	-	Np	-	-
Fimbristylis dichotoma (L.) Vahl.	Hb	-	Np	-	-
6. Iridaceae					

Iris aitchisonii (Baker) Boiss.	Hb	-	Np	-	-
7. Liliaceae					
Notholirion thomsonianum (Royle) Stapf.	Hb	-	Np	-	-
8. Orchidaceae					
Cephalanthera longifolia (L.) Fritsch.	Hb	-	Np	-	-
Epipactis veratrifolia Boiss. & Hohen	Hb	-	Np	-	-
9. Palmae					
Nannorrhops ritchiana H. Wendl.	Sb	-	Np	-	-
10. Poaceae					
Aristida cyanantha Nees ex Steud.	Hb	-	Np	-	-
Hyparrhenia hirta (L.) Stapf,	Hb	-	Np	-	-
Saccharum rufipilum Steud.	Hb	-	Np	-	-
11. Typhaceae					
Typha angustifolia Bory & Chaub	Hb	-	Np	-	-
12. Acanthaceae					
Justicia adhatoda L.	Sb	-	Np	-	-
Strobilanthes glutinosus Nees	Hb	-	Np	-	-
13. Amaranthaceae					
Chenopodium botrys L.	Hb	-	Np	-	-
14. Apocynaceae					
Nerium oleander L.	Sb	-	Np	-	-
15. Aracaceae					
Arisaema flavum (Forsk.) Schott	Hb	-	Np	-	-
16. Asteraceae					
Carduus edelbergii Rech. f.	Hb	-	Np	-	-
Centaurea benedicta L.	Hb	-	Np	-	-
Cirsium arvense (L.) Scop.	Hb	-	Np	-	-
Cirsium vulgare (Savi) Ten.	Hb	-	Np	-	-
Echinops cornigerus DC., Prodr.	Hb	-	Np	-	-
Filago hurdwarica (Wall. ex DC) Wagenitz	Hb	-	Np	-	-
Parthenium hysterophorus L.	Hb	-	Np	-	-
Pseudognaphalium luteoalbum (L.) Hilliard & B.L.Burtt	Hb	-	Np	-	-
Tagetes minuta L.	Hb	-	Np	-	-
Xanthium spinosum L.	Hb	-	Np	-	-
Xanthium strumarium L.	Hb	-	Np	-	-
17. Betulaceae					
Alnus nitida (Spach) Endl.	T	-	Np	-	-
18. Boraginaceae					
Anchusa arvensis (L.) Bieb.	Hb	-	Np	-	-
Buglossoides arvensis (L.) Johnston	Hb	-	Np	-	-
Heliotropium europaeum L.	Hb	-	Np	-	-
Onosma dichroantha Boiss.	Hb	-	Np	-	-
19. Brassicaceae					
Arabidopsis wallichii (Hook.f. & Thomson) N. Busch	Hb	-	Np	-	-
Coronopus didymus (L.), Smith.	Hb	-	Np	-	-
Lepidium apetalum Willd.	Hb	-	Np	-	-
Lepidium pinnatifidum Ledeb.	Hb	-	Np	-	-
20. Buddlejaceae					
Buddleja crispa Benth.	Sb	-	Np	-	-
21. Buxaceae					
Sarcococca saligna (D. Don) Muell.	Sb	-	Np	-	-
22. Campanulaceae					
Campanula pallida Wall.	Hb	-	Np	-	-
23. Caryophyllaceae					
Cerastium glomeratum Thuill.	Hb	-	Np	-	-
24. Crassulaceae					
Pistorinia hispanica (L.) DC., Prodr.	Hb	-	Np	-	-
25. Cucurbetaceae					
Citrullus colocynthis (L.) Schrad.	Hb	-	Np	-	-
26. Euphorbiaceae					

Andrachne cordifolia L.	Sb	-	Np	-	-
Euphorbia cognata (Klotzsch & Garcke) Boiss.	Hb	-	Np	-	-
Euphorbia serpens Kunth.	Hb	-	Np	-	-
Euphorbia thymifolia L.	Hb	-	Np	-	-
Ricinus communis L.	Sb	-	Np	-	-
27. Fabaceae					
Astragalus scorpiurus Bunge	Hb	-	Np	-	-
28. Illecebraceae					
Herniaria hirsuta L.	Hb	-	Np	-	-
29. Lamiaceae					
*Clinopodium umbrosu*m (M. Bieb.) C. Koch	Hb	-	Np	-	-
Marrubium vulgare L.	Hb	-	Np	-	-
Ocimum basilicum L.	Hb	-	Np	-	-
Phlomis spectabilis Falc. ex Benth.	Hb	-	Np	-	-
Salvia moorcroftiana Wall. ex Benth.	Hb	-	Np	-	-
Scutellaria linearis Benth.	Hb	-	Np	-	-
Stachys parviflora Benth.	Hb	-	Np	-	-
Teucrium royleanum Wall. ex Benth.	Hb	-	Np	-	-
Teucrium stocksianum Boiss.	Hb	-	Np	-	-
Thymus linearis Benth. ex Wall.	Hb	-	Np	-	-
30. Linaceae					
Reinwardtia trigyna (Roxb.) Planch.	Sb	-	Np	-	-
31. Myrtaceae					
Eucalyptus camaldulensis Dehnh.	T	-	Np	-	-
32. Nyctaginaceae					
Mirabilis jalapa L.	Hb	-	Np	-	-
33. Oleaceae					
Jasminum grandiflorum L.	Sb	-	Np	-	-
Jasminum humile L.	Sb	-	Np	-	-
34. Papaveraceae					
Hypecoum pendulum L.	Hb	-	Np	-	-
Papaver dubim L.	Hb	-	Np	-	-
Papaver pavoninum Schrenk	Hb	-	Np	-	-
Papaver rhoeas L.	Hb	-	Np	-	-
Papaver sominiferum L.	Hb	-	Np	-	-
35. Plantaginaceae					
Misopates orontium (L.) Raf.	Hb	-	Np	-	-
Veronica anagallis-aquatica L.	Hb	-	Np	-	-
36. Polygonaceae					
Persicaria glabra (Wild.) M. Gomes.	Hb	-	Np	-	-
Persicaria hydropiper (L.) Spach	Hb	-	Np	-	-
37. Ranunculaceae					
Delphinium ajacis (L.) Schur	Hb	-	Np	-	-
Ranunculus arvensis L.	Hb	-	Np	-	-
Thalictrum pedunculatum Edgew.	Hb	-	Np	-	-
38. Rosaceae					
Rubus ellipticus (Franch.) Thuan.	Sb	L	Np	-	-
39. Rubiaceae					
Kohautia aspera (Roth) Bremek.	Hb	-	Np	-	-
40. Sapindaceae					
Dodonaea viscosa (L.) Jacq.	Sb	-	Np	-	-
41. Scrophulariaceae					
Scrophularia stenothyrsa Pennell,	Hb	-	Np	-	-
42. Solanaceae					
Cestrum elegans (Brongn. ex Neumann) Schltdl.	Sb	-	Np	-	-
Datura fastuosa L.	Hb	-	Np	-	-
Datura innoxia Mill.	Sb	-	Np	-	-
Datura stramonium L.	Sb	-	Np	-	-
Physalis divaricata D. Don.	Hb	-	Np	-	-
Withania somnifera (L.) Dunal.	Sb	-	Np	-	-

43. Thymelaeaceae					
Daphne mucronata Royle	Sb	-	Np	-	-
Daphne papyracea Wall. ex Steud.	Sb	-	Np	-	-
44. Umbelliferae					
Eryngium coeruleum M. Bieb.	Hb	-	Np	-	-
Torilis leptophylla (L.) Reichb. f.	Hb	-	Np	-	-
45. Urticaceae					
Parietaria lusitanica L.	Hb	-	Np	-	-
Urtica dioica L.	Hb	-	Np	-	-
46. Verbenaceae					
Vitex negundo L.	Sb	-	Np	-	-

Key: NP= Non-Palatable, Hb= Herb, Sb= Shrub, T= Tree

Geographical distribution, climate and local ecological circumstances have a significant influence on the availability of palatable plants (Godde *et al.* 2021). In the present study, 95 species were documented as moderately palatable and 78 species were highly palatable (Table 3). The moderately and highly palatable species were composed of herbs, shrubs and trees. The palatable herbaceous plants included *Avena fatua, Erigeron canadensis*, *Cynodon dactylon*, *Cyperus niveus*, *Eragrostis minor*, *Launaea nudicaulis*. Among the shrubby species, *Berberis lycium*, *Gymnosporia royleana, Rubus fruticosus*, *Sageretia thea*, *Ziziphus oxyphylla* were found highly palatable, whereas the most common palatable trees species were *Morus alba, Morus nigra, Ailanthus altissima, Populus nigra, Quercus baloot, Quercus incana, Melia azedarach, Ziziphus jujuba* and *Olea europea.* The moderately palatable species whose number was 99, include *Fimbristylis cymosa, Bromus pectinatus*, *Cymbopogon distans*, *Hedera nepalensis*, *Tetrapogon villosus*, *Eruca vesicaria*, *Nasturtium officinale* and *Otostegia limbata.* The less palatable species were 60 (15.63%), while 54 species (14.06%) were rarely palatable (Figure 2). The majority of the palatable plants were herbaceous, and the animals preferred them for their varying degrees of palatability while the non-palatable plants had unpleasant tastes and odours due to the presence of poisonous chemicals (Khan and Hussain 2012).

Table 3. Palatable flora of Pashat Valley, Bajaur

Family/Botanical name	**Habit**	**Parts used**	**Palatability class**	**Plant condition**	**Animal preference**
Pteridophytes					
1. Adiantaceae					
Adiantum capillus-veneris L.	Hb	Wp	Rp	F	Goat
Adiantum caudatum (L.) Mant.	Hb	Wp	Rp	F	Goat
Adiantum incisum Forssk.	Hb	Wp	Rp	F	Goat
2. Athyriaceae					
Athyrium rupicola (Edgew. ex C. Hope) C. Chr.	Hb	L	Lp	F	Goat
3. Aspleniaceae					
Asplenium ceterach L.	Hb	L	Lp	F	Goat
Asplenium dalhousieae Hook.	Hb	L	Lp	F	Goat
4. Equisetaceae					
Equisetum arvense L.	Hb	L	Rp	F	Goat
5. Pteridaceae					
Pteridium aquilinum (L.) Kuhn.	Hb	Ap	Lp	F	Goat
Pteris cretica L.	Hb	Ap	Rp	F	Goat
Gymnosperms					
Angiosperms					
6. Alliaceae					
Allium griffithianum Boiss.	Hb	L	Mp	F,D	Goat, sheep, cow, buffalo
7. Amayllidaceae					
Ixiolirion tataricum (Pall.) Herb.	Hb	Ap	Rp	F	Goat, sheep
8. Asparagaceae					
Asparagus gracilis Royle	Hb	Wp	Lp	D	Goat, sheep
Asparagus officinalis Wall.	Hb	Wp	Lp	D	Goat, sheep
9. Asphodalaceae					

Eremurus himalaicus Baker.	Hb	Ap	Lp	F	Goat
10. Commelinaceae					
Commelina benghalensis L.	Hb	Ap	Lp	F,D	Goat, sheep, cow, buffalo
11. Cyperaceae					
Cyperus niveus Retz.	Hb	Ap	Hp	F	Goat, sheep, cow, buffalo
Cyperus rotundus L.	Hb	Wp	Hp	F,D	Goat, sheep, cow, buffalo
Fimbristylis cymosa R. Br.	Hb	Wp	Mp	F,D	Goat, sheep, cow, buffalo
12. Iridaceae					
Iris germanica L.	Hb	Wp	Rp	F	Goat
Moraea sisyrinchium (L.) Ker Gawl.	Hb	L	Rp	F	Goat, sheep, cow, buffalo
13. Liliaceae					
Tulipa clusiana DC.	Hb	Wp	Mp	F	Goat, sheep, cow, buffalo
14. Orchidaceae					
Microstylis wallichii Lindl.,	Hb	L	Rp	F	Goat
15. Poaceae					
Acrachne racemosa Heyne ex Roem & Schult	Hb	Wp	Hp	F,D	Goat, sheep, cow, buffalo
Agrostis viridis (Gouan) Hort.	Hb	Ap	Lp	F	Goat, sheep
Apluda mutica L.	Hb	Wp	Hp	D	Goat, sheep, cow, buffalo
Arthraxon prionodes (Steud.) Dandy	Hb	Wp	Lp	F	Goat, sheep, cow, buffalo
Avena fatua L.	Hb	Wp	Hp	F	Goat, sheep, cow, buffalo
Brachiaria ramosa (L.) Stapf.	Hb	Wp	Hp	F,D	Goat, sheep, cow, buffalo
Bromus japonicus Thunb. ex Murrr	Hb	Wp	Hp	F,D	Goat, sheep, cow, buffalo
Bromus pectinatus Thunb.	Hb	Wp	Mp	F	Goat, sheep, cow, buffalo
Cenchrus ciliaris L.	Hb	Wp	Hp	F,D	Goat, sheep, cow, buffalo
Chrysopogon serrulatus Trin.	Hb	Wp	Lp	F	Goat, sheep, cow, buffalo
Cymbopogon distans Nees ex Steud.	Hb	Wp	Mp	F,D	Goat, sheep, cow, buffalo
Cynodon dactylon (L.) Pers.	Hb	Wp	Hp	F,D	Goat, sheep, cow, buffalo
Dactyloctenium aegyptium (L.) Willd	Hb	Wp	Rp	D	Goat, sheep
Desmostachya bipinnata (L.) O. Ktze.	Hb	L	Mp	F,D	Goat, sheep, cow, buffalo
Dichanthium annulatum (Frossk) Stapf.	Hb	Wp	Hp	F,D	Goat, sheep, cow, buffalo
Digitaria ciliaris (Retz) Koeler	Hb	Wp	Mp	F,D	Goat, sheep, cow, buffalo
Echinochloa colona (L.) Link	Hb	Wp	Mp	F,D	Goat, sheep, cow, buffalo
Eragrostis minor Host	Hb	Wp	Hp	F,D	Goat, sheep, cow, buffalo
Eragrostis papposa (Roem & Schult.) Steud.	Hb	Wp	Lp	F,D	Goat, sheep
Heteropogon contortus (L.) P. Beauv. ex. Roem & Schult.	Hb	Wp	Lp	F,D	Goat, sheep, cow, buffalo
Hordeum murinum L.	Hb	Ap	Rp	F,D	Goat
Hordeum vulgare L.	Hb	Wp	Hp	F	Goat, sheep, cow, buffalo

Oryza sativa L.	Hb	L	Mp	F,D	Goat, sheep, cow, buffalo
Pennisetum orientale Rich.	Hb	Ap	Mp	F	Goat, sheep, cow, buffalo
Phalaris minor Retz	Hb	L	Mp	F	Goat, sheep, cow, buffalo
Phalaris paradoxa L.	Hb	L	Mp	F	Goat, sheep, cow, buffalo
Phragmites communis Trin.	Hb	L	Lp	F	Goat
Poa annua L.	Hb	L	Mp	F	Goat, sheep, cow, buffalo
Rostraria cristata (L.) Tzvelev.	Hb	L	Lp	F	Goat, sheep
Saccharum spontaneum L.	Hb	L	Mp	F	Goat
Setaria pumila (Poir.) Roem. & Schult	Hb	L	Mp	F	Goat, sheep, cow, buffalo
Sorghum halepense (L.) Pres.	Hb	Ap	Mp	F,D	Goat, sheep, cow, buffalo
Tetrapogon villosus Desf.	Hb	L	Mp	F,D	Goat, sheep, cow, buffalo
Triticum aestivum L.	Hb	Wp	Mp	F,D	Goat, sheep, cow, buffalo
Zea mays L.	Hb	Wp	Hp	F.D	Goat, sheep, cow, buffalo
16. Acanthaceae					
Barleria cristata L.	Hb	L	Mp	F	Goat, sheep, cow, buffalo
Dicliptera bupleuroides Nees	Hb	Wp	Lp	F	Goat, sheep
17. Amaranthaceae					
Achyranthes aspera L.	Hb	L	Mp	F	Goat, sheep, cow, buffalo
Achyranthes bidentata Blume	Hb	L	Lp	F	Goat, sheep
Alternanthera pungens Kunth.	Hb	L	Mp	F	Goat, sheep, cow, buffalo
Amaranthus spinosus L.	Hb	Wp	Hp	F	Goat, sheep, cow, buffalo
Amaranthus viridis L.	Hb	Wp	Hp	F	Goat, sheep, cow, buffalo
Atriplex lasiantha Boiss.	Hb	L	Rp	F	Goat, sheep
Chenopodium album L.	Hb	L	Hp	F,D	Goat, sheep, cow, buffalo
Chenopodium murale L.	Hb	Ap	Lp	F	Goat
Digera muricata (L.), Mart.	Hb	Wp	Hp	F	Goat, sheep, cow, buffalo
18. Anacardiaceae					
Pistacia chinensis Bunge	T	L	Lp	F	Goat, sheep
19. Araliaceae					
Hedera nepalensis K. Koch	Sb	L	Mp	F	Goat, sheep, cow, buffalo
20. Asclepiadaceae					
Calotropis procera (Ait.) Ait.f.	Sb	L	Rp	F	Goat, sheep
Caralluma tuberculata N. E. Brown	Hb	Ap	Hp	F,D	Goat, sheep, cow, buffalo
Periploca aphylla Dcne.	Sb	Ap	Hp	F	Goat, sheep, cow, buffalo
Vincetoxicum arnottianum (Wight) Wight	Hb	Wp	Rp	F	Goat
21. Asteraceae					
Artemisia maritima L.	Sb	Ap	Rp	F	Goat
Artemisia scoparia Waldst. & Kit.	Hb	Wp	Lp	F	Goat, sheep
Artemisia vulgaris L.	Hb	Ap	Mp	F	Goat, sheep, cow, buffalo
Bidens pilosa L.	Hb	L	Rp	F	Goat, sheep

Bidens tripartita L.	Hb	Ap	Rp	F	Goat, sheep, cow, buffalo
Calendula arvensis L.	Hb	Wp	Lp	F	Goat, sheep, cow, buffalo
Carthamus oxyacantha M. Bieb.	Hb	L	Rp	F	Goat, sheep
Cichorium intybus L.	Hb	Wp	Mp	F,D	Goat, sheep, cow, buffalo
Cousinia prolifera Jaub & Spach.	Hb	L	Rp	F	Goat, sheep
Dendranthema indicum (L.) Des Moul.	Hb	L	Lp	F	Goat, sheep, cow, buffalo
Erigeron bonariensis L.	Hb	Wp	Mp	F	Goat, sheep, cow, buffalo
Erigeron canadensis L.	Hb	Wp	Mp	F	Goat, sheep, cow, buffalo
Filago arvensis L.	Hb	Wp	Lp	F,D	Goat, sheep
Filago pyramidata L.	Hb	Wp	Lp	F	Goat, sheep
Galinsoga parviflora Cav.	Hb	Wp	Lp	F	Goat, sheep, cow, buffalo
Heteropappus altaicus (Willd.) Novopokr.	Hb	-	Rp	F	Goat
Lactuca dissecta D. Don	Hb	Wp	Hp	F,D	Goat, sheep, cow, buffalo
Lactuca serriola L.	Hb	Wp	Mp	F,D	Goat, sheep, cow, buffalo
Launaea nudicaulis (L.) Hook.f.	Hb	Wp	Mp	F,D	Goat, sheep, cow, buffalo
Matricaria aurea (Loefl.) Boiss	Hb	Wp	Rp	F	Goat, sheep
Onopordum acanthium L.	Hb	L	Rp	F	Goat
Pentanema indicum (L.) Y. Ling	Hb	L	Rp	F	Goat, sheep
Pentanema vestitum (Wall ex. DC.) Y. Ling	Hb	L	Lp	F	Goat, sheep
Phagnalon niveum Edgew.	Hb	Wp	Mp	F	Goat, sheep, cow, buffalo
Saussurea heteromalla (D. Don) Hand. Mazz.	Hb	Wp	Hp	F	Goat, sheep, cow, buffalo
Silybum marianum (L.) Gaertn	Hb	L	Lp	F	Goat, sheep
Sonchus asper (L.) Hill.	Hb	L	Hp	F	Goat, sheep, cow, buffalo
Sonchus oleraceus L.	Hb	L	Hp	F	Goat, sheep, cow, buffalo
Symphyotrichum graminifolium (Spreng.) G. L. Nesom.	Hb	Wp	Rp	F	Goat
Taraxacum officinale Webber.	Hb	L	Hp	F	Goat, sheep
Urospermum picroides (L.) Scop. ex F.W. Schmidt.	Hb	L	Lp	F	Goat, sheep
22. Aizoaceae					
Trianthema portulacastrum L.	Hb	L	Lp	F	Goat, sheep
23. Balsaminaceae					
Impatiens edgeworthii Hook. f.	Hb	L	Rp	F	Goat
24. Berberidaceae					
Berberis lycium Royle	Sb	L	Mp	F	Goat, sheep
25. Bignonaceae					
Incarvillea emodi Royle ex Lindl.	Hb	Wp	Rp	F	Goat
26. Boraginaceae					
Cynoglossum lanceolatum Forssk.	Hb	Wp	Rp	F	Goat
Nonea caspica (Willd.) G. Don.	Hb	L	Lp	F	Goat, sheep
Nonea edgeworthii A. DC.	Hb	L	Rp	F	Goat
Trichodesma indicum (L.) R. Br.	Hb	L	Rp	F	Goat
27. Brassicaceae					
Brassica campestris L.	Hb	Wp	Hp	F,D	Goat, sheep, cow, buffalo
Capsella bursa-pastoris (L.) Medik.	Hb	Wp	Hp	F,D	Goat, sheep, cow, buffalo
Cardamine impatiens L.	Hb	Ap	Lp	F	Goat, sheep

Descurainia sophia (L.) Webb & Berth.	Hb	L	Mp	F	Goat, sheep, cow, buffalo
Eruca vesicaria (L.) Cav.	Hb	L	Mp	F	Goat, sheep, cow, buffalo
Malcolmia africana (L.) R. Br. Aiton.	Hb	L	Lp	F	Goat
Nasturtium officinale R. Br.	Hb	WP	Mp	F	Goat, sheep, cow, buffalo
Neslia apiculata Fisch., C. A. Mey. & Ave-Lall.	Hb	L	Lp	F	Goat
Sisymbrium irio L.	Hb	L	Mp	F	Goat, sheep, cow, buffalo
Thlaspi arvense L.	Hb	L	Lp	F	Goat, sheep
28. Cannabaceae					
Cannabis sativa L.	Hb	L	Lp	F	Goat, sheep
29. Capparidaceae					
Cleome viscosa L.	HB	L	Rp	F	Goat
Capparis spinosa L.	Hb	L	Lp	F	Goat
30. Caprifoliaceae					
Viburnum cotinifolium D. Don.	Sb	L	Rp	F	Goat, sheep
Viburnum grandiflorum Wall. ex DC.	Sb	L	Rp	F	Goat, sheep
31. Caryophyllaceae					
Silene conoidea L.	Hb	Wp	Hp	F	Goat, sheep, cow, buffalo
Spergula arvensis L.	Hb	Wp	Mp	F	Goat, sheep, cow, buffalo
Stellaria media (L.) Vill.	Hb	Wp	Hp	F	Goat, sheep, cow, buffalo
32. Celastraceae					
Gymnosporia royleana Wall. ex M.A. Lawson.	Sb	Wp	Hp	F	Goat, sheep
33. Convolvulaceae					
Convolvulus arvensis L.	Hb	Wp	Hp	F	Goat, sheep, cow, buffalo
34. Crassulaceae					
Rosularia adenotricha (Wall. ex Edgew.) C.-A. Jansson.	Hb	Wp	Mp	F	Goat, sheep
35. Cucurbetaceae					
Cucumis melo L. subsp. *agrestis* (Naudin) Pangalo.	Hb	Wp	Mp	F	Goat, sheep, cow, buffalo
36. Cuscutaceae					
Cuscuta reflexa Roxb.	Hb	Wp	Lp	F,D	Goat, sheep
37. Dipsacaceae					
Scabiosa candollei DC., Prodr.	Hb	Wp	Mp	F,D	Goat, sheep, cow, buffalo
38. Ebenaceae					
Diospyros kaki L.	T	L	Hp	F,D	Goat, sheep, cow, buffalo
Diospyros lotus L.	T	L	Hp	F,D	Goat, sheep, cow, buffalo
39. Euphorbiaceae					
Chrozophora tinctoria (L.) A. Juss.	Hb	L	Rp	F	Goat
Euphorbia helioscopia L.	Hb	L	Rp	-	Goat, sheep, cow, buffalo
Euphorbia hirta L.	Hb	L	Hp	F,D	Goat, sheep, cow, buffalo
Euphorbia indica Lam.	Hb	L	Mp	F,D	Goat, sheep, cow, buffalo
Euphorbia prostrata Ait.	Hb	L	Mp	F	Goat, sheep, cow, buffalo
Mallotus philippensis (Lam.) Muell.	Sb	L	Mp	F	Goat, sheep, cow, buffalo
40. Fabaceae					
Argyrolobium roseum (Camb.) Jaub.	Hb	Ap	Hp	F	Goat, sheep, cow, buffalo

Astragalus grahamianus Boiss.	Hb	Wp	Mp	F	Goat, sheep, cow, buffalo
Astragalus leucocephalus Grah. ex Benth.	Hb	Wp	Mp	F	Goat, sheep, cow, buffalo
Astragalus retamocarpus Boissier & Hohen.	Hb	L	Lp	F	Goat
Atylosia scarabaeoides Benth.	Hb	L	Lp	F	Goat, sheep
Crotalaria medicaginea Lamk.	Hb	Wp	Mp	F	Goat, sheep, cow, buffalo
Desmodium elegans DC.	Sb	L	Mp	F	Goat, sheep, cow, buffalo
Indigofera heterantha Wall. ex Brandis.	Sb	Wp	Mp	F	Goat, sheep, cow, buffalo
Indigofera linifolia (L.f.) Retz.	Hb	Wp	Mp	F	Goat, sheep, cow, buffalo
Lathyrus aphaca L.	Hb	Wp	Hp	F	Goat, sheep, cow, buffalo
Lespedeza juncea (L.f.) Pers.	Sb	Wp	Mp	F	Goat, sheep, cow, buffalo
Lotus corniculatus L.	Hb	Wp	Hp	F	Goat, sheep, cow, buffalo
Medicago minima (L.) Grub.	Hb	Wp	Hp	F,D	Goat, sheep, cow, buffalo
Medicogo polymorpha L.	Hb	Wp	Hp	F,D	Goat, sheep, cow, buffalo
Melilotus indica (L.) All.	Hb	Wp	Hp	F,D	Goat, sheep, cow, buffalo
Onobrychis viciifolia Scop.	Hb	L	Mp	F	Goat, sheep, cow, buffalo
Rhynchosia minima (L.) DC.	Hb	Ap	Mp	F,D	Goat, sheep, cow, buffalo
Robinia pseudoacacia L.	T	L	Mp	F	Goat, sheep, cow, buffalo
Sesbania sesban (L.) Merr.	Sb	L	Lp	F,D	Goat
Trifolium repens L.	Hb	Wp	Hp	F,D	Goat, sheep, cow, buffalo
Trigonella incisa Benth.	Hb	Wp	Mp	F	Goat, sheep, cow, buffalo
Vicia hirsuta (L.) S.F. Gray	Hb	Wp	Hp	F	Goat, sheep, cow, buffalo
Vicia sativa L.	Hb	Wp	Hp	F	Goat, sheep, cow, buffalo
41. Fagaceae					
Quercus baloot Griffith	T	L	Mp	F,D	Goat, sheep, cow, buffalo
Quercus dilatata A. Kern.	T	L	Hp	F,D	Goat, sheep, cow, buffalo
Quercus incana Roxb.	T	L	Hp	F,D	Goat, sheep, cow, buffalo
42. Fumariaceae					
Fumaria indica (Hausskn.) Pugsely.	Hb	Wp	Hp	F	Goat, sheep, cow, buffalo
43. Gentianaceae					
Centaurium pulchellum (SW.) Druce	Hb	Wp	Mp	F	Goat, sheep, cow, buffalo
Centaurium tenuiflorum (Hoffmanns. & Link) Fritch	Hb	Wp	Mp	F	Goat, sheep, cow, buffalo
44. Geraniaceae					
Erodium cicutarium (L.) L'Herit. ex Aiton	Hb	L	Rp	F	Goat
Geranium ocellatum Camb	Hb	L	Rp	F	Goat
Geranium rotundifolium L.	Hb	Wp	Hp	F	Goat, sheep, cow, buffalo

Geranium wallichianum D. Don ex Sweet	Hb	Ap	Mp	F	Goat, sheep, cow, buffalo
45. Hyacinthaceae					
Scilla griffithii Hochr.	Hb	L	Mp	F	Goat, sheep, cow, buffalo
46. Hyperaceae					
Hypericum perforatum L.	Hb	L	Lp	F	Goat
47. Juglandaceae					
Juglans regia L.	T	L	Rp	D	Goat, sheep
48. Lamiaceae					
Ajuga bracteosa Wall. ex Benth.	Hb	Ap	Rp	F	Goat
Clinopodium vulgare L.	Hb	L	Mp	F,D	Goat, sheep, cow, buffalo
Isodon rugosus (Wall. ex Benth.) Codd	Sb	L	Rp	F	Goat
Lamium amplexicaule L.	Hb	L	Mp	F	Goat, sheep, cow, buffalo
Mentha arvensis L.	Hb	L	Lp	F,D	Goat, sheep
Mentha longifolia L.	Hb	Ap	Mp	F,D	Goat, sheep
Micromeria biflora (Buch. Ham. ex D. Don) Benth.	Hb	Ap	Lp	F	Goat
Nepeta cataria L.	Hb	L	Lp	F	Goat, sheep
Origanum vulgare L.	Hb	L	Rp	D	Goat, sheep
Otostegia limbata (Benth.) Boiss	Sb	L	Mp	D	Goat, sheep, cow, buffalo
49. Lythraceae					
Punica granatum L.	T	L	Hp	F,D	Goat, sheep, cow, buffalo
50. Malvaceae					
Abutilon indicum (L.) Sweet.	Sb	L	Mp	F	Goat, sheep, cow, buffalo
Grewia optiva Drum. ex Burret.	T	L	Mp	F	Goat, sheep, cow, buffalo
Malva parviflora L.	Hb	L	Mp	F,D	Goat, sheep
Malva sylvestris L.	Hb	L	Mp	F,D	Goat, sheep, cow, buffalo
Malvastrum coromandelianum (L.) Garcke	Hb	Wp	Mp	F	Goat, sheep, cow, buffalo
51. Meliaceae					
Melia azedarach L.	T	L	Hp	F,D	Goat, sheep, cow, buffalo
52. Mimosaceae					
Senegalia modesta (Wall.) P.J.H.Hurter	T	L	Hp	F,D	Goat, sheep, cow, buffalo
Vachellia nilotica (L.) P.J.H.Hurter & Mabb.	T	L	Hp	F	Goat, sheep
53. Mollugonaceae					
Mollugo nudicaulis Lam.	Hb	L	Mp	F	Goat, sheep, cow, buffalo
54. Moraceae					
Broussonetia papyrifera (L.) Vent.	T	L	Rp	D	Goat
Ficus carica L.	T	L	Mp	F,D	Goat, sheep, cow, buffalo
Ficus palmata Forssk.	T	L	Mp	F,D	Goat, sheep, cow, buffalo
Ficus sarmentosa Buch.-Ham. ex Wall.	Clm	L	Mp	F,D	Goat, sheep, cow, buffalo
Morus alba L.	T	L	Hp	F,D	Goat, sheep, cow, buffalo
Morus laevigata Wallich. ex Brandis	T	L	Mp	F,D	Goat, sheep, cow, buffalo
Morus nigra L.	T	L	Hp	F,D	Goat, sheep, cow, buffalo
55. Myrtaceae					

Myrtus communis L.	Sb	L	Mp	F,D	Goat, sheep, cow, buffalo
56. Nyctaginaceae					
Boerhavia procumbens Banks ex Roxb.	Hb	Wp	Hp	F,D	Goat, sheep, cow, buffalo
57. Oleaceae					
Jasminum officinale L.	Sb	L	Lp	F	Goat, sheep
Olea europea subsp. *cuspidata* (Wall. & G.Don) Cif.	T	L	Mp	F,D	Goat, sheep, cow, buffalo
58. Onagraceae					
Epilobium hirsutum L.	Hb	L	Rp	F	Goat, sheep
Oenothera rosea L'Her. ex Aiton	Hb	L	Lp	F	Goat, sheep
59. Oxalidaceae					
Oxalis corniculata L.	Hb	Wp	Hp	F,D	Goat, sheep, cow, buffalo
60. Plantaginaceae					
Plantago himalaica Pilger	Hb	Wp	Hp	F,D	Goat, sheep, cow, buffalo
Plantago lanceolata L.	Hb	Wp	Hp	F,D	Goat, sheep, cow, buffalo
Plantago major L.	Hb	Wp	Hp	F,D	Goat, sheep, cow, buffalo
Veronica biloba L.	Hb	L	Lp	F	Goat, sheep
Veronica persica Poir	Hb	L	Lp	F	Goat, sheep
Veronica polita Fr.	Hb	L	Lp	F	Goat, sheep
61. Platanaceae					
Platanus orientalis L.	T	L	Mp	F,D	Goat, sheep, cow, buffalo
62. Plumbaginaceae					
Limonium cabulicum (Boiss.) O. Kuntze	Hb	L	Lp	F	Goat, sheep, cow, buffalo
63. Polygonaceae					
Bistorta amplexicaulis (D.Don) Greene	Hb	L	Rp	F	Goat, sheep
Persicaria nepalensis (Meisn.) H. Gross	Hb	L	Lp	F	Goat
Polygonum aviculare L.	Hb	Wp	Hp	F,D	Goat, sheep, cow, buffalo
Polygonum barbatum L.	Hb	Ap	Mp	F	Goat, sheep
Polygonum plebeium R. Br.	Hb	Wp	Hp	F	Goat, sheep
Rheum emodi L.	Hb	L	Mp	F	Goat, sheep, cow, buffalo
Rumex dentatus L.	Hb	L	Mp	F	Goat, sheep, cow, buffalo
Rumex hastatus D. Don.	Hb	L	Mp	F	Goat, sheep, cow, buffalo
64. Portulacaceae					
Portulaca oleracea L.	Hb	Wp	Hp	F	Goat, sheep, cow, buffalo
65. Primulaceae					
Anagallis arvensis L.	Hb	Wp	Mp	F	Goat, sheep, cow, buffalo
Androsace rotundifolia Hardw.	Hb	L	Rp	F	Goat, sheep
66. Ranunculaceae					
Ceratocephala falcata (L.) Pers.	Hb	L	Rp	F	Goat
Clematis grata Wall.	Clm	L	Rp	F	Goat
Clematis graveolens Lindl.	Hb	L	Rp	F	Goat, sheep
Ranunculus laetus Wall. ex Hook. f. & Thoms.	Hb	Ap	Rp	F	Goat
Ranunculus muricatus L.	Hb	Ap	Rp	F	Goat
Ranunculus sceleratus L.	Hb	Ap	Rp	F	Goat
67. Rhamnaceae					
Sageretia thea (Osbeck) M. C. Johnston	Sb	L	Hp	F	Goat, sheep

Ziziphus jujuba Mill.	T	L	Hp	F,D	Goat, sheep, cow, buffalo
Ziziphus nummularia (Burm.f.) Wight & Arn.	Sb	Wp	Hp	F	Goat, sheep, cow, buffalo
Ziziphus oxyphylla Edgew.	Sb	L	Hp	F,D	Goat, sheep, cow, buffalo
68. Rosaceae					
Cotoneaster microphyllus Wall. ex Lindl.	Sb	L	Mp	F	Goat, sheep
Cotoneaster nummularia Fesh & May.	Sb	L	Lp	F	Goat, sheep
Duchesnea indica (Jacks.) Focke	Hb	Wp	Mp	F	Goat, sheep, cow, buffalo
Eriobotrya japonica Lindl.	T	L	Hp	F,D	Goat, sheep, cow, buffalo
Fragaria vesca L.	Hb	Wp	Mp	F	Goat, sheep, cow, buffalo
Prunus armeniaca L.	T	L	Hp	F,D	Goat, sheep, cow, buffalo
Pyrus communis L.	T	L	Hp	F,D	Goat, sheep, cow, buffalo
Pyrus malus L.	T	L	Hp	F,D	Goat, sheep, cow, buffalo
Pyrus pashia Ham. ex D. Don.	T	L	Hp	F,D	Goat, sheep, cow, buffalo
Rosa brunonii Lindl.	Sb	L	Hp	F,D	Goat, sheep, cow, buffalo
Rosa webbiana Wall. ex Royle	Sb	L	Mp	F	Goat, sheep, cow, buffalo
Rubus fruticosus L.	Sb	L	Hp	F,D	Goat, sheep, cow, buffalo
Rubus niveus Thunb.	Sb	L	Mp	F,D	Goat, sheep, cow, buffalo
Rubus sanctus Schreb.	Sb	L	Mp	F,D	Goat, sheep, cow, buffalo
69. Rubiaceae					
Galium aparine L.	Hb	L	Lp	F	Goat
Rubia cordifolia L.	Hb	Ap	Mp	F	Goat, sheep, cow, buffalo
70. Rutaceae					
Zanthoxylum armatum DC., Prodr.	T	L	Lp	F,D	Goat, sheep, cow, buffalo
71. Salicaceae					
Populus nigra L.	T	L	Hp	F,D	Goat, sheep, cow, buffalo
Salix acmophylla Boiss.	T	L	Mp	F,D	Goat, sheep
72. Saxifragaceae					
Bergenia ciliata (Haw.) Stemb. f.	Hb	L	Rp	F	Goat
73. Scrophulariaceae					
Verbascum thapsus L.	Hb	Wp	Hp	F	Goat, sheep, cow, buffalo
74. Simaroubaceae					
Ailanthus altissima (Mill.) Swingle	T	L	Hp	F,D	Goat, sheep, cow, buffalo
75. Smilacaceae					
Smilax glaucophylla Klotzsch.	Sb	L	Mp	F	Goat, sheep, cow, buffalo
76. Solanaceae					
Solanum nigrum L.	Hb	Wp	Hp	F	Goat, sheep, cow, buffalo
Solanum surattense Brum.f.	Hb	Wp	Hp	F	Goat, sheep, cow, buffalo
77. Tamaricaceae					

Tamarix aphylla (L.) Karst.	T	Ap	Lp	F	Goat, sheep
78. Ulmaceae					
Celtis eriocarpa Decne.	T	L	Mp	F,D	Goat, sheep, cow, buffalo
Celtis caucasica Wild.	T	L	Mp	F,D	Goat, sheep, cow, buffalo
79. Umbelliferae					
Bupleurum longicaule Wall. ex DC., Prodr.	Hb	L	Lp	F	Goat, sheep
Foeniculum vulgare Mill.	Hb	Wp	Mp	F,D	Goat, sheep, cow, buffalo
Pimpinella diversifolia DC. Prodr.	Hb	L	Mp	F,D	Goat, sheep
Scandix pecten-veneris L.	Hb	L	Lp	F	Goat, sheep
80. Urticaceae					
Debregeasia salicifolia (D. Don) Rendle	Sb	L	Mp	F	Goat, sheep, cow, buffalo
81. Valerianaceae					
Valerianella szovitsiana Fisch. & C. A. Mey.	Hb	L	Rp	F	Goat
82. Verbenaceae					
Lantana camara L.	Sb	L	Lp	F,D	Goat, sheep
Lantana indica Roxb.	Sb	L	Lp	F,D	Goat, sheep
Verbena officinalis L.	Sb	Wp	Hp	F	Goat, sheep, cow, buffalo
83. Violaceae					
Viola canescens Wall. ex Roxb.	Hb	Wp	Mp	F	Goat, sheep, cow, buffalo
Viola pilosa Blume	Hb	Wp	Mp	F	Goat, sheep, cow, buffalo
84. Vitaceae					
Vitis jacquemontti Parker	Clm	L	Lp	F,D	Goat
Vitis vinifera L.	Clm	L	Hp	F,D	Goat, sheep, cow, buffalo
85. Zygophyllaceae					
Tribulus terrestris L.	Hb	L	Mp	F	Goat, sheep

Key:.P= Whole Plant, A.P= Areal Parts, L= Leaves, NP= Non Palatable, RP= Rarely Palatable LP= Low Palatable, MP= Moderately Palatable, HP= Highly Palatable, F= Fresh, D= Dry, B= Both, C= Common, VC= Very common, R= Rear, Go= Goat, Sh= Sheep, Co= Cow, Bu= Buffalo

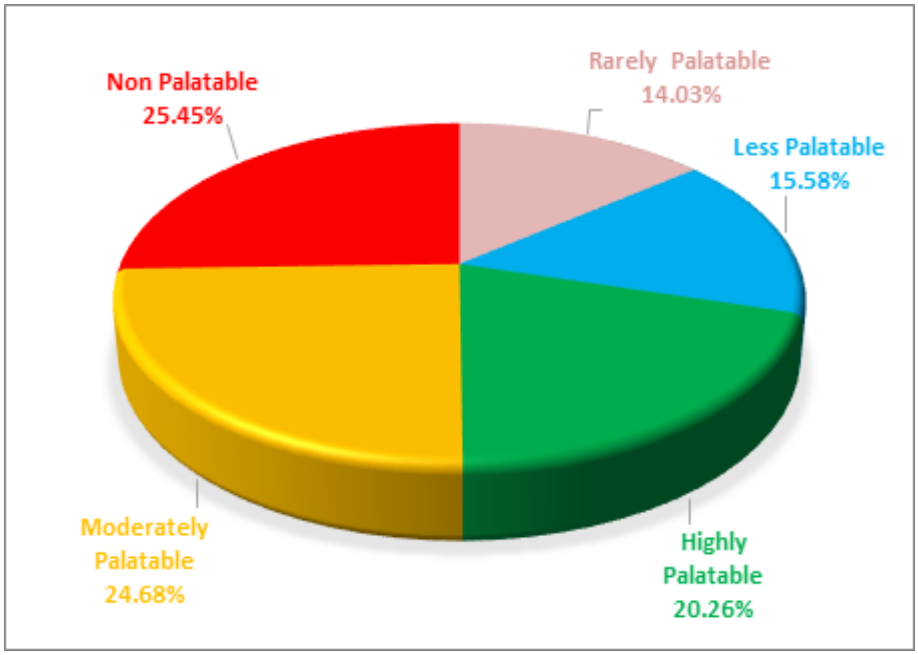

Figure 2. Percentage of palatability classes

During the grazing season, the goats, sheep, cows and buffalos freely grazed and browsed the area. They usually reject the less palatable plants but prefer them under specific circumstances. When the palatable species are overgrazed and become scarce, the cattle in the field subsequently consume non-palatable species (Gorade and Datar 2014). The non-palatable nature of plant species is due to their textural morphology, chemical composition and unpleasant aroma (Badshah and Hussain 2011; Abdullah *et al*. 2017). Secondary metabolites such as phenolics, alkaloids, saponins, and other unpleasant compounds endow plants with a distinct taste and odour that protects them from herbivory (Divekar *et al.* 2022). The alkaloids had a bitter taste, whilst the volatile oil had a distinct odour due to the presence of terpenes that influence the plant's palatability. Plants harboring these compounds can lower animal performance, resulting in significant morbidity and mortality (Tadele 2015).

Seasonal availability of fodder plants

The availability of fodder species in an area during the year depends on the season. Most of the fodder plants are available in the spring (40.65%) and summer (34.48%) as shown in Figure 3. In general, the selectivity of the forage has a strong link to the number of available fodders. It was found that the majority of the highly palatable species were available in the spring followed in the summer which progressively dwindled from autumn to winter. During the spring and summer seasons, plenty of rainfall, high relative humidity and warm temperature favour the growth of many annual and perennial herbs and grasses. Goats and sheep mostly preferred to graze available plant species in spring and summer. Extreme weather conditions could limit animals' access to pastures and cause more serious disruptions to the feed supply (Godde *et al.* 2021). Cattle feed supply disruptions can have significant consequences on animal health, production, and the agricultural sector as a whole. Similar findings were made by (Zhang *et al*. 2022), who reported that sheep consume more forage in the spring and summer than they do in the winter due to availability. In times of drought and extreme weather, there are fewer opportunities for animals to forage, so the livestock's primary source of feed is dried forage. Similar practices have been observed in China (Geng *et al.* 2017) which support the findings of the present research. The herbaceous and grass species are most frequently available in fresh form for the cattle, available in fresh condition for the cattle during the spring and summer seasons because of favorable environmental conditions, whereas shrub and tree species are only available during the autumn and winter (Navale *et al.* 2022; Rahman *et al.* 2022). Some regions may have the availability of fodder species whole year due to moderate weather conditions, while others may experience significant seasonal fluctuations in availability (Gilhaus and Holzel 2016). It is essential to recognize and identify the specific fodder plants that are consumed by livestock during different seasons.

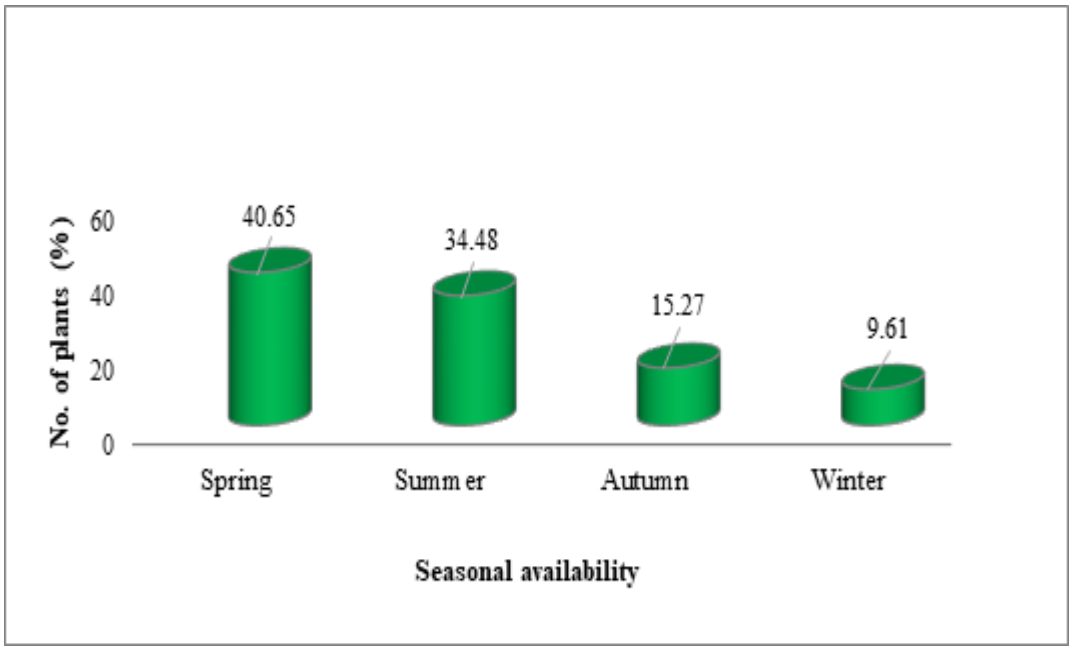

Figure 3. Seasonal availability of the palatable species

Plant parts consumed by the animals

Plant parts that least disturb the digestive system and provide more nutrients to animals are consumed during grazing (Erickson and Kalscheur 2020). Plants had a variety of features such as the presence of hairs, spines, thorns, rigidity, production of poisonous chemicals and indigestible materials with an unpleasant odour, causing grazing animals to select

different plant parts (Amjad *et al*. 2014; Abdullah *et al*. 2017). The flora of Pashat Valley was divided into distinct categories based on the parts consumed by animals. The data revealed that leaves were the most frequently consumed part of the plant (157 species) followed by the whole plant (103 species) The results of the present study revealed that 187 species were consumed by the animals in fresh form while 92 species were preferred in both fresh and dry form (Table 4). The palatable plants frequently consumed by the animals were *Cyperus niveus*, *Eragrostis minor*, *Rumex hastatus*, *Berberis lycium*, *Gymnosporia royleana, Rubus fruticosus*, *Sageretia thea*, *Senegalia modesta, Ailanthus altissima, Morus alba, Morus nigra, Punica granatum, Melia azedarach, Ziziphus jujuba, Quercus incana, Melia azedarach*, *Populus nigra* and *Olea europea*. Additionally, these fodder plants contain active constituents that have therapeutic properties and serve to improve the digestion and alleviation of various diseases as well (Shuaib *et al.* 2021). The palatable plants have soft, fleshy leaves that are readily digested by livestock, especially goats and sheep. Close to our findings, Raufirad *et al.* (2015) reported that goats and sheep mostly consumed the leaves of the plants in their natural condition. During the harsh winter, the herbaceous plants become scarce, and the cattle are restricted to homes, the locals gathered the palatable herbs before the arrival of winter, dried and stored them, and then used them as cattle fodder.

Table 4. Parts of palatable plants consumed by the animals and their condition

Parts used	**Species**	**%age**	**Plant condition**	**Species**	**%age**
Palatable plants			**Palatable plants**		
Whole Plant	103	35.88	Fresh	187	65.15
Aerial Parts	27	9.40	Dry	8	2.80
Leaves	157	54.70	Both	92	32.05
Total	287	74.54	Total	287	74.54
Non-palatable plants	98	25.46	**Non-palatable plants**	98	25.46

Animal preference

Preference refers to an animal's selection of a plant species as a food source. The preferences of grazing animals vary according to the seasons. The quantity of plants consumed by animals varies depending on their age and breed. In the present study, goats preferred 287 species (33.37%), sheep 233 species (27.09%), cows and buffalos 170 species (19.77%) each (Figure 4). Direct observations in the field can be used to record the first choice of animals that are being eaten (Palkova and Leps 2008). Most animals prefer fresh foliage over dried and succulent over non-succulent which can be consumed more rapidly. In general, livestock prefers green foliage because it is more easily digestible than dried plant materials, whereas the choice of dried plant materials is declining due to their loss of taste, feel and nutritional value (Amjad *et al*. 2014; Ibrahim *et al*. 2015).

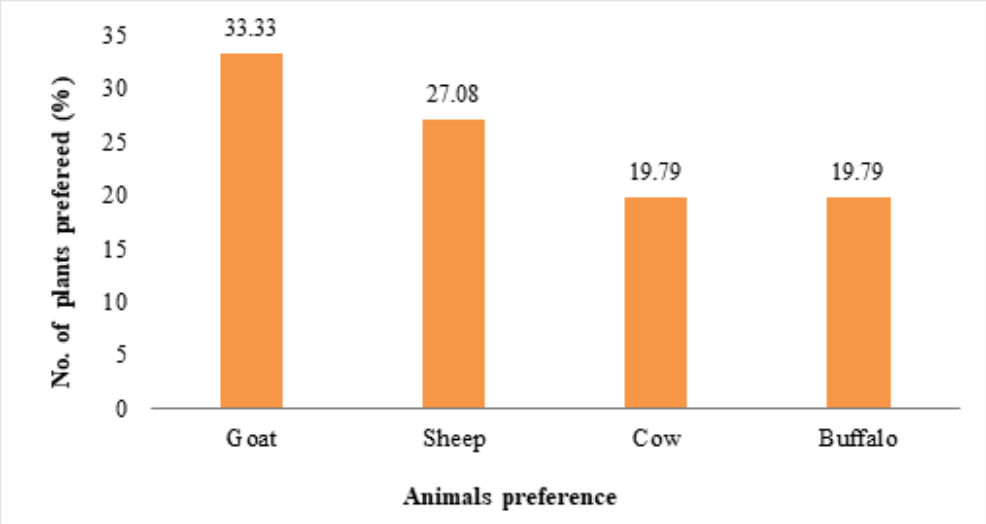

Figure 4. Preference of the grazing animals

The preference for herbaceous species was at its peak in April and May that declined in October. The animal preference is influenced by the position of the leaf, leaf trichrome, leaf-spine, branch density, stem thorns, stem trichrome, leaf-stem ratio

and inflorescence morphology (Raufirad *et al*. 2015). The current study results also agree with earlier research by Hussain and Durrani (2009), who noted the seasonal availability, palatability and animal preference of forage plants in the Harboi dry rangeland, Kalat, Pakistan. Usually, animals prefer to consume herbaceous plants to woody ones. In comparison to herbaceous plants, woody forages are less palatable, contain less dry matter and protein, and are more difficult for cattle to digest (Archer *et al.* 2017). According to Sanso *et al*. (2007), the browsing activity of goats and sheep is at a peak during the dry season. has been noted that sheep prefer grasses and forbs, while goats prefer shrubs. The results of the current study are in line with the studies carried out (Sanso *et al*. 2007; Hussain and Durrani 2009; Khan and Hussain 2012; Amjad *et al.* 2014; Raufirad *et al.* 2015; Abdullah *et al.* 2017; Kochare *et al.* 2018) who also recorded the plant palatability and animal preference in their respective research areas.

Pictoral view of the research area and collection of information

Conclusion

The present study recorded 98 non-palatable, 95 moderately palatable, 78 highly palatable, 60 less palatable and 54 rarely palatable species from Pashat Valley, District Bajaur, Pakistan. Of the 385 plant species, the animals preferred 187 in fresh form while 92 species in both fresh and dry forms. Domestic animals are the main sources of income for the people of the local inhabitants of the area. The feed of their animals is directly linked with plant resources of the area. When there was no alternative source of animal feed in the area during the harsh winter season, it was discovered that the locals would harvest and collect herbaceous plants from the Valley and dry them to feed their livestock. From the study, it was also observed that the palatability of plants was linked with a variety of factors such as animal type, seasonal activities, morphology, phenology, habitat, climatic condition and chemical nature of the plants. The presence of secondary metabolites and specific minerals concentration protected the plants from the biotic stress of overgrazing and browsing. It is suggested that the plants should be confirmed based on elemental and nutritional value to improve the food requirements of domestic animals in the area.

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Declarations

Ethics approval and consent to participate: All participants provided oral prior informed consent.

Consent for publication: All participants shown in images provided oral prior informed consent.

Availability of data and materials: The first author can be consulted for any data.

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