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Ethnobotany of Grazing Resources: Fodder and Forage Plants Used by Gaddi and Sippi Pastoralists in the NW Himalaya.

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Abstract: The Himalayan region supports a rich diversity of plant species and traditional pastoral systems that are closely linked to the livelihoods of Himalayan tribal communities. The present study explores ethnobotany of forage and fodder plants utilized by semi-nomadic Gaddi and Sippi tribes, emphasizing traditional knowledge systems, plant diversity and seasonal grazing practices. A total of 70 plant species belonging to 59 genera and 35 families were recorded out of which 68 were angiosperms and 2 were gymnosperms. Rosaceae, represented by 8 species, was the most dominant family, while aerial parts (61.4%) constituted the most commonly used plant part. Plants with high UV were *Cynodon dactylon* (2.1), *Themeda anathera* (0.9), *Zea mays* (0.9) and *Quercus floribunda* (0.8). Some fodder plants, such as *Pilea umbrosa*, *Indigofera heterantha* and *Robinia pseudoacacia* were also used as galactagogues and nutraceuticals. The study highlights the rich ethnobotanical knowledge of two Himalayan pastoral communities, who live in complete harmony with nature. The findings underline the dual role of pastoralism in both supporting livelihoods and influencing plant biodiversity, emphasizing the need for integrated conservation strategies that incorporate traditional ecological knowledge.

Keywords: Agropastoral, alpine pastures, ecosystem services, green fodder, tribal groups.

Introduction

Ethnobotany explores the complex relationships between indigenous societies and plant resources, offering key insights into traditional ecological knowledge systems, especially in biodiversity-rich areas like Himalayas (Singh et al., 2025a). The Himalayas are one of the world's most important biodiversity hotspots, characterized by a wide range of ecological zones and endemic plant species (Anthal et al., 2026). Indigenous and semi-nomadic communities in Indian Himalayan regions have historically depended on locally available plant resources for fulfilling their subsistence needs, including food, fodder, medicine and shelter. (Malhotra et al., 2021). Among these, fodder and forage plants constitute a vital component of pastoral and agro-pastoral livelihoods, especially for livestock-dependent tribal groups (Singh et al., 2025). The Indian Himalayan region is inhabited by many tribal and agro-pastoral communities such as the Gaddi, Sippi, Gujjar, Bakarwal etc. (Singh et al., 2025b). These communities are primarily herders by occupation and their economy mainly revolves around wild plant-based resources and sustenance agriculture (Samant et al., 2007; Sharma et al., 2018).

India ranks among the leading countries in livestock production, with over 75% of the rural population relying on it for their livelihood (Das et al., 2020). Despite this, systematic fodder cultivation is inadequate and animals primarily rely on fodder extracted from grasslands, forests, agriculture and agroforestry (Rawat and Vishvakarma, 2010). Furthermore, the seasonal scarcity of green forage during summer and winter poses a serious constraint, often resulting in nutritional deficiencies in milch animals (Thakur et al., 2021). Forests fulfill about 87% of the fodder demand in the Himalayan region, supporting livestock feeding for nearly five to six months each year (Pandey and Singh, 1984). A variety of fodder-yielding tree species are distributed across different altitudinal zones of the Himalayas, ensuring a continuous supply of forage. (Shekhar et al., 2022). The utilization pattern of fodder species varies with altitude and season, depending on the availability of species in different altitudinal zones and seasons (Yadav and Bisht, 2013).

The Gaddi and Sippi tribes are semi-nomadic herders who migrate seasonally in search of pastures for their livestock and are highly reliant on local vegetation for feeding their livestock (Dutt et al., 2015). They graze their animals across different climatic zones namely sub-tropical, temperate and alpine zones along the altitudinal gradient of the Northwestern Himalayas, practicing transhumance to make efficient use of available fodder resources (Singh et al., 2025a). Thus, the semi-nomadic Gaddi and Sippi tribes of district Doda, Jammu and Kashmir, maintain a close association with forest ecosystems and alpine pastures (Dutt et al., 2015). Gaddis are, therefore, known as shepherds of snowy ranges (Chakravarty, 1998). The seasonal migration patterns of the Gaddi and Sippi tribes and their dependence on livestock have led to the development of a rich repository of traditional knowledge related to grazing resources and fodder species (Singh and Malik, 2025). However, the previous ethnobotanical investigations in the region have primarily focused on wild edible plants, ethnomedicinal flora, ethnoveterinary flora, magico-religious plants and plant based utility products documenting significant plant diversity utilized by these communities (Singh et al., 2023; Singh, et al., 2023 ; Dutt et al., 2015; Singh et al. 2025 ;Singh et al., 2025b; Singh and Ahmed, 2025) . Similarly, ethnoveterinary studies have emphasized the reliance of Gaddi pastoralists on plant-based remedies for livestock health, indicating a deep understanding of plant properties and their applications in animal husbandry (Singh and Ahmed, 2025). Such knowledge systems are closely linked with traditional grazing practices and often transmitted orally across generations (Sharifian et al., 2022).

Despite the rich ethnobotanical exploration in the Himalayan region, relatively less attention has been paid to fodder and forage plants, which form the backbone of pastoral economies. Existing studies suggest that traditional knowledge is rapidly eroding due to socio-economic changes, modernization and reduced dependence on forest resources (Singh et al., 2016). Therefore, there is an urgent need to systematically document and analyze fodder plant diversity and associated indigenous knowledge before it disappears. Owing to the significant research gap, there is an urgent need to systematically document and analyse fodder plant diversity along with the associated indigenous knowledge in the study area before it is lost.

In this context, the present study was carried out with the following objectives:

1. To document fodder and forage plant species used by Gaddi and Sippi pastoralists.
2. To analyze traditional knowledge related to grazing and fodder utilization.
3. To evaluate the economic significance of fodder and fodder plants.
4. To highlight biodiversity conservation in fragile Himalayan ecosystems.

Materials and Methods

Study Area

Doda district is located in the eastern part of the Jammu and Kashmir in northern India (Fig 1). It is a mountainous district which lies within the middle Himalayan region and is characterized by steep slopes and deep valleys. Geographically, the district extends between 32°53′ to 34°21′ North latitude and 75°01′

to 76°47′ East longitude. It shares boundaries with Ramban district in the west, Kishtwar district in the east and Kathua district toward the south.

The district is drained by the river Chenab which plays a significant role in shaping its topography and drainage system. The district has a wide range of elevation, ranging from about 800 meters to 4,000 meters above sea level, resulting in different climatic zones along altitudinal gradient like subtropical in the lower valleys to temperate and alpine in higher reaches. This climatic variability supports a wide range of vegetation types, including subtropical forests, temperate coniferous forests and alpine pastures in the study area. Gaddi and Sippi settlements are found at higher elevations in close vicinity of forests.

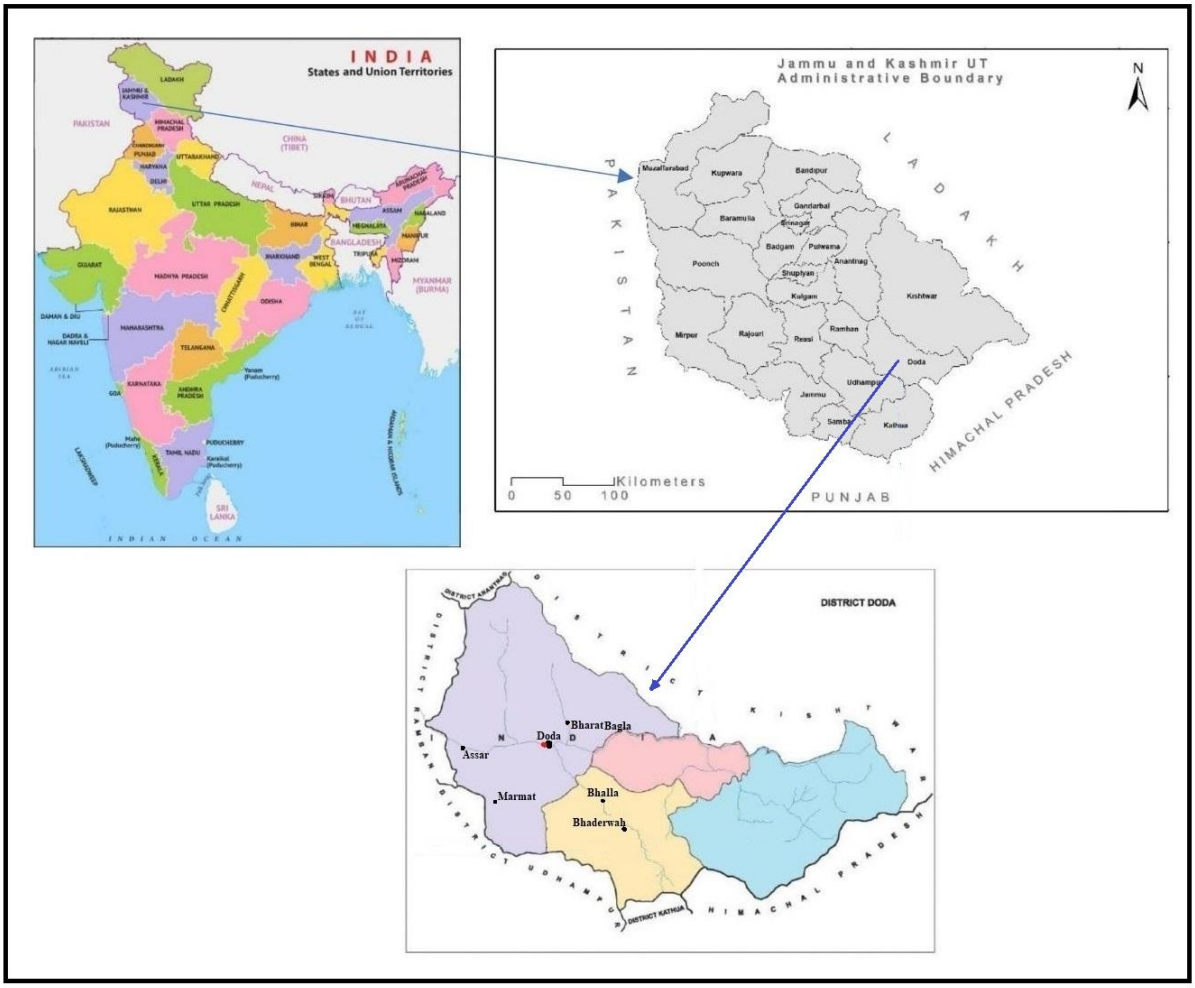

Fig 1. Geographical map of study area (not upto scale).

Gaddi and Sippi tribes

The Gaddis and Sippis of Jammu are semi-nomadic pastoral communities whose economy primarily revolves around shepherding. Most households maintain large flocks ranging from 100 to 400 sheep and goats, along with a few horses. Gaddi and Sippi communities are typically settled at higher elevations in the Northwestern Himalayas, in close vicinity of forests and grazing lands, which facilitate livestock rearing. These tribes are predominantly found cohabiting in the same villages within the study area. Usually, one or two male members of each family, dedicated to shepherding, spend extended periods in remote forests and grazing areas tending their flocks. In addition, the shepherds of the Gaddi and Sippi

tribes practice seasonal migration, moving with their livestock between the Himalayan highlands and the plains descending to lower altitudes during winter and returning to higher regions in summer. This movement helps ensure continuous access to pasture and protects their livestock from extreme weather conditions. Thus, the lifestyle, culture and traditions of the Gaddi and Sippi tribes are closely intertwined with their pastoral profession of shepherding.

Field Surveys and Data Collection

Frequent field surveys were conducted in the study area across different seasons from March 2023 to August 2025 to document ethnobotanical information from local informants. The stratified random sampling technique was employed to ensure representative data collection from the study area.

Fig 2 (a – d): (a). First author conducting interview of the informants at Tibba Dhar, an alpine pasture in Bhaderwah, (b). Author conducting interview of an elderly informant at village Gadyari, Doda, (c). A temporary house, known as Adhwari, at Tibba Dhar, (d). Hayrack (Gaali) storing *Themeda anathera* grass bales.

Population of *Gaddi* and *Sippi* tribes is confined to only six tehsils of Doda district namely Doda, Bharat Bagla, Bhaderwah, Bhalla, Assar and Marmat which constitute six sampling strata for the present study. Sample of informants was obtained from fourteen randomly selected Gaddi and Sippi inhabited villages representing all these six tehsils. These villages are Dhamunda, Kakol, Manthla, Dandi, Kansar, Bharie, Buttla, Banjla, Dalha, Bhagratha, Chadota, Bayota, Barshalla and Gadyari. Data was also collected from migratory shepherds at their camps. Ethnobotanical data were collected through semi-structured interviews and group discussions conducted in the local Gaddyali language. Plant specimens were also collected and photographed during field visits. The samples were pressed in newspaper sheets using a field press, dried and mounted on herbarium sheets following standard herbarium techniques.

The herbarium specimens were deposited in the Herbarium of the University of Jammu and an accession number was assigned to each species. Plant identification was carried out with the assistance of taxonomists from the University of Jammu, by consulting regional floras and comparing specimens with those housed in the Herbarium of the University of Jammu and Janaki Ammal online Herbarium of IIIM, Jammu. Nomenclature was standardized using accepted plant names from the website Plants of the World Online https://powo.science.kew.org.

Quantitative Analysis

Use Value (UV)

It is a quantitative ethnobotanical index that reflects the relative importance of a plant species based on how frequently it is reported by informants.

It is calculated using the formula:

$$UV = \Sigma U / n$$

Where:

U = number of use reports cited by each informant for a given plant species

n = total number of informants interviewed

The Use Value increases when a plant is mentioned frequently and for multiple uses, indicating its greater cultural or practical significance. Conversely, a low UV suggests that the plant is less commonly used within the community. In short, UV helps researchers identify which plant species are most valued and widely utilized by local people.

Results and Discussion

Fodder plants are those plant species which are harvested and taken to animals for feeding them whereas forage plants are those plant species which are browsed or grazed by the animals while still rooted in the soil in their natural habitat. In this study, 210 informants were interviewed, leading to the documentation of 70 fodder and forage plant species belonging to 59 genera and 35 families.

Herbs, with 35 species, were the most commonly used life forms, followed by trees (17 species), shrubs (13 species) and climbers (5 species). Among these, 68 species were angiosperms and only 2 were gymnosperms. Dicots were the most dominated group with 64 species whereas monocots were represented by only 4 species. Among the families, Rosaceae was dominant with eight species, followed closely by Fabaceae with seven species. Polygonaceae comprised five species, while Asteraceae included four species. Fagaceae, Lamiaceae, Moraceae, and Poaceae were represented by three species each, whereas all remaining families contained only one or two species.

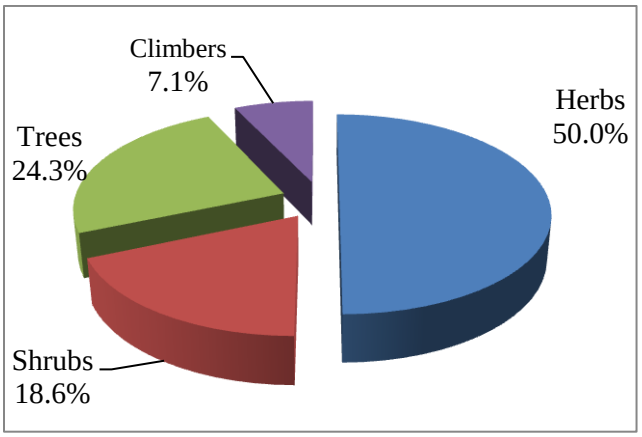

Fig 3. Percentage contribution of different habits of fodder/forage plants.

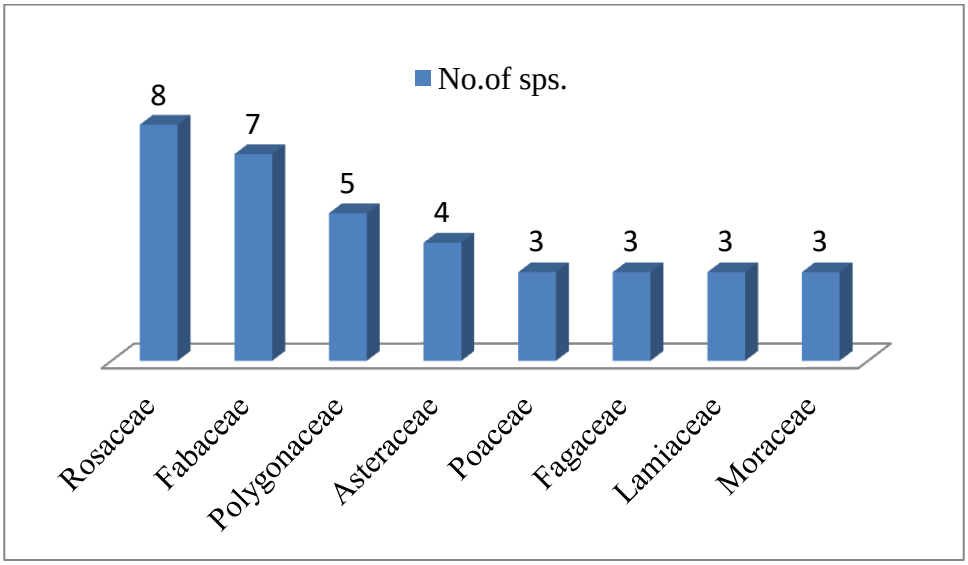

Fig. 4. The most represented families of fodder/forage plants.

Only three types of plant parts viz. aerial parts, leaves and branches were utilized as fodder or forage for livestock. Among these, aerial parts were the most commonly used (61.4%), followed by leaves (35.7%) and branches (2.9%). Plants with highest Use Value (UV) were *Cynodon dactylon* (2.1), *Themeda anathera*, *Zea mays* (0.9 each), *Indigofera heterantha*, *Quercus floribunda* (0.8 each), *Berberis lyceum*, *Ficus palmata*, *Olea ferruginea*, *Parrotiopsis jacquemontiana*, *Rosa brunonii*, *Spiraea canescens*, and *Viburnum grandiflorum* (0.7 each). The higher use of these plant species indicates their greater preference, frequent utilization and wider availability among the local communities. Such species play a crucial role in sustaining livestock, particularly during periods of fodder scarcity, due to their palatability and nutritional potential. Species with high use value are subjected to intense exploitation and therefore require conservation through community involvement, nursery development, sustainable harvesting methods and rotational grazing; otherwise, they may become threatened with depletion. Highly preferred fodder species may be cultivated in community lands, agroforestry systems to ensure year round fodder availability. Forests and grazing lands should be protected from deforestation and land degradation.

The dominance of the species with high use value as fodder and forage plants reflects their adaptability to local climatic conditions and resilience under grazing pressure. Their continued use suggests that they could be prioritized for pasture improvement, domestication and conservation programs. Promoting these high-utility species through scientific management and integration with traditional practices may enhance fodder security, support livestock productivity and contribute to the sustainable management of rangeland ecosystems in the study area.

Table 1. Fodder and forage plants used by Gaddi and Sippi tribes.

S. No	Name of the plant species	Local Name	Accession No.	Family	Habit	Part used	ΣUR	Use value (UV)
1	*Abies pindrow* (Royle ex D.Don) Royle.	Rae	HBJU-16883	Pinaceae	Tree	Tender branches	15	0.1
2	*Achillea millefolium* L.	Dand-jadi	HBJU-16764	Asteraceae	Herb	Aerial parts	14	0.1
3	*Aesculus indica* (Wall. ex	Goon	HBJU-	Sapindaceae	Tree	Leaves	110	0.5

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4	*Artemisia scoparia* Waldst. And Kit.	Jhao	HBJU-16767	Asteraceae	Herb	Aerial Parts	108	0.5
5	*Artemisia vestita* Wall. ex Besser.	Jhao	HBJU-16768	Asteraceae	Herb	Aerial Parts	108	0.5
6	*Berberis lycium* Royle.	Kishmay	HBJU-16776	Berberidaceae	Shrub	Leaves	156	0.7
7	*Betula utilis* D.Don.	Bhuj	HBJU-16778	Betulaceae	Tree	Leaves	50	0.2
8	*Cannabis sativa* L.	Bhang	HBJU-16783	Cannabaceae	Herb	Aerial parts	84	0.4
9	*Capsella bursa- pastoris* (L.) Medik.	Ban- sharoon	HBJU-17550	Brassicaceae	Herb	Aerial parts	80	0.4
10	*Cedrus deodara* (Roxb.) G. Don.	Gaid	HBJU-16884	Pinaceae	Tree	Tender branches	15	0.1
11	*Celtis australis* L.	Khedak	HBJU-16788	Cannabaceae	Tree	Leaves	9	0
12	*Chaerophyll um villosum* Wall. ex. DC.	Handori	HBJU-16759	Apiaceae	Herb	Aerial parts	38	0.2
13	*Cynodon dactylon* (L.) Pers.	Darub	HBJU-17569	Poaceae	Herb	Aerial parts	380	2.1
14	*Cynoglossum lanceolatum* Forssk.	Nikki kithdi	HBJU-16779	Boraginaceae	Herb	Aerial parts	84	0.4
15	*Daphne oleoides* Schreb.	Kashadi	HBJU-16876	Thymelaeacae	Shrub	Leaves	10	0.1
16	*Desmodium elegans* DC.	Pree	HBJU-16796	Fabaceae	Shrub	Leaves	106	0.5
17	*Dioscorea deltoidea Wall. ex Griseb.*	Kins	*HBJU-16791*	*Dioscoreacea*	Climber	Aerial parts	15	0.1
18	*Dipsacus inermis Wall.*	Thanthana	HBJU-16784	*Caprifoliaceae*	Herb	Aerial parts	16	0.1
19	*Dysphania ambrosioides* (L.) Mosyakin & Clemants.	Bawase er-ari- dawa	HBJU-16900	Amaranthaceae	Herb	Aerial parts	8	0
20	*Erigeron bonariensis* L.	Jhao	HBJU-16772	Asteraceae	Herb	Aerial parts	100	0.5
21	*Fagopyrum cymosum* (Trevir.) Meisn.	Fafra	HBJU-16835	Polygonaceae	Herb	Aerial parts	78	0.4
22	*Ficus palmata* Forssk.	Fagra	HBJU-16819	Moraceae	Shrub	Aerial parts	146	0.7
23	*Galium aparine* L.	Chippu	HBJU-16865	Rubiaceae	Herb	Aerial parts	78	0.4

24	*Hedera nepalensis* K.Koch.	Kurray	HBJU-17544	Araliaceae	Climber	Aerial parts	16	0.1
25	*Impatiens glandulifera* Royle.	Hallu	HBJU-16775	Balsaminaceae	Herb	Aerial parts	74	0.4
26	*Indigofera heterantha* Brandis.	Kathu	HBJU-16797	Fabaceae	Shrub	Aerial parts	160	0.8
27	*Ipomoea purpurea* (L.) Roth.	Shakar kandi	HBJU-17554	Convolvulaceae	Herb	Aerial parts	60	0.3
28	*Isodon rugosus* (Wall. ex Benth.) Codd.	Kothal	HBJU-16807	Lamiaceae	Shrub	Aerial parts	25	0.1
29	*Jasminum officinale* L.	Suin	HBJU-16821	Oleaceae	Climber	Aerial parts	55	0.3
30	*Koenigia polystachya* (Wall. ex Meisn.) T.M.Schust. & Reveal.	Amthilla	HBJU-16837	Polygonaceae	Herb	Aerial parts	52	0.2
31	*Melia azedarach* L.	Darenk	HBJU-16818	Meliaceae	Tree	Aerial parts	10	0
32	*Mentha longifolia* (L.) L.	Maldhei	HBJU-16809	Lamiaceae	Herb	Aerial parts	18	0.1
33	*Morus alba* L.	Toot	HBJU-16820	Moraceae	Tree	Leaves	76	0.4
34	*Morus nigra* L.	Kala Toot	HBJU-17564	Moraceae	Tree	Leaves	20	0.1
35	*Nasturtium officinale* W.T Aiton.	Loot-ari-dawa	HBJU-16781	Brassicaceae	Herb	Aerial parts	57	0.3
36	*Olea ferruginea* Royle.	Kahu	HBJU-16823	Oleaceae	Tree	Leaves	142	0.7
37	*Oxalis carniculata* L.	Amloodi	HBJU-16825	Oxalidaceae	Herb	Aerial partss	77	0.4
38	*Oxyria digyna* (L.) Hill.	Chukru	HBJU-16838	Polygonaceae	Herb	Aerial partss	75	0.4
39	*Parrotiopsis jacquemontiana* (Decne.) Rehder.	Killar	HBJU-16805	Hamamelidaceae	Tree	Leaves	143	0.7
40	*Plantago lanceolata* L.	Chapdotra	HBJU-16829	Plantaginaceae	Herb	Aerial parts		
41	*Plantago major* L.	Chapdotra	HBJU-16830	Plantaginaceae	Herb	Aerial parts	60	0.3
42	*Prinsepia utilis* Royle.	Jeentay	HBJU-16854	Rosaceae	Shrub	Leaves	98	0.5
43	*Prunella vulgaris* L.	Ushat	HBJU-16812	Lamiaceae	Herb	Aerial parts	75	0.4
44	*Prunus armeniaca* L.	Cheer	HBJU-16855	Rosaceae	Tree	Leaves	98	0.5

45	*Prunus cornuta* (Wall. ex Royle) Steud.	Jamo	HBJU-16856	Rosaceae	Tree	Leaves	88	0.4
46	*Quercus floribunda* Lindl. ex A.Camus.	Maru	HBJU-16801	Fagaceae	Tree	Leaves	172	0.8
47	*Quercus leucotrichophora* A.Camus.	Banj	HBJU-16802	Fagaceae	Tree	Leaves	126	0.6
48	*Quercus semecarpifolia* Sm.	Kharshu	HBJU-16803	Fagaceae	Tree	Leaves	120	0.6
49	*Robinia pseudoacacia* L.	Rubeen	HBJU-16799	Fabaceae	Tree	Leaves	113	0.5
50	*Rosa brunonii* Lindl.	Kojein	HBJU-16859	Rosaceae	Climber	Leaves	150	0.7
51	*Rubia cordifolia* L.	Ridwal	HBJU-16866	Rubi aceae	Herb	Aerial parts	90	0.4
52	*Rubus ellipticus* Sm.	Aakhedi	HBJU-16861	Rosaceae	Shrub	Leaves	90	0.4
53	*Rubus niveus* Thunb.	Aakhedi	HBJU-16862	Rosaceae	Shrub	Leaves	87	0.4
54	*Rumex hastatus* D. Don.	Amloda	HBJU-16843	Polygonaceae	Herb	Aerial parts	85	0.4
55	*Rumex nepalensis* Spreng.	Harbal	HBJU-16844	Polygonaceae	Herb	Aerial parts	80	0.4
56	*Sageretia thea* (Osbeck) M.C. Johnst.	Dhrenkolu	HBJU-16849	Rhamnaceae	Shrub	Leaves	30	0.1
57	*Solanum villosum* Mill.	Kanya	HBJU-16875	Solanaceae	Herb	Aerial parts	15	0.1
58	*Sorbaria tomentosa* (Lindl.) Rehder.	Kirdhae	HBJU-16863	Rosaceae	Shrub	Leaves	25	0.2
59	*Spiraea canescens* D.Don.	Pribri	HBJU-16864	Rosaceae	Shrub	Aerial parts	145	0.7
60	*Stellaria media* (L.) Vill.	Fukku	HBJU-16789	Caryophyllaceae	Herb	Aerial parts	78	0.4
61	*Themeda anathera* (Nees ex Steud.) Hack.	Aalo/faatah	HBJU-16831	Poaceae	Herb	Aerial parts	192	0.9
62	*Trifolium dubium* Sibth.	Gha	HBJU-17559	Fabaceae	Herb	Aerial parts	64	0.3
63	*Trifolium pratense* L.	Shatala	HBJU-17560	Fabaceae	Herb	Aerial parts	64	0.3
64	*Trifolium repens* L.	Gha	HBJU-17561	Fabaceae	Herb	Aerial parts	64	0.3
65	*Ulmus wallichiana* Planch.	Maral	HBJU-16877	Ulmaceae	Tree	Leaves	168	0.8

66	*Urtica dioica* L.	Nikki aen	HBJU-16880	Urticaceae	Herb	Aerial parts	88	0.4
67	*Viburnum cotinifolium* D.Don.	Ban toondhay	HBJU-16748	Ado xaceae	Shrub	Leaves	125	0.6
68	*Viburnum grandiflorum* Wall.ex DC. Family:Ado xaceae Accession No.:HBJU- 16749	Toondhay	HBJU-16749	Adoxaceae	Shrub	Leaves	140	0.7
69	*Vicia sativa* L.	Kukshein	HBJU-16800	Fabaceae	Herb	Aerial parts	30	0.1
70	*Zea mays* L.	Kukdi	HBJU-16833	Poaceae	Herb	Aerial parts	185	0.9

Although fodder is available in abundance during the rainy season, other seasons face fodder scarcity because people are not familiar with proper conservation techniques (Tiwari & Rawat, 2017). All 70 documented plant species were provided to cattle in fresh form. However, four species - *Ficus palmata*, *Themeda anathera*, *Ulmus wallichiana* and *Zea mays* were used both fresh and dried. As the study area receives heavy snowfall, it remains covered with a thick blanket of snow during winter. During the winter season, when fresh fodder is scarce, dried material of *Themeda anathera* and *Zea mays* is stored in large quantities to meet the nutritional needs of livestock. The dried grass bales of *Themeda anathera* are stored above ground level in hay racks, locally referred to as “gaali,” (Fig. 2) which are installed near residential houses. These structures are supported by many strong wooden poles measuring approximately 15 feet in height. In contrast, dried *Zea mays* grass is stacked in large conical formations known as haycocks (kundu) (Fig. 3) within agricultural fields and later utilized as animal feed during lean periods of winter seasons when green fodder is not unavailable.

Several important fodder plants fed to cattle by the Gaddi and Sippi tribes include *Abies pindrow*, *Cedrus deodara*, *Quercus floribunda*, *Celtis australis*, *Desmodium elegans*, *Indigofera heterantha*, *Isodon rugosus*, *Melia azedarach*, *Morus alba*, *Olea ferruginea*, *Prunus armeniaca*, *Prunus cornuta*, *Robinia pseudoacacia*, *Sorbaria tomentosa*, *Spiraea canescens*, *Themeda anathera*, *Ulmus wallichiana*, and *Zea mays*. In addition, various species are naturally grazed or foraged by livestock in grasslands and forest areas, such as *Achillea millefolium*, *Artemisia scoparia*, *Berberis lyceum*, *Capsella bursa-pastoris*, *Chaerophyllum villosum*, *Cynodon dactylon*, *Cynoglossum lanceolatum*, *Dysphania ambrosioides*, *Erigeron bonariensis*, *Fagopyrum cymosum*, *Galium aparine*, *Impatiens glandulifera*, *Indigofera heterantha*, *Isodon rugosus*, *Jasminum officinale*, *Koenigia polystachya*, *Mentha longifolia*, *Oxalis corniculata*, *Plantago lanceolata*, *Prunella vulgaris*, *Rosa brunonii*, *Trifolium pratense*, and *Trifolium repens*.

In the study region, the majority of Gaddi and Sippi settlements are confined to Himalayan highlands at elevations ranging from 1900 to 2400 masl, where most of the recorded fodder plants are found growing. They also construct seasonal shelters called *Adhwari* at elevations of approximately 2700 meters near alpine areas (Fig. 3). They migrate to these locations during summer and occupy these shelters for livestock grazing but are deserted in winter owing to heavy snowfall. At elevations ranging between 2300 to 2750 meters, several high-altitude Himalayan fodder and forage species are found growing, including

Abies pindrow, *Achillea millefolium*, *Aesculus indica*, *Betula utilis*, *Hedera nepalensis*, *Koenigia polystachya*, *Parrotiopsis jacquemontiana*, *Prunella vulgaris*, *Prunus cornuta*, *Quercus leucotrichophora*, *Oxyria digyna*, *Viburnum cotinifolium*, and *Viburnum grandiflorum*. These alpine plants are grazed by goats and sheep owned by the semi-nadic Gaddi and Sippi communities, who migrate seasonally between the plains of Kathua and the mountainous regions of Doda district, crossing alpine pastures at

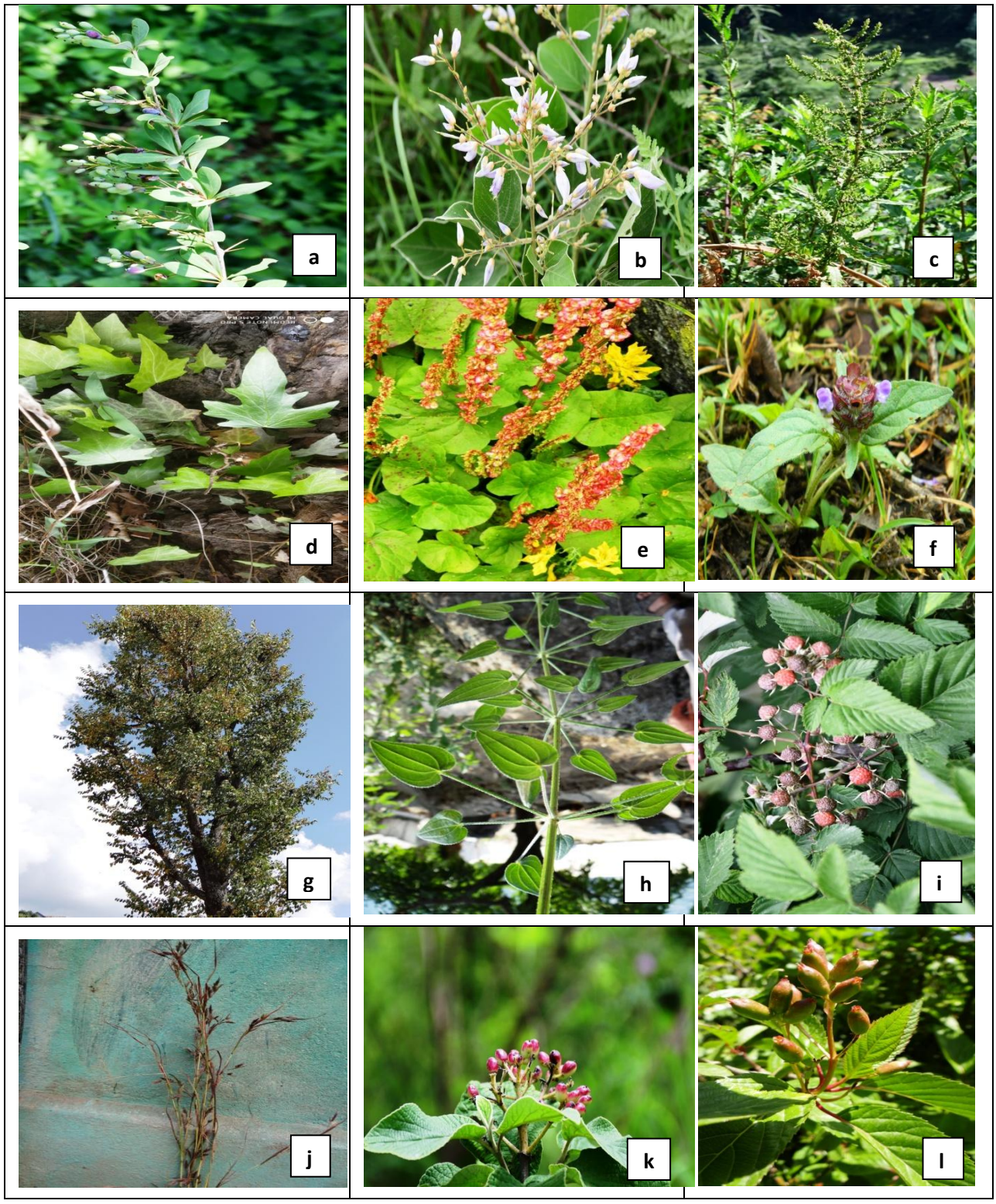

Fig. 5 (a-l): Some of the Fodder and forage plants used by Gaddi and Sippit tribes: *(a) Berberis lyceum, (b) Desmodium elegans, (c) Dysphania ambrosioides, (d) Hedera nepalensis, (e) Oxyria digyna, (f) Prunella vulgaris, (g) Quercus floribunda, (h) Rubia cordifolia, (i) Rubus niveus, (j) Themeda anathera, (k) Viburnum cotinifolium, (l) Viburnum grandiflorum*

around 3,000 meters elevation and navigating high mountain passes along the way. These migratory routes enable access to diverse grazing resources. The seasonal movement of pastoral groups plays a significant role in shaping plant use patterns and vegetation dynamics.

Thus, Himalayan pastoral systems represent a dynamic interaction between indigenous communities, livestock and phyto-diversity. Cattle, sheep and goat rearing remain central to the socio-economic stability of tribal groups, while also exerting pressure on fragile ecosystems. The indigenous pastoral systems of the Gaddi and Sippi communities are characterized by rotational grazing and seasonal migration, which not only facilitate livestock grazing but also prevents overgrazing, thereby contributing to the sustainable utilization of ecosystem services in the fragile Himalayan ecosystems. Thus, indigenous knowledge systems provide valuable insights for sustainable plant use and conservation. Integrating traditional practices with modern conservation strategies is essential to protect both biodiversity and the socio-economic well-being of Himalayan pastoral communities.

Some of the fodder and forage plants mentioned above also possess ethnoveterinary medicinal properties and are therefore regarded as nutraceuticals. These plants not only fulfill the nutritional needs of livestock but are also used to treat various diseases and health disorders, thereby contributing to the overall well-being of cattle. For instance, tender branches of *Abies pindrow* and *Cedrus deodara* along with the aerial parts of *Indigofera heterantha* and leaves of *Robinia pseudoacacia* are given to cattle as a general health tonic. Similarly, the aerial parts of *Koenigia polystachya* and *Fagopyrum cymosum* are used in the treatment of foot-and-mouth disease. Additionally, plants such as *Pilea umbrosa*, *Trifolium pratense*, and *Trifolium repens* are fed to cows as galactagogues to enhance milk production.

Conclusion

The present study highlights the rich traditional knowledge of fodder and forage plants utilized by the Gaddi and Sippi tribes of Doda district, Jammu and Kashmir, reflecting a close relationship between indigenous communities and their natural rangeland resources. A diverse range of grasses, legumes, shrubs and tree species are used to sustain livestock, forming the backbone of pastoral livelihoods in the region. However, the livestock sector faces a persistent shortage of green and dry fodder, necessitating enhanced fodder production. In Jammu and Kashmir, forage resources are threatened by land conversion, pasture degradation, deforestation, encroachment, increasing weed infestation and unsustainable grazing practices.

Key interventions include improved grazing management, pasture rehabilitation, removal of unpalatable weeds, introduction of high-yielding species and soil conservation. Grassland protection through live or physical fencing is also essential. Introducing suitable grass-legume mixtures can improve productivity and carrying capacity of grasslands. Sustainable grazing systems such as deferred grazing, rotational grazing or cut-and-carry grazing can help prevent overgrazing, maintain species balance and ensure long-term pasture productivity (Banke et al., 2025). Integrating traditional knowledge with scientific interventions can enhance fodder availability, improve livestock productivity, and ensure ecological stability. Preservation of this ethnobotanical knowledge is equally important for supporting the socio-economic resilience of the Gaddi and Sippi communities and for promoting sustainable livestock-based livelihoods in the fragile Himalayan ecosystem.

Declarations

Ethics approval and consent to participate: The informants were thoroughly explained the purpose of study and written consent was obtained from all the informants before collecting ethnobotanical information.

Consent for publication: Written informed consent was obtained from all the informants for publication of the data and accompanying information.

Competing interests: The authors have no competing interests to disclose.

Authors' contributions: BPS devised the study, framed its draft, collected the data and wrote the manuscript. **KK** compiled and interpreted data and helped to design, draft, revise and edit the manuscript.
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