



## Exploring the nutritional composition of fodder resources utilized by transhumant Gaddi shepherds in the western Himalayas, India

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### Abstract

The Gaddi shepherds of the northwestern Himalayan region practice transhumance, migrating their sheep and goats to alpine pastures in summer and lower Shiwalik hills in winter. These animals graze on various vegetation during migration, whose nutritional value remains largely unstudied. Therefore, this study aimed to assess the nutritional quality of key fodder resources (including trees, shrubs, herbs, and grasses) crucial for small ruminant feeding. Gaddi farmers were interviewed using a semi-structured questionnaire to gauge their preferences for these fodder resources. Representative samples 20 most important fodder species (in triplicate) were hand plucked to mimic the diet selection by migratory small ruminants from the Bharmour block of District Chamba and were subjected to nutritional evaluation. The study revealed significant variation in nutritional attributes among the different preferred fodder species. The DM % was highest in *Quercus semecarpifolia* ( $61.80 \pm 0.77$ ) and lowest in *Buddleja crispa* ( $32.40 \pm 0.26$ ) [ $p < 0.05$ ]. The CP% (DM basis) was highest in *Indigofera heterantha* ( $22.03 \pm 0.27$ ) and lowest in *Quercus semecarpifolia* ( $9.93 \pm 0.17$ ) [ $p < 0.05$ ]. EE % was higher in *Quercus leucotrichophora* ( $3.26 \pm 0.20$ ) and lowest in *Morus serrata* ( $1.33 \pm 0.25$ ) [ $p < 0.05$ ]. The CF, NDF, and ADF (%) were greater [ $p < 0.05$ ] in *Quercus semecarpifolia* and lowest in *Trifolium pratense* ( $37.00 \pm 0.31$ ,  $53.13 \pm 0.39$  and  $47.66 \pm 0.29$  vs.  $21.23 \pm 0.42$ ,  $36.13 \pm 0.36$  and  $25.16 \pm 0.58$ , respectively). The TA (%) was found highest in *Populus deltoides* ( $8.06 \pm 0.39$ ) and lowest in *Indigofera heterantha* ( $2.56 \pm 0.30$ ) [ $p < 0.05$ ]. AIA (%) was highest in *Salix alba* ( $4.66 \pm 0.21$ ) and lowest in *Oxyria digyna* ( $0.66 \pm 0.23$ ) [ $p < 0.05$ ]. The NFE (%) was highest in *Festuca arundinacea* ( $57.13 \pm 0.40$ ) and lowest in *Populus deltoides* ( $43.30 \pm 0.27$ ) [ $p < 0.05$ ]. Based on farmer preferences and nutritional analysis, the study identified the most preferred species for Gaddi farmers feeding small ruminants in the Bharmour block of District Chamba, including *Desmodium elegans*, *Indigofera heterantha*, *Rubus saxatilis*, *Buddleja crispa*, *Trifolium pratense*, *Festuca arundinacea*, *Salix alba*, *Robinia pseudoacacia*, *Pyrus pashia*, and *Morus serrata*.

### Introduction

Himachal Pradesh, located in the North-Western Himalayas of India, is divided into four distinct zones: dry temperate–alpine, moist temperate, sub-temperate, and sub-tropical. The Chamba district, which lies deep within Himachal Pradesh, has a significant tribal population (Rana et al. 2014). Within Chamba, two tribal regions—Pangi and Bharmour—are home to the Gaddi tribe. This tribe primarily resides in the Bharmour and Holi areas of

Chamba district, as well as in parts of Kangra district. In these regions, Gaddi farmers predominantly raise sheep and goats to meet their household nutritional needs. The Gaddis practice transhumance, migrating with their flocks to different parts of the state: they move to the lower Shiwalik hills in winter and to the alpine pastures during the summer. A major challenge for livestock farming in Himachal Pradesh is the seasonal availability of green fodder. While fodder is abundant during the monsoons, it becomes scarce in the winter and peak summer months, prompting nomadic farmers to migrate to find enough nutrition for their animals. This shortage of green fodder has increased the reliance on fodder trees and shrubs during these scarcity periods. A study by Vashist and Pathania (2001) revealed that there was a 59 (%) and 37 (%) shortfalls in dry and green fodder, respectively, in Himachal Pradesh. Due to a lack of research on the nutritional content of both conventional and non-conventional feed used by the Gaddi tribe for their sheep and goats, the present study titled “Exploring the Nutritional Composition of Fodder Resources Utilized by Transhumant Gaddi Shepherds in the Western Himalayas, India” was conducted in the Bharmour block of Chamba district, Himachal Pradesh.

### Methods

To evaluate the nutritional content of fodder resources the samples were collected between July-September 2020 from Bharmour region of Himachal Pradesh, which is situated at an elevation of 7,000 feet above sea level. The region is located between 32° 11'–33° 13' N latitude and 76° 22'–76° 53' E longitude. The climate is generally temperate, with cool winters characterized by heavy snowfall and temperatures dropping below 0°C. Summers are pleasant, with temperatures ranging from 15°C to 25°C. The mean annual rainfall is 1,500 mm, and the average annual temperature ranges between 3°C and 30°C. As per the information received from the gaddi farmers the important fodder species (fodder trees, shrubs, herbs, legumes and grasses) were collected from pastures, farm bunds in Bharmour block by random sampling. The fodder tree species was hand plucked with a mix of all edible parts (leaves, flower, fine stem and pods), while for herbs and other grasses were harvested at about 5cm above the ground level. After harvesting, individual species sample were separated and a total of three composite samples of 1kg each were collected for individual fodder species. Hence in this manner, samples were collected for 20 species consisting of total 60 representative samples.

The collected leaf samples were then dried in hot air oven at temperature 60±5°C until a constant weight was achieved. The dried leaf samples were then crushed in a mechanical grinder fitted with stainless steel blades to form fine powder which was used in the determination of the leaf nutritional composition. The estimation of DM, CP, EE, CF, TA, and NFE was done by employing the methods devised by Association of Official Analytical Chemist (A.O.A.C., 2000). The procedures of (Van Soest et al. 1991) were adopted for the estimation of ADF and NDF. The AIA was also determined. Data analyzed by one way classification as per the procedure suggested by (Gomez and Gomez 1984) wherever the experimental effects exhibited significance per cent level of probability, the critical difference was calculated.

### Results

The overall average of DM in fodder tree leaves was 49.58 ± 0.56%. The mean percentage DM was highest in *Quercus semecarpifolia* (61.80 ± 0.77) and lowest in *Salix alba* (38.38 ± 0.55). The overall mean DM of shrubs was 40.05 ± 0.34% (Table 1). The overall DM (%) in herbs was 38.33 ± 0.21 %. The mean DM (%) was highest in *Rumex nepalensis* (40.13 ± 0.57) and lowest in *Aconogonum molle* (35.70 ± 0.45). The DM % followed a downward trend as *Rumex nepalensis* (40.13 ± 0.57) > *Oxyria digyna* (39.16 ± 0.49) > *Aconogonum molle* (35.70 ± 0.45). The overall means of DM (%) in legumes and grasses was 36.63 ± 0.26. The mean DM (%) was greatest in *Festuca arundinacea* (39.16 ± 0.53) and least in *Trifolium pratense* (34.10 ± 0.59). The overall means DM of shrubs was 40.05± 0.34%. The overall DM (%) in herbs was 38.33 ± 0.21. The mean DM (%) was highest in *Rumex nepalensis* (40.13 ± 0.57) and lowest in *Aconogonum molle* (35.70 ± 0.45) (Table 1).

The mean CP (%) was higher in *Prunus spinosa* (16.53 ± 0.33) and lowest in *Quercus semecarpifolia* (9.93 ± 0.17). The overall mean of CP in leaves of shrubs was 17.49 ± 0.70%. The average CP (%) was highest in the leaves

of *Indigofera heterantha* ( $22.03 \pm 0.27$ ) and lowest in *Elaeagnus angustifolia* ( $14.46 \pm 0.32$ ) (Table 1). The overall mean of CP in herbs was  $13.51 \pm 0.49\%$  where the CP (%) in *Aconogonum molle* was highest ( $15.20 \pm 0.23$ ) and lowest in *Oxyria digyna* ( $11.86 \pm 0.42$ ). The overall mean of CP % in legume and grasses was  $15.15 \pm 0.32$  (Table 1). The findings of the present study revealed that the mean CP (%) was  $18.70 \pm 0.41$  and  $11.60 \pm 0.31$  in the leaves of *Trifolium pratense*, *Festuca arundinacea*, respectively.

The overall means of EE in tree leaves was  $2.63 \pm 0.46\%$ . The mean EE (%) was highest in *Quercus leucotrichophora* ( $3.26 \pm 0.20$ ) and lowest in *Morus serrata* ( $1.33 \pm 0.25$ ). The overall means of EE in leaves of shrubs was  $3.17 \pm 0.40\%$ . The mean EE (%) was highest in *Indigofera heterantha* ( $3.66 \pm 0.44$ ) and lowest in *Rubus saxatilis* ( $2.50 \pm 0.21$ ). The overall means of EE in herbs was  $1.14 \pm 0.46\%$ . The overall means of EE in legumes and grasses was  $2.87 \pm 0.16\%$ . The mean EE content (%) was greatest in *Trifolium pratense* ( $2.40 \pm 0.30$ ) and least in *Festuca arundinacea* ( $1.90 \pm 0.19$ ) (Table 1).

The overall mean CF in tree leaves was  $31.62 \pm 0.35\%$  (Table 1). The mean CF (%) was highest in *Quercus semecarpifolia* ( $37.00 \pm 0.31$ ) and lowest in *Robinia pseudoacacia* ( $25.46 \pm 0.40$ ). The overall mean of CF in shrubs was  $25.38 \pm 0.60\%$ . The maximum CF (%) was exhibited by *Desmodium elegans* ( $28.36 \pm 0.39$ ) and the minimum in *Buddleja crispa* ( $22.00 \pm 0.28$ ). The total mean of CF in herbs was  $22.69 \pm 1.04\%$ . Mean CF (%) was highest in *Rumex nepalensis* ( $25.60 \pm 0.31$ ) and lowest in *Oxyria digyna* ( $23.16 \pm 0.18$ ). The CF (%) followed a downward trend, as *Rumex nepalensis* ( $25.60 \pm 0.31$ ) > *Aconogonum molle* ( $23.33 \pm 0.27$ ) > *Oxyria digyna* ( $23.16 \pm 0.18$ ). The overall mean of CF in legumes and grasses was  $22.63 \pm 1.40\%$  (Table 1). The mean CF (%) was highest in *Festuca arundinacea* ( $24.03 \pm 0.35$ ) and lowest in *Trifolium pratense* ( $21.23 \pm 0.42$ ) (Table 1). The overall mean NDF in tree leaves was  $44.22 \pm 0.73\%$ . The average NDF (%) was highest in *Quercus semecarpifolia* ( $53.13 \pm 0.39$ ) and lowest in *Salix alba* ( $31.83 \pm 0.25$ ) (Table 1). The overall means of NDF in shrubs was  $40.14 \pm 0.30\%$ . The mean NDF (%) was highest in *Desmodium elegans* ( $43.86 \pm 0.33$ ) and minimum in *Buddleja crispa* ( $40.46 \pm 0.54$ ). The overall mean of NDF in herbs was  $37.61 \pm 0.75\%$ . The mean NDF (%) was highest in *Aconogonum molle* ( $38.40 \pm 0.44$ ) and lowest in *Rumex nepalensis* ( $36.33 \pm 0.35$ ). The overall mean of NDF in legumes and grasses was  $36.73 \pm 0.69\%$ . The mean NDF (%) was highest in *Festuca arundinacea* ( $37.33 \pm 0.42$ ) and lowest in *Trifolium pratense* ( $36.13 \pm 0.36$ ) (Table 1). The overall mean of ADF in tree leaves was  $36.13 \pm 0.57\%$  (Table 1). The ADF (%) was highest in *Quercus semecarpifolia* ( $47.66 \pm 0.29$ ) and lowest in *Salix alba* ( $23.50 \pm 0.37$ ). The overall averages of the ADF in shrubs leaves were  $28.60 \pm 0.49\%$ . Mean of ADF (%) was highest in *Desmodium elegans* ( $38.16 \pm 0.45$ ) and the lowest in *Buddleja crispa* ( $25.17 \pm 0.33$ ). The overall means of ADF in herbs was  $27.27 \pm 0.47\%$ . The mean ADF (%) was highest in *Aconogonum molle* ( $28.80 \pm 0.51$ ) and lowest in *Oxyria digyna* ( $25.66 \pm 0.36$ ) (Table 1). The overall means of ADF in legumes and grasses was  $26.43 \pm 1.02\%$ . The mean ADF (%) was maximum in *Festuca arundinacea* ( $27.70 \pm 0.44$ ) and minimum in *Trifolium pratense* ( $25.16 \pm 0.58$ ).

The overall mean TA content in the tree leaves was  $3.98 \pm 0.19\%$ . The mean TA (%) was recorded highest in *Populus deltoides* ( $8.06 \pm 0.39$ ) > and lowest in *Pyrus pashia* ( $2.57 \pm 0.24$ ). The mean TA content in shrubs was  $4.17 \pm 0.70\%$ . The overall mean of TA content (%) in herbs was  $4.29 \pm 0.75$ . The mean TA (%) was observed highest in *Rumex nepalensis* ( $5.13 \pm 0.23$ ) and lowest in *Aconogonum molle* ( $2.80 \pm 0.36$ ) (Table 1). The trend followed in TA content (%) was as follows, i.e. *Rumex nepalensis* ( $5.13 \pm 0.23$ ) > *Oxyria digyna* ( $4.93 \pm 0.24$ ) > *Aconogonum molle* ( $2.80 \pm 0.36$ ). The overall mean of TA in legumes and grasses was  $4.48 \pm 0.95\%$ . The mean TA (%) was highest in *Festuca arundinacea* ( $5.43 \pm 0.35$ ) and lowest in *Trifolium pratense* ( $3.53 \pm 0.31$ ). The overall mean of AIA in tree leaves was  $2.27 \pm 0.44\%$ . The mean AIA (%) was highest in *Salix alba* ( $4.66 \pm 0.21$ ) and lowest in *Quercus leucotrichophora* ( $0.67 \pm 0.28$ ). The overall mean of AIA in shrubs was  $2.19 \pm 0.25\%$ . The mean of AIA (%) was higher in *Elaeagnus umbellata* ( $3.33 \pm 0.23$ ) and lowest in *Desmodium elegans* ( $1.50 \pm 0.21$ ) (Table 1). The overall mean of AIA in herbs was  $2.39 \pm 0.91\%$ . The mean AIA (%) was highest in *Rumex nepalensis* ( $3.76 \pm 0.38$ ) and lowest in *Oxyria digyna* ( $0.66 \pm 0.23$ ). The overall mean of AIA in legumes and grasses was  $1.71 \pm 0.05\%$ . The mean AIA (%) was highest in *Festuca arundinacea* ( $1.76 \pm 0.24$ ) and lowest in *Trifolium pratense* ( $1.66 \pm 0.30$ ) (Table 1). The means of NFE (%) in the different fodder samples are presented in table 1. The overall

mean NFE in tree leaves was  $48.82 \pm 1.13$  (Table 1). The mean NFE (%) was recorded highest in *Salix alba* ( $54.34 \pm 0.46$ ) and lowest in *Populus deltoides* ( $43.30 \pm 0.27$ ). The overall mean of NFE in shrubs was  $49.78 \pm 1.31\%$ . The highest mean NFE was recorded in *Elaeagnus umbellata* ( $53.23 \pm 0.43\%$ ) and lowest in *Indigofera heterantha* ( $45.00 \pm 0.23\%$ ). The trend in NFE (%) was as follows i.e. *Elaeagnus umbellata* ( $53.23 \pm 0.43$ ) > *Buddleja crispa* ( $52.23 \pm 0.36$ ) > *Elaeagnus angustifolia* ( $51.46 \pm 0.34$ ) > *Rubus saxatilis* ( $49.83 \pm 0.37$ ) > *Desmodium elegans* ( $46.93 \pm 0.13$ ) > *Indigofera heterantha* ( $45.00 \pm 0.23$ ) (Table 1). The overall mean NFE in the herbs was  $55.02 \pm 0.82\%$ . The *Oxyria digyna* contained highest NFE i.e.  $57.10 \pm 0.32\%$  and the minimum NFE content was recorded in *Rumex nepalensis* i.e.  $52.40 \pm 0.72\%$ . The overall mean of NFE in legumes and grasses was  $55.68 \pm 0.53\%$ . The mean NFE (%) was highest in *Trifolium pratense* ( $54.23 \pm 0.48$ ) and lowest in *Festuca arundinacea* ( $57.13 \pm 0.40$ ) (Table 1).

### Discussion and Conclusion

The results obtained in the present study are in agreement with previous studies of (Kumar et al. 2017) who reported that the *Q. leucotrichophora* contained 57.82 to 64.36 (%) of DM. The DM content in this investigation is consistent with that reported by (Azim et al. 2001) who stated that leaves of *Elaeagnus angustifolia* contain 46.7% DM. The DM content recoded in the study are in agreement with the study of (Wangmo, 2018) who stated that *Rumex nepalensis* contains 41.25% DM and *Aconogonum spp.* contained 39.21% DM. (Tomar and Sharma, 2002) reported 15.8 and 18.5% CP in *Salix* and *Robinia*, respectively. Verma, 2020 also reported that leaves of *Quercus leucotrichophora* contained 9.70% CP. Singh et al. 2019 reported that the leaves of *Trifolium* contained 23.98% CP. Verma, 2020 reported that leaves of *Quercus semecarpifolia*, *Q. leucotrichophora* and *Q. glauca* contained 4.25, 4.13 and 4.23% EE, respectively. (Geng et al. 2020) reported that *Aconogonum molle* 0.97% EE which is lower than the findings of the present study. Verma, 2020 also reported that the leaves of *Quercus leucotrichophora* and *Q. glauca* contained 30.69 and 32.27 (%) CF. Chandra et al. 2014 recorded 19.65% CF in the leaves of *Indigofera heterantha*. Results of present study are in agreement with the findings of (Koukolova et al. 2010) reported *Trifolium pratense* contained 18.15% CF. Azim et al. (2001) reported 44.2% NDF in *Robinia pseudoacacia*, which is in agreement with the results of the current study. The findings in the present study are in accordance with results of (Geng et al. 2020) who observed that *Rubus spp.* contained 46.56% NDF. Azim et al. 2001, reported 21% ADF in *Elaeagnus spp.* which is in agreement with the findings of the present study and also reported that the TA in *Populus spp.* and *Robinia pseudoacacia* contained 8.5 and 6.9%. Pandey and Bhatt 2016, also reported that *Rubus spp.* contained 2.97% TA which is in agreement with the findings of the present study. The results in this study are in line with previous study of (Prasanth and Chandran 2017) who reported that *Rubus spp.* contained 0.66% AIA. Verma, 2020 reported that the leaves of *Quercus leucotrichophora*, *Q. glauca* and *Q. semecarpifolia* contained 50.45, 47.34, and 43.97% NFE, respectively. The findings of the present study are in line with the earlier study of (Koukolova et al. 2010) who recorded *Trifolium pratense* contained 42.66% NFE and (Singh et al. 2019) also reported that 44.41% NFE in *Trifolium*. Bagley et al. 1983, reported 39.50% NFE in *Festuca arundinacea*. Based on both analytical data and field observations, it can be concluded that the CP (%) was highest in shrubs ( $17.49 \pm 1.27$ ) and lowest in tree leaves ( $12.99 \pm 0.72$ ). The highest average CF (%) was found in tree leaves ( $31.62 \pm 0.35$ ), while legumes and grasses had the lowest ( $22.63 \pm 1.40$ ). Moreover, the farmer preferences correspond with the nutritional findings, highlighting the most suitable fodder species for optimal animal nutrition. These results provide valuable insights for improving feeding practices among Gaddi shepherds, ultimately enhancing livestock health and productivity in the region.

Table 1: Nutritional parameters of different fodder species utilized in sheep and goat feeding

Category			DM %	CP %	EE %	CF %	NDF %	ADF %	TA %	AIA %	NFE %
	Scientific name	Local Name	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Fodder tree leaves	Quercus semecarpifolia	Kharsu	61.80	9.93	3.20	37.00	53.13	47.66	3.36	1.70	46.23
	Pyrus pashia	Kainth	48.50	14.20	3.00	29.70	42.50	32.66	2.57	1.93	50.63
	Robinia pseudoacacia	Robinia	47.70	14.93	3.06	25.46	42.90	29.33	4.36	2.07	52.16
	Salix alba	Baise	38.38	13.43	3.00	25.46	31.83	23.50	3.73	4.66	54.34
	Morus serrata	Krun	44.73	13.70	1.33	31.50	41.23	34.50	3.63	2.46	49.83
	Populus deltoides	Poplar	49.43	12.56	2.30	33.76	44.10	34.46	8.06	4.03	43.30
	Quercus glauca	Banni	54.56	10.70	2.11	34.40	50.10	44.60	3.23	0.91	49.55
	Quercus leucotrichophora	Ban	57.70	10.93	3.26	35.70	49.90	43.86	3.43	0.67	46.66
	Prunus spinosa	Rihan (Paaja)	43.50	16.53	2.26	30.86	42.33	34.60	3.46	2.03	46.76
Overall Mean (Tree fodders)			49.58	12.99	2.63	31.62	44.22	36.13	3.98	2.27	48.82
Shrubs	Desmodium elegans	Priy	38.43	14.76	3.13	28.36	43.86	38.16	6.80	1.50	46.93
	Buddleja crispa	Kasleyn	32.40	18.80	2.80	22.00	40.46	25.17	4.16	1.96	52.23
	Indigofera heterantha	Kathu	34.03	22.03	3.66	26.73	38.43	27.00	2.56	2.03	45
	Rubus saxatilis	Ankhe	42.10	19.60	2.50	22.46	40.00	29.40	5.60	2	49.83
	Elaeagnus umbellata	Ghinulu	45.36	15.26	3.50	25.40	38.66	25.70	2.60	3.33	53.23
	Elaeagnus angustifolia	Pandrodu	48.00	14.46	3.43	27.30	39.43	26.23	3.33	2.33	51.46
Overall Mean (Shrubs)			40.05	17.49	3.17	25.38	40.14	28.60	4.17	2.19	49.78
Herbs	Aconogonum molle	Tarodi	35.70	15.20	3.20	23.33	38.40	28.80	2.80	2.76	55.56
	Rumex nepalensis	Albar (Jungli palak)	40.13	13.40	3.40	25.60	36.33	27.36	5.13	3.76	52.40
	Oxyria digyna	Suchali	39.16	11.86	2.76	23.16	38.10	25.66	4.93	0.66	57.10
Overall Mean (Herbs)			38.33	13.51	1.14	22.69	37.61	27.27	4.29	2.29	55.02
Legumes and grasses	Trifolium pratense	Berseen	34.10	18.70	2.40	21.23	36.13	25.16	3.53	1.66	54.23
	Festuca arundinacea	Khajar	39.16	11.60	1.90	24.03	37.33	27.70	5.43	1.76	57.13
Overall Mean (Legumes and Grasses)			36.63	15.15	2.15	22.63	36.73	26.43	4.48	1.71	55.68

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