Quercus semecarpifolia Sm in the Himalayan region: ecology, importance, dependency, threats and conservation status

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ABSTRACT

Quercus semecarpifolia is a high altitude oak, ranging up to the timberline in the Himalayan region and forming the climax community on the southern aspect. A study was carried out in Himachal Pradesh to determine the community dependency on oak fodder and to evaluate the effect of season, aspect and altitude on the nutritive composition of oak in 2018-2019. Leaf samples of oak were collected from different provenances starting from 2,400-3,300 m amsl. It was found that leaf ash content didn't vary significantly in different seasons. The nutritional parameters namely moisture (13.93%) and crude fat (4.66%) in winter, crude fibre (32.61 and 32.50%) in monsoon and winter respectively, crude protein (12.17%) in summer and carbohydrates (39.97%) in spring collection were found to be highest. Leaf carbohydrates didn't vary significantly among different aspects. The mean values of nutritional parameters namely ash (4.98%) and crude fibre (33.14%) were found to be significantly better in northern aspect. However, moisture content was at par in northern (14.26%), eastern (13.92%) and western (13.68%) aspects; crude fat in northern (5.11%) and eastern (4.98%) aspects and crude protein in northern (11.68%) and eastern (11.23%) aspects. The ash (5.05 and 4.22%), crude fat (6.12 and 5.95%) and crude protein (10.97 and 10.69%) content was highest >3,200 and 3,000-3,200 m amsl respectively. Moisture content was higher (14.41, 14.08 and 13.97%) >3,200, 3,000-3,000 and 2,800-3,000 m amsl respectively than lower altitudes. However, crude protein was highest (33.09%) >3,200 m amsl and carbohydrates <2,600 m amsl.

Keywords: *Q semecarpifolia*; conservation; ecology; nutritional composition; seasonal variation

INTRODUCTION

The Indian Himalayan region is characterized by its unique ecosystem with a wide range of climates and habitat types which support different flora and fauna. The floral wealth of this region comprises 18,440 species of plants of which 1,748 species are medicinal, 675 wild edibles, 155 of sacred belief, 118 essential oil yielding medicinal plants and 279 fodder plants (Samant and Dhar 1997, Samant 1998, Samant and Pant 2003, Samant and Palni 2000). Forests constitute an important natural resource base in Himalayan region, most important being the temperate broad leaf forests, which are largely dominated by different species of oak (*Quercus* spp). In the western Himalaya, oak species assume considerable conservation significance as they are providers of numerous ecosystem services (conservation of soil, water, native flora and fauna) and serve as lifeline for the local inhabitants. In Himachal Pradesh, availability of green fodder in harsh winter months is very low. Milk yield is also reduced in that period drastically. The growing conditions in winter months are not congenial for growth and development of plants. However, there are few fodder trees in the state which remain green during winter months and leaf fall does not occur in these species during winter months. Oaks are such majestic trees of Himalaya which not only provide aesthetic look throughout the year but also provide quality fodder and fuel-wood during harsh winter months.

Quercus semecarpifolia forests are not only important from the eco-floristic point of view but they are also part of the livelihood of people living in the area. Indeed, it is a multipurpose tree used for fodder, fuel-wood, timber etc (Singh et al 2010), wood for agricultural implements and tannin (Singh et al 2010, Shrestha 2003). Because of high human pressure

(Subedi 2006, Bisht 2001) exploitation and predation (Aryal and Kreigenhofe 2009), forests degenerated in areas where the species was abundant, which may lead to expansion of xerophytic conditions and possibly to the complete extinction of the species (Singh and Singh 1987, Thakuri 2010). Oak leaves and twigs are often grazed by animals during fodder deficit periods (Saklani 1999). Owing to changing climatic conditions, a farmer's preference for a particular tree species is also variable, according to the low, mid and high hill regions depending on where he lives (Verma and Mishra 1998). Oaks (*Quercus* spp) form the dominant, climax forest between 1,000 to 3,500 m elevations in the Indian Himalayan region (Troup 1921) and cover approximately 20,000 km^2 area in parts of the central and western Nepal, Uttarakhand and Himachal Pradesh (Singh and Rawat 2000). Oak tree species are a source of fuel-wood and fodder and can be correlated with natural springs and wildlife (Bargali et al 2013). More than 35 species of *Quercus* have been reported from the Indian Himalayan region (Negi and Naithani 1995), most of which are abundant in temperate forest. *Q semecarpifolia*, which grows naturally in western Himalaya, may show more than 70-80 per cent dominance in oak forest stands located above 2,600 m (Singh and Singh 1992, Zobel and Singh 1997).

Oak tree leaves are an important feed of livestock (Holechek 1984, Papachristou and Nastis 1996, Saklani 1999) and provide nutrition to animals in areas where few or no alternatives are available (Meuret et al 1991).). However, use of tree and shrub leaves by livestock is restricted by defending or inhibitory mechanisms due to the presence of high tannin content (Provenza 1995, Rubanza et al 2003, Bakshi and Wadhwa 2004).

Elahi (2010) assessed the nutritive value of three species of oak tree leaves: *Q persica, Q infectoria* and *Q libani* by chemical analysis and in situ method. The chemical composition (g/kg dry matter basis) of the above species was as follows: 951, 927 and 946 organic matter (OM); 115, 92 and 123 crude protein (CP); 532, 540 and 512 neutral detergent fiber (NDF); 317, 300 and 331 acid detergent fiber (ADF); 98, 103 and 95 lignin (ADL); 78, 115 and 104 total phenols; 73, 109 and 100 total tannins (TT); 14, 15 and 12 condensed tannin (CT) and 46, 87 and 62 hydrolysable tannin (HT) respectively. Protein precipitable phenolics (PPP) were 160, 190 and 230 (g/kg total phenols) respectively.

The fibre composition of young and mature leaves of *Q incana* was evaluated. It contained 16.47 per cent crude protein, 18.29 per cent CF, 5.71 per cent EE, 3.87 per cent ash and 55.66 per cent NFE, while the mature leaves contained 9.40 per cent CP, 33.62 per cent CF, 6.22 per cent EF, 2.13 per cent ash and 48.63 per cent NFE (Makkar et al 1991).

Paswan and Sahoo (2012) analyzed the nutrient composition of oak (*Q leucotrichophora*) leaves from Kumaon Himalaya and reported that the it contained 59.9 g ether extract, 802 g total carbohydrates, 631 g neutral detergent fibre, 492 g acid detergent fibre, 216 g lignin, 37.2 g ash, 3.10 g acid insoluble ash, 11.1 g Ca and 0.72 g P per kg of dry matter. Barman and Rai (2008) studied the tannin fractionation in the top foliage of *Q incana* and reported that the leaves of it contained 9.39 per cent total phenols, 1.23 per cent non-tannin phenols, 8.16 per cent total tannins, 5.33 per cent hydrolysable tannins and 2.83 per cent condensed tannins.

In recent few decades, due to over exploitation, widespread logging, overgrazing and removal of leaves and wood by the local communities (Gorrie 1937, Chaturvedi 1985), replacement of oak by pine (Singh et al 1984) has become a common and ever increasing phenomenon in the western Himalayan region. All the gentle and accessible meadows in the temperate, alpine and sub-alpine regions have undergone extensive habitat degradation and exploitation, with over 70 per cent of the natural vegetation reported to have been lost (Singh 1991). In some pastures, grazing is essential to maintain species diversity (Naithani et al 1992, Negi et al 1993, Saberwal 1996) mainly in the Himalayan alpine region, but some other studies (Ram et al 1989, Sundriyal and Joshi 1990, Singh 1991, Rawat and Uniyal 1993, Kala et al 1998) observed that intermediate level of grazing maintains species diversity. Kala et al (1995) reported that besides livestock grazing and other abiotic factors like snowfall, soil, altitudes and aspects also influence the structure and composition of these pastures.

This paper mainly highlights the three major forms of activities that have affected the western Himalayan Kharsu oak forests viz community dependency on Kharsu oak forests, seasonal pattern of fodder collection and ascertaining seasonal variation in nutritive value of Kharsu oak fodder. All these three activities are linked with subsistence living of the local population of the hills.

METHODOLOGY

Study area

The present study was conducted in five forest divisions of Himachal Pradesh having good Kharsu oak forests (Fig 1). The area is characterized by its unique undulating topography, wide variation in the altitude, rainfall, temperature and soil conditions. The area is an important wintering ground for several high altitude animals and is used by a large number of local agro-pastoral and migratory community (Gujjars) besides tourists during summer. The intensive study area covered a wide altitudinal range from 2,400-3,500 m amsl with the varying mean annual temperature range (–4 to 30°C). The main pressure on it is in the winter season involving grazers like sheep, goats and buffaloes along with the load of agro-pastoral migratory community and collection of fuel-wood and fodder. Livestock rearing and tourism are the main land use practices across different altitudinal zones in the region.

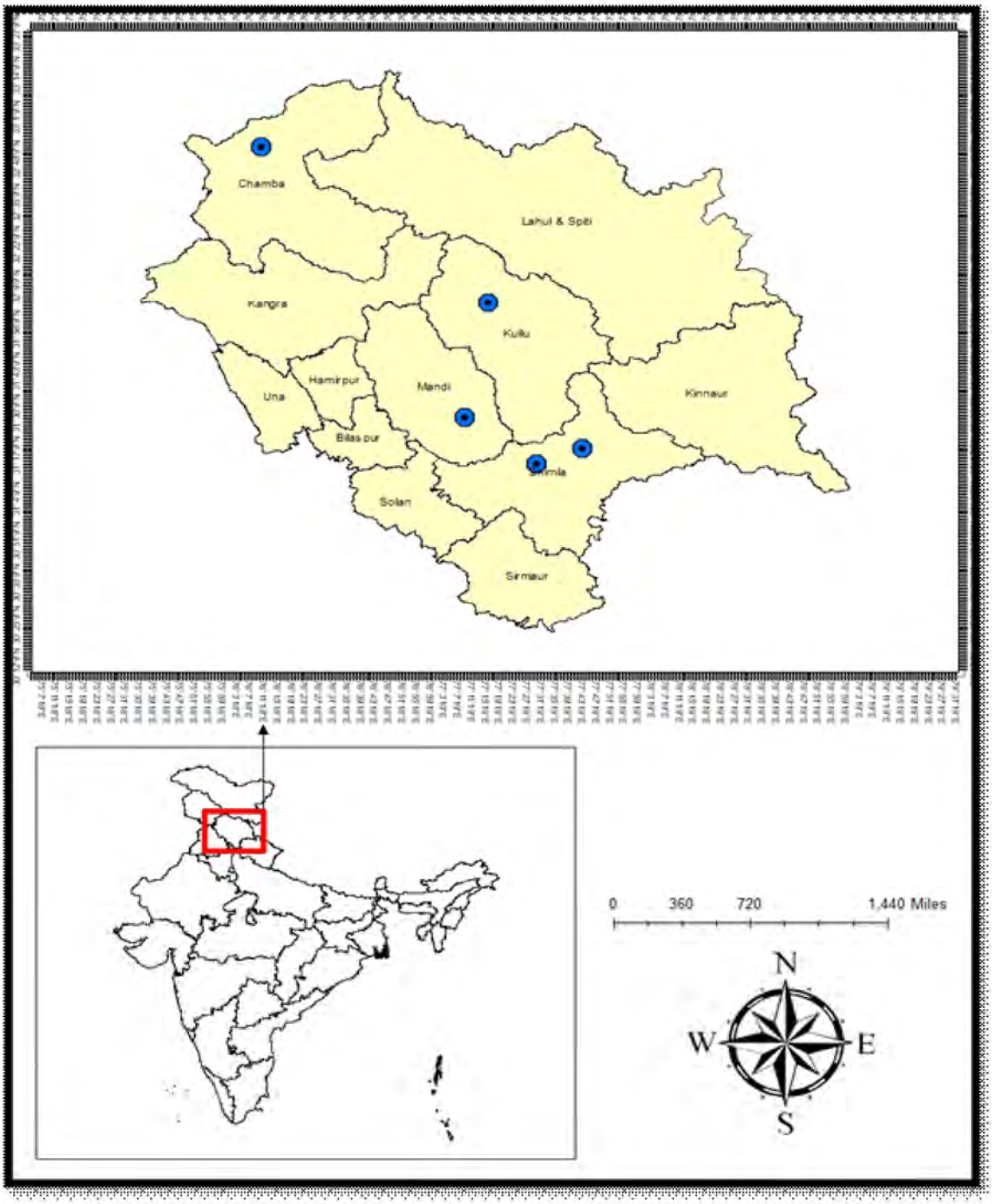

Fig 1. Map showing the study area

Data collection and analysis

A field survey was carried out from March 2018 to January 2019 to study the fodder dependency on Kharsu oak forests and seasonal variation in its nutritive value along the altitudinal gradient. Based on extensive reconnaissance survey and dominance, community dependency survey on its fodder, five forest/wildlife divisions viz Churah, Kotgarh, Nachan, WL Sarahan and Parvati were selected for the vegetation study. From all the five selected forest divisions, where its good forest was present, one forest range was selected randomly for the community dependency survey. From different forest ranges, blocks were selected in similar way. Multistage random sampling was followed for the survey in villages under different forest divisions. Only those beats having 33 per cent or more of Kharsu oak species were surveyed.

To assess the nutritional components in Kharsu oak leaves, foliage was harvested from selected sites between 2,400 to 3,400 m elevations. Leaf samples were collected from March 2018 to January 2019 on seasonal basis. After sun drying, leaves were crushed in mechanical grinder to get fine powder for determination of the chemical composition. All the nutritional values were recorded in percentage (Anon 1990). Moisture content was determined using the weight difference method. Dry ash was also determined using the weight difference method. Crude fat was determined by weight difference method using the Soxhlet apparatus. The nitrogen value, which is the precursor for protein of a substance, was determined by digestion, distillation and titration in Micro-Kjeldahl apparatus as described by Pearson (1976). The nitrogen value was converted to protein by multiplying with protein factor 6.25. Crude fiber was determined using acid-alkali treatment method. Carbohydrate content was determined using the difference method.

Variation in the nutritive value of Kharsu oak species was determined at 2,400-3,400 m amsl. An altitudinal gap of 200-400 m was maintained to collect the leaf samples. Leaf samples were collected at different altitudes from selected forest divisions of the state and brought to the laboratory. The samples were crushed in the plant grinder and then weighed. The ground samples were thoroughly mixed, weighed and subjected to analysis of chemical composition (crude protein, crude fat, crude fibre, moisture content and carbohydrates) and leaf biomass production.

Variation in nutritive value of Kharsu oak species along different aspects was also determined. In the present study, four aspects were taken viz north (N), west (W), east (E) and south (S). Kharsu oak forests generally occur in northern aspect, hence, northern and eastern aspects were the important aspects for the study.

Field data were analyzed both in regress (scientific purpose) and simple (convenience of local people and management authority) methods, where these were quantitatively analysed for moisture content, ash content, crude fat, crude fibre, crude protein and carbohydrates following the standard ecological methods. Various parameters like fodder dependency and seasonal patterns of collection of oak fodder were assessed by using graphical methods.

RESULTS and DISCUSSION

Survey of community dependency on Kharsu oak fodder

The oak fodder dependency survey was carried out to achieve the objectives of estimation of dependency of local communities on Kharsu oak fodder and to determine the seasonal pattern of collection of fodder in various forest divisions of the state. The household dependency on private land or forest land for fodder is presented in Table 1 (Fig 2). The perusal revealed heavy dependency on Kharsu oak leaf fodder currently from forest land in all five divisions studied. The forest divisions Churah, Kotgarh, Nachan and Parvati exhibited higher fodder dependency on forest land as compared to private land. In contrast, the WL division, Sarahan exhibited the slightly higher dependency on private land in comparison to forest land. Kotgarh, Parvati and Churah forest divisions recorded >90 per cent dependency on forest land.

The household dependency on private or forest land for Kharsu oak fodder 10 years ago is presented in Table 2 (Fig 3). The perusal revealed heavy dependency on Kharsu oak leaf fodder 10 years ago from forest land in all five divisions studied. Forest divisions Churah, Kotgarh, Nachan, Parvati and WL Sarahan exhibited higher fodder dependency on forest land as compared to private land. The forest divisions Nachan, Parvati and Kotgarh also exhibited higher dependency (60%) on private land, whereas, WL division Sarahan recorded minimum dependency (22.20%) on private land.

Table 1. Current household dependency on Kharsu oak fodder from private and forest land

Forest/wildlife division	Household dependency for fodder (%)	
	Private land	Forest land
Churah	36.0	93.30
Kotgarh	70.80	97.90
Nachan	81.20	89.50
Parvati	80.40	96.90
WL Sarahan	84.40	77.70

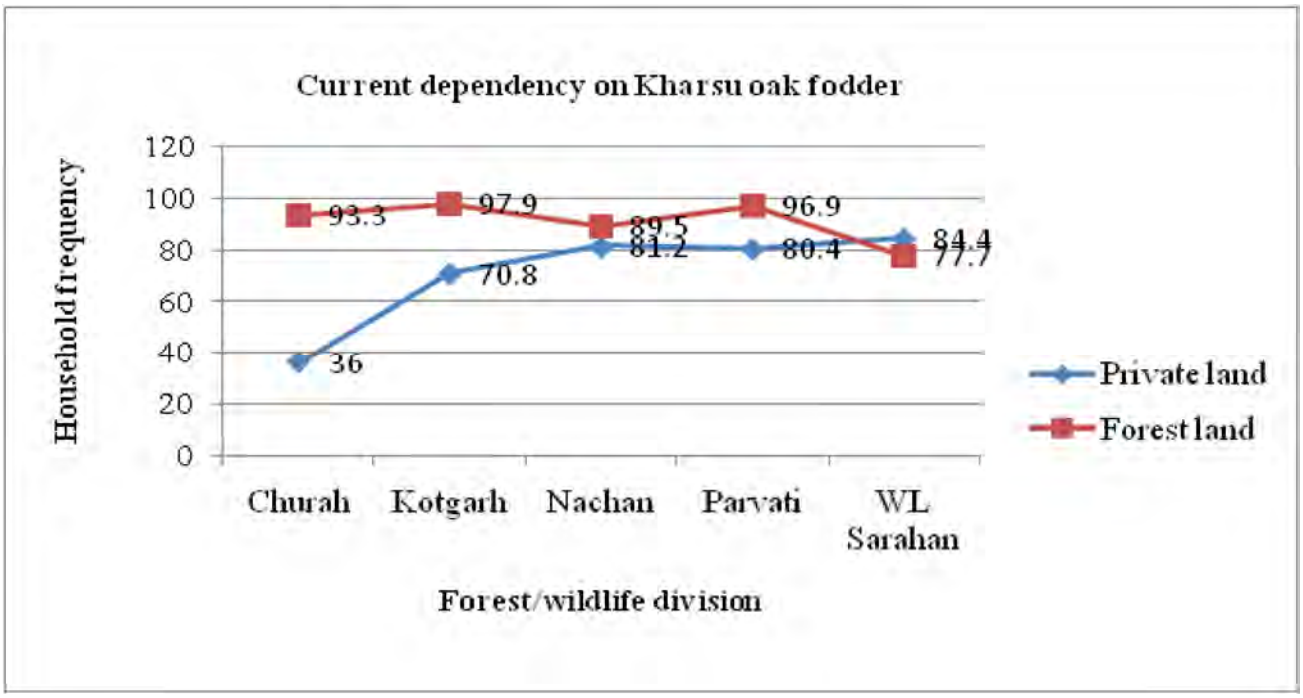

Fig 2. Current community dependency on Kharsu oak fodder in various forest/wildlife divisions of Himachal Pradesh on private and forest land

The study revealed that Kotgarh, Parvati and Churah forest divisions recorded >90 per cent dependency on forest land for the collection of leaves for green fodder. However, in WL division Sarahan, an increase in dependency on private land from 22.20 (10 years ago) to 84.40 (current) per cent for collection of leaves was recorded. It indicates that now strict implementation of wildlife sanctuary rules and regulations, local communities have shifted preference towards private land for collection of Kharsu oak leaves and other forms of green or dry fodder.

Seasonal pattern of collection of Kharsu oak fodder

In the state of Himachal Pradesh, the local communities are heavily dependent on oak fodder particularly in the winter season when there is scarcity of other types of green fodders in the hills. The study revealed that some of the divisions recorded higher and some recorded least dependency on oak fodder in particular season of the year. The data on household dependency on Kharsu oak leaf fodder in different seasons from private land and percentage of seasonal collection are presented in Table 3 (Fig 4) which revealed that seasonal fodder collection variability existed in various studied divisions. In general, winter season was found to be the most preferred season in all the forest divisions to collect fodder from private land. In the studied divisions, fodder was collected only during winter and summer seasons and recorded zero collection during monsoon season. Even in summer season, Nachan and Kotgarh forest divisions recorded some Kharsu oak collection from private land, whereas, it was negligibly collected in other divisions.

Table 2. Household dependency on Kharsu Oak fodder from private and forest land 10 years ago

Forest/wildlife division	Household dependency for fodder (%)	
	Private land	Forest land
Churah	33.30	96.00
Kotgarh	60.40	83.30
Nachan	81.20	93.70
Parvati	68.00	88.60
WL Sarahan	22.20	75.50

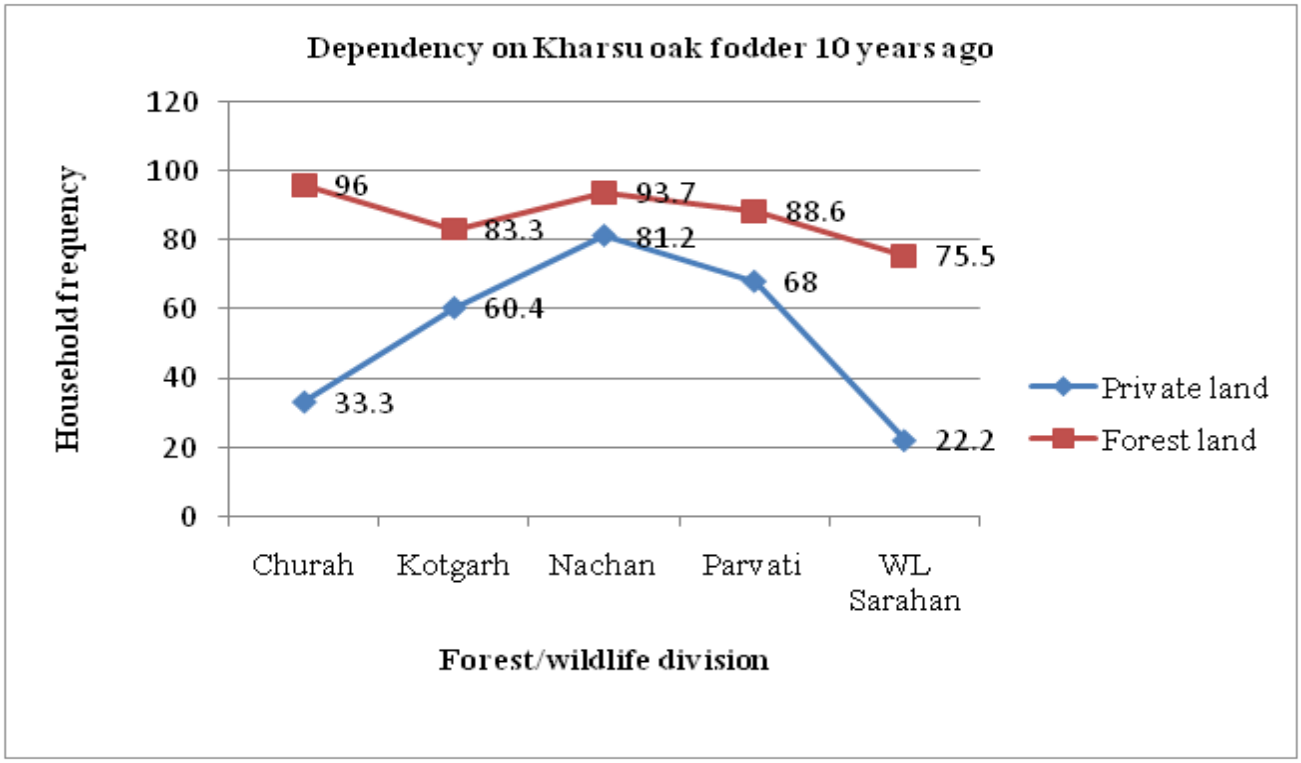

Fig 3. Community dependency on Kharsu oak fodder in various forest/wildlife divisions of Himachal Pradesh on private and forest land 10 years ago

Thus maximum fodder was collected only during winter and summer seasons and zero collection was recorded during monsoon in private land. Nachan and Kotgarh forest divisions recorded some Kharsu oak collection in summer season from private land, whereas, its collection was negligible in other forest divisions. Only winter preference was recorded in the forest land of the WL Sarahan division for collection.

Seasonal variation in nutritive value of Kharsu oak fodder

The Kharsu oak fodder in Himachal Pradesh is collected in various seasons by local communities to meet their green fodder requirements. Accordingly, the seasonal influence on various nutritional parameters of fodder was assessed. The corresponding mean values of different parameters have been depicted in Table 4. The perusal of the data revealed that leaf ash content didn't vary significantly in different seasons. The mean values of nutritional parameters namely moisture (13.93%) and crude fat (4.66%) in winter, crude fibre (32.61 and 32.50%) in monsoon and winter respectively, crude protein (12.17%) in summer and carbohydrates (39.97%) in spring collection were found to be highest as compared to other seasons.

Influence of aspect on nutritional value of Kharsu oak fodder

The influence of aspect on various nutritional parameters of Kharsu oak leaf fodder was assessed. Local communities collect leaf fodder of this oak species to meet their green fodder requirements

Table 3. Seasonal pattern of Kharsu oak fodder collection in private land in various forest/wildlife divisions

Forest/wildlife division	Collection (%)		
	Summer	Winter	Monsoon
Churah	2.6	39.4	0
Kotgarh	20.7	74.7	0
Nachan	39.4	80.2	0
Parvati	3.09	79.25	0
WL Sarahan	5.7	52.6	0

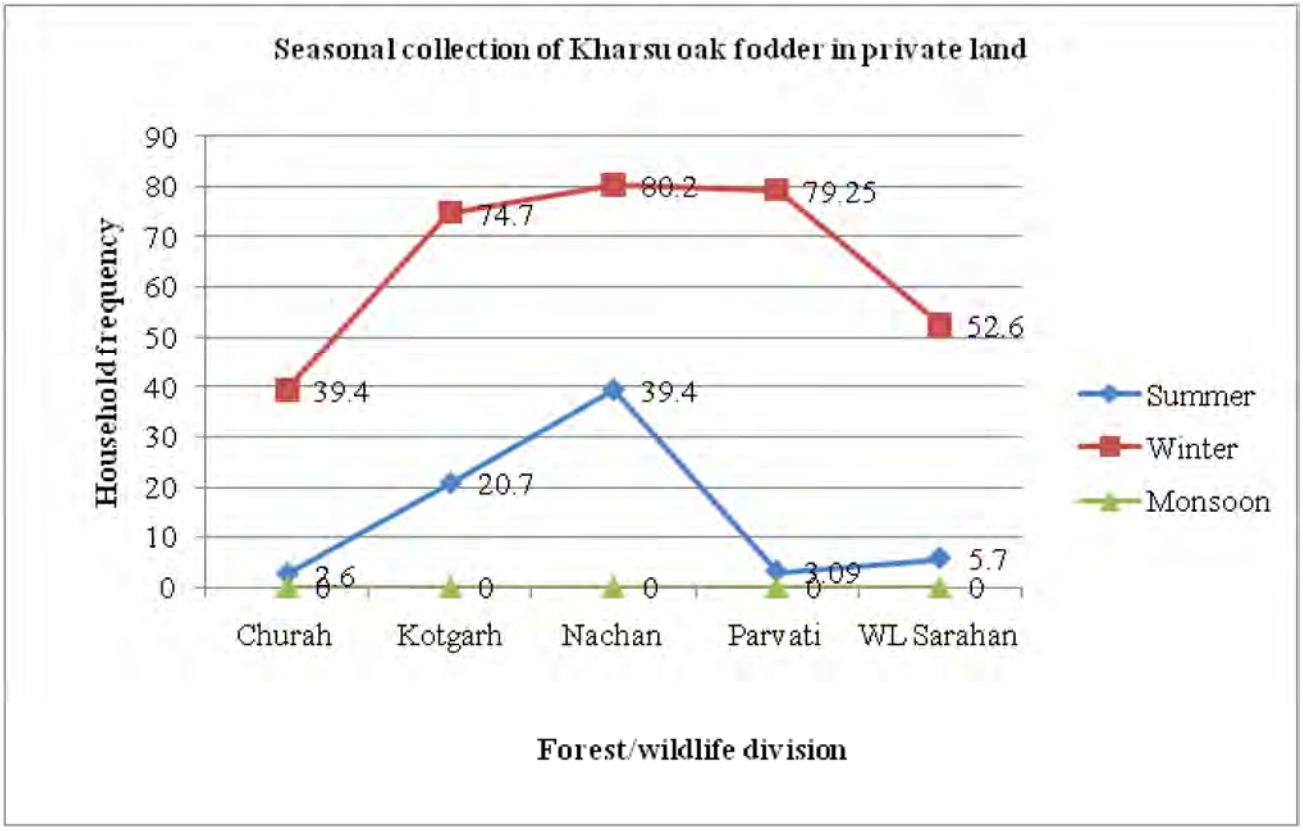

Fig 4. Seasonal pattern of Kharsu oak fodder collection from private land in various forest/wildlife divisions

irrespective of the aspect. The data (Table 5) revealed that carbohydrates present in leaves didn't vary significantly among different aspects. However, content of ash, moisture, crude fat, crude fibre and crude protein varied significantly in different aspects.

The mean values of nutritional parameters namely ash (4.98%) and crude fibre (33.14%) were found to be significantly better in leaves collected from northern aspect as compared to other aspects. However, moisture content was at par in northern (14.26%), eastern (13.92%) and western (13.68%) aspects; crude fat in northern (5.11%) and eastern (4.98%) aspects and crude protein in northern (11.68%) and eastern (11.23%) aspects.

Influence of altitude on nutritional value of Kharsu oak fodder

The influence of altitude on various nutritional parameters of Kharsu oak leaf fodder was assessed. The fodder was collected from forest land as well as from private land wherever it was located. In general, it is found in altitude ranging from 2,600 m to 3,000 m in the state. However, owing to micro-climatic conditions, it comes down to around 2,500 m along water streams extending up to 3,500 m in warmer localities in Himalayan region. The corresponding mean values of different parameters have been depicted in Table 6. A perusal of the data revealed that content of ash (5.05 and 4.22%), crude fat (6.12 and 5.95%) and crude protein (10.97 and 10.69%) content was highest

Table 4. Seasonal influence on various nutritional parameters of Kharsu oak leaf fodder

Season	Content (%)					
	Ash	Moisture	Crude fat	Crude fibre	Crude protein	Carbohydrates
Spring	4.19	11.19	4.06	29.41	11.18	39.97
Summer	4.31	10.85	3.76	29.94	12.17	38.97
Monsoon	4.42	10.88	4.19	32.61	11.29	36.61
Winter	4.41	13.93	4.66	32.50	10.44	34.06
$CD_{0.05}$	NS	2.65	0.12	2.33	0.10	0.19
SEm(±)	-	1.17	0.05	1.03	0.05	0.09

Table 5. Influence of aspect on various nutritional parameters of Kharsu oak leaf fodder

Aspect	Content (%)					
	Ash	Moisture	Crude fat	Crude fibre	Crude protein	Carbohydrates
Northern	4.98	14.26	5.11	33.14	11.68	30.83
Eastern	4.56	13.92	4.98	32.68	11.23	32.63
Southern	3.11	13.14	4.26	32.12	10.14	36.3
Western	3.98	13.68	4.41	32.34	10.34	36.12
$CD_{0.05}$	0.33	0.67	0.68	0.43	0.66	NS
SEm(±)	0.15	0.30	0.30	0.19	0.29	NS

>3,200 and 3,000-3,200 m amsl respectively than lower altidudes. Moisture content was higher (14.41, 14.08 and 13.97%) >3,200, 3,000-3,000 and 2,800-3,000 m amsl respectively than lower altitudes. However, crude protein was highest (33.09%) >3,200 m amsl and carbohydrates <2,600 m amsl.

CONCLUSION

Kharsu oak is an important tree species for the livelihood of the local people in the temperate broadleaved Himalayan forests. It is valued for multiple benefits reaped by the local communities in the Himalayan region. This species seems to be degrading day by day. The outcome of the present study revealed that Kharsu oak species was collected mainly in winter through spring up to summer season in various regions of Himachal Pradesh corresponding to green fodder deficiency during that period. It was found that its leaves collected in winter had maximum moisture and crude fat content; in summer had maximum crude protein content and in spring had maximum carbohydrates. Crude fibre content was higher in monsoon and winter. Northern aspect had highest ash and crude fibre, northern, eastern and western aspects had higher moisture, northern and eastern aspects had higher crude fat and crude protein content. The nutritional content increased with the increase in altitude except carbohydrates where it decreased with the altitude. Therefore, based on the findings, it is recommended to collect Kharsu leaf fodder from higher altitudes in their natural distributional range.

Table 6. Influence of altitude on various nutritional parameters of Kharsu oak leaf fodder

Altitude (m) amsl	Content (%)					
	Ash	Moisture	Crude fat	Crude fibre	Crude protein	Carbohydrates
<2600	3.66	12.86	4.07	30.88	9.76	38.77
2,600-2,800	3.65	13.34	4.52	31.42	9.80	37.26
2,800-3,000	4.06	13.97	5.02	31.76	10.18	34.37
3,000-3,200	4.22	14.08	5.95	30.88	10.69	32.18
>3,200	5.05	14.41	6.12	33.09	10.97	30.35
$CD_{0.05}$	0.85	0.68	0.80	1.14	0.72	1.23
SEm(±)	0.39	0.31	0.37	0.52	0.33	0.56

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