CHAPTER IV

FORAGE RESOURCES AND LIVESTOCK FORAGING BEHAVIOUR

4.1 INTRODUCTION

An important aspect for forage evaluation is to augment fodder quantity and quality, primarily through the yield assessment of different species, as well as nutritive compositions of forage (Grovum 1988). A large variety of tree species, forest floor phytomass and agricultural by-products are used as animal fodder in the Himalaya (Sundriyal 1995). Digestion and metabolism trails on fodder and grasses contribute to their metabolic evaluation (Van Soest 1994). Palatability of a species depends on its chemical constituents, growth stage and plant-compositions (Heady & Child 1994). Palatability is best understood as the interaction between taste and post-ingestive feedback, which is determined by an animal's physical condition relative to a plant's chemical characteristics. Thus if food is useful, palatability increases, and conversely, if the food is harmful, palatability decreases (Heady & Child 1994; Provenza 1995). The chemical composition of forage changes with maturity of plants (Phillips *et al.* 1954; Loper & Smith 1961; Decker *et al.* 1967; Brown *et al.* 1968) and in different plant components, i.e. inflorescence, leaves and stem (Fleming 1963; Davey & Mitchell 1968; Krueger *et al.* 1969; Smith 1970). Attempts have been made to know comparative botanical and chemical composition of the grazing animals' dietary composition (Cook 1954; Cook *et al.* 1963; Van Dyne & Heady 1965a, 1965b; Sundriyal 1995). The factors governing palatability of range forages and preference by grazing animals are complex and are not well understood, because of

the difficulty of accurately measuring dietary composition (Cook & Stoddart 1953; Heady 1964). Calcium and phosphorous are required for normal growth of animals. Crop residues and dry fodder are fibrous in nature due to the presence of structural carbohydrates like cellulose, hemicellulose and pentosans. These structural carbohydrates are in physical association with lignin in the plant cell walls. With maturity of plants the amount of lignin is closely bounded to cellulose by means of linno-cellulosic bonds. Thus lignin reduces the digestibility of dry fodder.

The Sikkim State is recognised as a potential region for intensive livestock production (Balaraman & Golay 1991). A large number of species are used as fodder resources in Sikkim State, out of which a few are considered good quality fodder. However, limited attempt has been made to augment the fodder resources in the state, which can go a long way in translating this potentiality into a practical reality. A recent assessment of feed and fodder availability position for livestock in the state indicate an acute shortage in terms of green fodder, dry forage and concentrates (Balaraman & Golay 1991; Paljor 1998). Generally, stall feeding of animals is popular at low and mid-hills, which is slowly converting to free grazing due to easy access to forest areas. At higher elevations, however, free grazing by locals and nomads is most popular and traditional.

In the core zone of the Khangchendzonga Biosphere Reserve, free grazing is officially banned, however the locals still practise free grazing in forested pastures and alpine and subalpine areas. The mid-elevations

support animals throughout the year, while the higher elevations are visited during summer and rainy seasons only. Khangchendzonga Biosphere Reserve has a large variety of fodder resources, which includes herbs, shrubs and trees, and some of these are highly palatable and rich in nutrient content. However, till date no attempt has been made to evaluate all these fodder resources quantitatively as well as qualitatively. The present chapter provides details about the available fodder resources and their annual production, and an estimation of the nutritive values of some potential species. An attempt has also been made to study animal foraging behaviour in the process of free grazing. It is considered that the information will have larger implications for livestock management in this Biosphere Reserve.

4.2 METHODS

Detailed surveys were made with reference to the availability of fodder resources, types of plant species used, mode of feeding at different elevations from Yuksam to Dzongri in the Khangchendzonga Biosphere Reserve. Formal and informal interviews were made with the villagers and graziers, and fodder collections sites as well as livestock rearing places were visited physically to verify the fodder source. The total number of grazing livestock was counted through household survey. Fodder collected from the forest were quantified on back-load basis, as this is most common expression by the villagers and graziers throughout the state (Balaraman & Gollay 1991; Sundriyal *et al.* 1994). Different households collect such back-loads on daily basis, and 52 representative

sample households were investigated. The fresh weight of fodder per back-load was quantified and thus a mean value was derived.

Local residents were interviewed with reference to animal preference of fodder. Animals were fed with composite samples of many fodder plants. Observations were made on number of bites for each fodder. It was assumed that the fodder received higher number of bites is most preferred by an animal. The ranking of preference (high, medium and least preferred) was developed. The average quantity of forage consumption per animal per day was estimated by feeding an animal with the known quantity of fodder, and thus total consumption was recorded for different types of animals. Observations on duration of grazing time by livestock at different elevations, bite frequency, size and composition of each diet, forage preference, availability of food and degree of herbage exploitation was noted through field study.

Forage production

The forage biomass production of agroforestry fodder species was calculated by recording tree measurements, mainly height, canopy covers, bole height and number of branches. Thereafter branches of different sizes were lopped for all available fodder, which was quantified and calibrated for whole tree considering total number of branches. Such method is considered of high accuracy and is preferred for all agroforestry tree species (Sharma *et al.* 1992; Sundriyal *et al.* 1994). As the grasslands meet most annual fodder demand, a detailed description of the forage quantity and productivity along the trekking trail is presented separately in Chapter V and VI.

Animal grazing behaviour

Total days foraged in temperate, subalpine/near timberline and alpine pastures were counted for different grazing animal types. Foraging period, grazing bite rate, bite size and daily forage consumption rate by the different animal types in different ecological zones were calculated for the estimation of total forage demand or animal requirement (Sundriyal & Joshi 1989). Since alpine and subalpine have almost similar foraging characteristics, only one value is presented.

Foraging period

Time period of grazing by animals was noted by recording time for free grazing in the pasture. Time was recorded for animals removed for free grazing in the morning and collected from free grazing in the evening. Time spent by single marked individuals of different animal groups for various activity e.g. walking, resting, and other activities during the grazing hours of a day was noted. The grazing hours per day per animal group i.e. the period for which animals remain in the field for grazing was recorded during different months. Hours spent on grazing per day by different animal group were calculated as;

Foraging hours (hrs day^{-1}) = Grazing hour day^{-1} – (time spent on walking + time spent on resting + time spent on other activities).

Bite rate

Bite rate means the number of bites per unit time. The number of grazing bites per animal group was counted in a fixed time interval of 15 minutes. Animals were observed closely and calmly from a very near

distance to note the bite cut of plants, which gives an audible sound. The intensity of grazing vary from morning to evening hours, therefore number of bites was noted at 10 a.m., 1.00 p.m. and 3.00 p.m. on each sampling date. Data were recorded for each individual animal ($n = 4$) and values were averaged and converted as bite per animal per hour or per day.

Bite size

To note the bite size of different animal groups, two patches of 30×30 cm, almost similar in species composition were selected before grazing. A number of such patches were selected at each sampling date. Individuals of different animal groups were allowed to graze one of such patches and numbers of bites were counted. Thereafter, intact patch was harvested at ground level, oven dried and weighed. Similarly, grazed patch was also harvested and dried mass was weighed. No data were recorded when animals grazed both of the adjacent patches. Bite size was calculated as;

$$\text{Bite size} = (W_2 - W_1)/N$$

Where, W_2 = biomass weight of the intact patch, W_1 = biomass weight of grazed patch, N = number of bites on grazed patch.

Forage dry matter consumption per animal per day = Bite size × total number of bites per day during total hours of grazing.

Nutrient analyses

Alpine and subalpine plants were surveyed to estimate nutritive values of the most commonly and preferably grazed species. Samples were collected in August, when biomass peaked and species was most

available for grazing. Chemical analyses were done in the laboratory for leaves of fodder tree species and for whole aboveground material in case of alpine/subalpine herbaceous species. The leaves of most palatable fodder species were brought to laboratory, and oven dried at 60°C till constant weight. The dried samples of different species were ground into powder by an electrical grinding machine and sieved through 1 mm wire gauge for uniform particle size. Such material was used for estimation of nutrients following standard methods (Allen 1989; Anderson & Ingram 1993).

Crude fibre

Crude fibre is essentially the residue left after subsequential hot digestion with H_2SO_4 and NaOH. It mainly consists of cellulose together with a little lignin. Crude fibre was determined by acid and alkali digestion method using Tecator Fibretec apparatus.

Acid detergent lignin

Acid detergent lignin (ADL) was determined using Fibretec apparatus by de-fatting a known weight of plant sample (W_1) with acetone (cold extraction) and with acid detergent solution (hot extraction), and washed with hot water. The sample was mixed with H_2SO_4 for three hours, again washed to free from acid. It was dried, weighed (W_2) and ashed in muffle furnace at 525°C for three hours and again weighted (W_3). The ADL was calculated as per following formula:

$$\text{ADL (\%)} = \frac{(W_2 - W_3) \times 100}{W_1}$$

Cellulose and hemicellulose

Cellulose was determined by de-lignification of plant samples, which yield the product consisting of cellulose plus various other polysaccharides, mainly hemi-cellulose. Cellulose was determined by difference of acid detergent fibre minus acid detergent lignin. Hemi-cellulose was determined as the difference of nutrient detergent fibre and acid detergent fibre using Fibretec apparatus.

Nitrogen and crude protein

Nitrogen was estimated following modified Kjeldahl method by digesting the samples with sulphuric acid and catalysts (copper sulfate, mercuric oxide, selenium powder and potassium sulfate) (Allen 1989). Crude protein was obtained by multiplying with a factor 6.25 to the nitrogen per cent which is based on the assumption that plant protein consist of 16% nitrogen.

Phosphorus

Phosphorus was estimated by the colorimetric determination using molybdate reagent and the ascorbic acid (Anderson & Ingram 1993). Absorbance was taken at 880 nm in the UVS spectrascan.

4.3 RESULTS

Fodder resources varied at different elevations along the Yuksam-Dzongri trail. At Yuksam, the fodder demand was met from forest floor phytomass, trees, agroforestry species and agricultural byproducts. With the increasing elevation the contribution of forest floor phytomass incresaed upto almost 100%. At subalpine and alpine sites the pasture

meet the total fodder demand of the animals. This chapter reports on the fodder from forest, agricultural lands, and alpine and subalpine pastures. A checklist of fodder species along with preference ranking and availability period in temperate, agriculture land, alpine and subalpine areas has been presented (Table 4.1).

4.3.1 Fodder from the Forests and Agriculture Land

Fodder from forests

At Yuksam settlement, the doorstep to the buffer zone of the Khangchendzonga Biosphere Reserve, an average family maintains 5-6 animals, which consists of cattle, sheep, goat, dzo and pig. A total of 43 fodder species were collected from forest (Table 4.1), out of them 24 species were trees, 11 shrubs, 4 herbs, 3 climbers and one epiphyte (Table 4.2). These plants belong to 35 genera of 25 families. Species representation from the families Moraceae (7 spp.), Araliaceae (4 spp.), Aceraceae (3 spp.), and Poaceae (3 spp.), were more. In terms of fodder-preference ranking, 17 species were recorded as highly preferred, 19 with medium-preference, while remaining 7 species were relatively less preferred (Table 4.2). Community collected fodder from forest during different seasons, and an average family collected 38 kg fodder per day from forest. Thus annually 13,500 kg fodder was collected by each household at the Yuksam Block. Total grazing animal numbering 1559 was reared by 274 households at Yuksam (399 cattle, 435 sheep, 320 goat, 120 dzo, 31 horse and 254 pig). Based on individual household fodder requirement, a total of 1303 ton fodder was needed annually

averaging 3.57 tons household^{-1} yaer^{-1} at the Yuksam Block. Around 83% of the fodder requirement come from the forest and the remaining from agroforestry and agriculture residues (Table 4.4).

Tshoka is the last settlement in this trail and 10 families reared animals like cow, dzo and horse. Animals were generally left for free grazing except small calves and a few lactating animals. Most animals were given small quantity of fodder at the sheds once in the late evening. Fodders belonging to a few species, viz. *Acer campbellii* (Milo Kapasey), *Arundinaria maling* (Malingo), *Schefflera impressa* (Bhalu chindey) and *Pentapanax leschenaultii* (Chindey) were collected and fed to animals.

Fodder from the agriculture land

Farmers at Yuksam block also maintain a few species in their farms as forage bank, particularly for dry and lean season (i.e. January-March). Ten fodder tree species were recorded being maintained for lean season (Table 4.2). Eight species (*Arundinaria maling*, *Bambusa* sp., *Brassaiopsis mitis, Ficus cunia, F. nemoralis, F. roxburghii, Saurauia napaulensis* and *Thysanolaena maxima*) were most preferred. Each household was maintaining on an average of 30 fodder trees in their farms. Among agroforestry fodder species, *Ficus roxburghii* produced highest forage biomass, which doubled than any other fodder trees, and this species is most preferred by animals. On an average each household produced 445 kg annum^{-1} fodder from *Ficus roxburghii* (c. 45 kg tree^{-1} annum^{-1}). Contrarily, the forage production for *Ficus nemoralis* was recorded less amounting to 49 kg annum^{-1} household^{-1} (c. 12 kg tree^{-1}

annum^{-1}). Other species had intermediate range of fodder production (Table 4.3). Household estimates revealed that each family could generate at least 793 kg of dry fodder per annum from agroforestry species in the Yuksam Block (Table 4.3). The annual fodder from the agricultural land was estimated to be 217 ton raised in 274 households. This amounts to around 17% of green fodder requirement as contributed by the agroforestry fodder trees (Table 4.4).

4.3.2 Fodder from Subalpine and Alpine Pastures

In alpine and subalpine areas all the graziers practise free grazing, and the pastures composed a large variety of lush green species, which is a mixture of both dicot and monocot species. The animals visit all accessible locations and generally cow, yak, dzo and horse prefer plateau, while sheep can graze effectively even in steeper regions. Though the animals graze a large number of species, on the experimental basis high preference was recorded for *Poa* spp., *Juncus thomsonii*, *Aletris pauciflora*, *Potentilla coriandrifolia*, *Geranium nakaoanum*, etc. Generally, livestock grazed 17 common forage species in alpine/subalpine pastures, out of which 41.2% were highly palatable, 29.4% medium preferred and remaining 29.4% were least preferred (Table 4.2).

4.3.3 Animal Foraging Behaviour

In temperate pasture dzo has the highest bite rate (51.5 bite min^{-1}) whereas sheep had the least (41.2 bite min^{-1}). Dzo also showed maximum bite size (105.6 mg bite^{-1}) and minimum bite size (53.0 mg bite^{-1}) by

goat. Highest foraging hour was recorded in dzos (11.9 hrs day^{-1}) and least in goat (9.3 hrs day^{-1}). Cow and goat grazed throughout the year in temperate zone except a few cows that grazed briefly (3 months) in alpine areas. Sheep grazed about 255 days in temperate pastures. The forage intake rate on dry weight basis was maximum for dzo (3.88 kg day^{-1}) and least for sheep (1.27 kg day^{-1}). In temperate pastures, cow consumes 1250 kg of dry forage per annum whereas least by sheep (323 kg yr^{-1}) (Table 4.5).

The foraging characteristics of cow, dzo, yak, horse, sheep and goat at different ecological zones are given in Table 4.5. In alpine/subalpine zones, dzo has the highest grazing bite rate (59.5 bites min^{-1}) whereas least by sheep (48.5 bites min^{-1}). The biggest bite size was recorded for dzo (99.8 mg $bite^{-1}$) whereas least for sheep (52 mg $bite^{-1}$). Foraging hours was highest for horse (11.5 hrs day^{-1}) whereas least for sheep (7.75 hrs day^{-1}). Total foraging period was highest for yak (365 days yr^{-1}) whereas least for cow (90 days yr^{-1}) in alpine/subalpine pastures. Forage intake rate was highest by dzo (4.03 kg day^{-1}) and least by sheep (1.17 kg day^{-1}). The total forage intake was highest in yak (1214 kg yr^{-1}) whereas least by sheep (129 kg yr^{-1}) in alpine pasture (Table 4.5).

4.3.4 Nutritive Values of Fodder Species

4.3.4.1 Cellulose, hemicellulose, crude fibre and lignin content

Cellulose, hemicellulose, crude fibre and lignin contents of 21 temperate forest species, 8 agroforestry species and 10 alpine and

subalpine species was estimated and presented (Table 4.6). Among temperate species, cellulose content was highest in *Acer campbellii* (37.32%) while least in *Silaginella* sp. (7.3%); among agroforestry species it was highest in *Saurauia napaulensis* (27.9%) and least in *Ficus cunia* (10.7%); and among alpine and subalpine species the cellulose content was highest in *Poa* sp. I (27.53%) while least in *Bistorta affinis* (4.59%) (Table 4.6).

Hemicellulose content was highest in *Brachiaria* sp. (26.9%) and least in *Ficus foveolata* (12.2%) among temperate forest species; highest in *Prunus cerasoides* (17.23%) and least in *Saurauia napaulensis* (6.0%) among agroforestry species, whereas it was highest in *Hemiphragma heterophyllum* (35.84%) and least in *Potentilla coriandrifolia* (19.71%) of alpine/subalpine pastures (Table 4.6).

Crude fibre content was highest in *Urtica dioica* (30.43%) while least in *Commelina benghalensis* (8.55%) among the temperate forest species; highest in *Thysanolaena maxima* (31.21%) and least in *Ficus cunia* (16.47%) among agroforestry species and was highest in *Potentilla peduncularis* (28.21%) and least in *Poa* sp. III (11.41%) among alpine and subalpine species (Table 4.6).

Lignin content was highest in *Acer oblongum* (35.89%) and least in *Pteris* sp. (6.56%) among temperate forest species; highest *in Prunus cerasoides* (17.36%) and least in *Brassaiopsis mitis* (10%) among agroforestry species; and it was highest in *Potentilla peduncularis* (26.72%) and least in *Poa* sp. III (9.32%) among alpine/subalpine species (Table 4.6).

4.3.4.2 *Nitrogen, phosphorus and crude protein concentration*

Nitrogen, phosphorus and crude protein of 21 temperate forest species, 8 agroforestry species and 10 alpine and subalpine species have been estimated (Table 4.6). Among the forest species, highest concentration of nitrogen was recorded in *Diplazium umbrosum* (3.68%) while least in *Aconogonum molle* (1.04%). Among agroforestry species, nitrogen concentration was highest in *Ficus cunia* (4.97%) and least in *Prunus cerasoides* (1.17%). In alpine and subalpine pastures, highest nitrogen concentration was recorded in *Poa* sp. II (1.87%) while least in *Aletris pauciflora* (1.06%) (Table 4.6).

Phosphorus concentration among temperate forest species was highest in *Hedychium ellipticum* (0.229%) and least in *Litsaea polyantha* (0.038%); it was highest in *Ficus nemoralis* (0.282%) and least in *Prunus cerasoides* (0.122%) among agroforestry species and was highest in *Poa* sp. III (0.377%) and least in *Aletris pauciflora* (0.185%) among alpine and subalpine species (Table 4.6). Crude protein content ranged from 6.25 to 23% among temperate species, 7.31 to 31.06% among agroforestry species and from 6.63 to 11.69% among alpine and subalpine species (Table 4.6).

4.4 DISCUSSION

The fodder need of livestock at low and mid-elevations throughout the Sikkim state is presently met through natural resources like forest floor phytomass, fodder tree, agroforestry species and crop residues and byproducts (Sundriyal *et al.* 1994). Fodder trees can be used as

multipurpose trees (fruits, fuelwood, timber, medicine, etc.) and regarded as a 'forage bank' for the villagers of Sikkim. These fodder trees have high potential for further development and uplifting the economy of the people. Fuel and fodder are two most important basic requirements of the mountain society that are met from the forests, but with increasing population pressure, these resources are rapidly depleting in natural habitats (Nautiyal *et al.* 1987). The rising human population and improved living standards have increased the demand for various livestock products and high yielding animals that require a high quality and quantity of fodder and sustainable management systems. Animal population is growing continuously in the recent past due to family fragmentation and involvement of livestock in tourism sector, therefore grazing may cause a threat to forest regeneration in the future (Sundriyal *et al.* 1994).

Generally *Ficus* leaves possess lower values of cellulose and lignin content and therefore preferred most. *Ficus* species from agroforestry showed moderate to higher protein content. Higher content of cellulose, crude fibre and lignin (e.g. *Brassaiopsis mitis* and *Saurauia napaulensis*) by species are indicator of less preferred fodder. Reduction of lignin, cellulose and fibre content in plants of grazed areas can be attributed to growth of new tissue, which is always replaced, thus reduces the total fibre content. In the present study temperate plants were generally having higher crude protein than the alpine plants, which is in contrary to the alpine plants of Central Himalaya as reported to contain more nitrogen

and consequently higher crude protein than the plants of lower elevations (Ram 1988).

Nitrogen content was more in grass than forbs, which is in contradiction to the findings from the Garhwal Himalaya (Ram 1988) where 1.99 to 2.71% nitrogen concentration in grasses and 1.39 to 3.71% in forbs reported was comparatively higher than the present study (1.02 to 1.87% in grasses and 1.03 to 1.35% in forbs.

Animal nutritional requirements, particularly for lactating animals, cannot be met by free grazing alone. Grasses found in forest during October to March are nutritionally poor and may contain only 2-18 per cent of crude protein (Verma 1988). Currently, cultivated forage and pasture-lands are the major sources of inexpensive, good quality feed for livestock. Therefore plantation of fodder trees is compulsory to supplement the fodder needs during scarcity period (Sundriyal 1995). The improvement of forage resources in the Himalaya implies a simultaneous development of both pastures and cultivated fodder, as both of these resources are used continuously or sequentially across the spectrum of animal husbandry system.

In alpine and subalpine areas, free grazing may be allowed with a frequent shifting of animals from place to place, which will avoid overgrazing at a single place. In temperate areas, however, dependence on the forests should be reduced through promotion of some alternatives such as by maintaining more agroforestry forage banks, and sustained production of other agricultural crop residues. As local inhabitants practise free grazing, certain pockets have already been becoming bare

lands, particularly surroundings of animal herds and concentration areas. There is a need to regulate such activities. Free grazing inside the forest should be controlled and regulated because free grazing not only affects the ground vegetation but also hampers growth of young seedlings and saplings particularly in temperate zones. Fodder collection from these areas, though a labour intensive exercises, should be the best option for management efforts. While in stall-fed, the fodder should be kept in proper designated place, otherwise large amount of fodder will be destroyed due to faecal dirty. Putting huge amount of fodder at a time make the animal choosy. Therefore, less quantity should be kept and after completion of it, more can be put according to the requirement. Less palatable fodder should be fed mixed with other more palatable fodder species. Over 81% of total fodder demand are met from the forest areas and thus these areas provide a cheapest source of fodder availability for rearing animals. Though the local state Government has fixed a nominal fee for pack animals operating along the Yuksam-Dzongri trail.

A large number of tree species have been recorded as potential fodder species, which are collected for fodder purpose from the temperate forests. However, most of these species provided fodder during summer and rainy seasons. Only 13 species provided fodder during winter. Therefore the animals move to temperate zone. It was recorded that there was no dearth of fodder during rainy season, however during winter months the good quality fodder comes from agroforestry species only. Thus strengthening of agroforestry species at farm particularly

those provide fodder during winter months will have larger implications and acceptance from villagers point of view.

Bite rate, bite size and foraging hours of horse and sheep are closely comparable with the reports from the Central Himalaya (Negi *et al.* 1993). Each animal was having relatively low bite rate per unit time in temperate zone than the alpine areas, which can be attributed to lower grazing hours at higher elevations. Also may be the forage of the alpine areas have more number of palatable species, thus animals may require less time in food search and their per unit time bite frequency increases. However, the less bite frequency in the temperate zone is substantiated by bigger bite size as all animals recorded a higher bite size in this zone. Further more fodder species are taller in height, which also increased the bite size in temperate zone. All animals except yak move to lower elevation during winter season, and among all, cow move first, followed by horse, sheep and dzos. As the climatic conditions were very severe at alpine during winter, and there is hardly any fodder available, most of the yak fed on small bushes especially rhododendron twigs by coming down slightly to subalpine areas. Often yaks suffer causalities during this period. Winter season is a fodder scarcity period and at this period all animals rely on poor quality fodder. Therefore the villagers maintain forage bank in the form of agroforestry trees, which provide fodder during winter months. Plantation of better quality fodder species (like *Ficus* spp.) in wasteland, community lands and other agricultural lands would bring opportunity of more high quality fodder availability during winter months. The State Forest Department (1995) has estimated the

annual requirement of fodder for the livestock of the state and according to them as against the requirement of 2.08 million tons of green fodder only 1.32 million tons of green fodder are available leaving a deficit of 0.76 million tons or 36.54% (Paljor 1998). Out of the total 709,600 ha area of Sikkim, about 162,392 ha (23%) is available for fodder production and pasture development in the state compared to 15% of the total land available for cultivation (Paljor 1998). Still there is high potential for fodder production and pasture development because of its vast area. Scientific intervention on the development of fodder species and pasture management can excel the livestock production as well as pasture conservation. ■

Table 4.1 Common fodder species collected from forest and agriculture lands at Yuksam village and in alpine (Dzongri) and subalpine (Deorali) pastures

Species	Vernacular name	Habit	Ranking	Availability
Forest				
Acer campbellii.	'Kapasey'	Tree	††	Aug-Nov
Acer laevigatum	'Kapasey'	Tree	††	Aug-Nov
Acer oblongum	'Putley'	Tree	††	Aug-Nov
Aconogonum molle	'Thotney'	Shrub	††	Jun-Sep
Artocarpus lakoocha	'Badar'	Tree	†††	Jul-Oct
Arundinaria maling	'Malingo'	Shrub	†††	Round
Bassia butyracea	'Chewri'	Tree	††	Jun-Aug
Betula cylindrostachys	'Saur'	Tree	††	May-Oct
Brachiaria sp.	'Bonsoghans'	Herb	†††	Apr-Nov
Brassaiopsis mitis	'Chuletro'	Shrub	†††	Round
Castanopsis tribuloides	'Katus'	Tree	†	Jun-Aug
Commelina benghalensis	-	Herb	††	May-Sep
Cyperus sp.	-	Herb	†††	Round
Diplazium umbrosum	'Ningro'	Herb	††	Round
Pteris sp.	'Unyo'	Shrub	††	May-Dec
Erythrina indica	'Falado'	Tree	†††	Apr-Oct
Ficus clavata	'Lute-khanew'	Tree	†††	Apr-Sep
Ficus cunia	'Khanew'	Tree	†††	Apr-Nov
Ficus foveolata	'Dudilhara'	Climber	†††	Mar-Dec
Ficus hirta	'Khasrey''	Shrub	††	May-Nov
Ficus nemoralis	'Dudhilo'	Tree	†††	Round
Ficus roxburghii	'Nebhara'	Tree	†††	Round
Gamblia ciliata	'Khursimal'	Shrub	†	May-Sep
Garuga pinnata	'Dabdabe'	Tree	††	May-Sep

Glochidion acuminatum	'Latikat'	Tree	†††	May-Oct
Heynea trijuga	'Ankha-tarua'	Tree	††	Apr-Oct
Litsaea polyantha	'Kutmero'	Tree	†††	May-Sep
Macaranga pustulata	'Malata'	Tree	††	Apr-Nov
Machilus edulis	'Kawla'	Tree	†††	May-Dec
Maesa chisia	'Bilaune'	Shrub	†	May-Sep
Morus laevigata	'Kimbu'	Tree	††	May-Sep
Mussaenda frondosa	'Dhobi'	Shrub	††	Jun-Sep
Pentapanax racemosa	'Chindey'	Climber	††	Mar-Dec
Prunus cerasoides	'Payun'	Tree	††	May-Oct
Quercus lamellosa	'Bajrant'	Tree	†	Jul-Sep
Rhaphidophora divursiva	'Kanchirna'	Climber	†	Round
Saurauia napaulensis	'Gagoon'	Tree	†††	Round
Schefflera impressa	'Balu-chinde'	Tree	†††	May-Oct
Thysanolaena maxima	'Amliso'	Shrub	†††	Round
Turpinia nepalensis	'Thali'	Tree	††	May-Sep
Vaccinium serratum	-	Epiphyte	†	Apr-Dec
Vitex heterophylla	'Panchpate'	Shrub	†	Jun-Sep
Zanthoxylum alatum	'Timboor'	Shrub	††	May-Oct
Agroforestry				
Alnus nepalensis	'Uttis'	Tree	†	Round
Arundinaria maling	'Malingo'	Shrub	†††	Round
Bambusa sp.	'Bans'	Tree	†††	Round
Brassaiopsis mitis	'Chuletro'	Shrub	†††	Round
Ficus cunia	'Khanew'	Shrub	†††	Round
Ficus nemoralis	'Dudhilo'	Shrub	†††	Round
Ficus roxburghii	'Nebhara'	Tree	†††	Round
Prunus cerasoides	'Payun'	Tree	††	May-Oct
Saurauia napaulensis	'Gagoon'	Shrub	†††	Round

Thysanolaena maxima	'Amliso'	Shrub	†††	Round
Alpine/Subalpine				
Aletris pauciflora	-	Graminoid	†††	May-Sep
Anemone tetrasepala	-	Forb	†	May-Aug
Bistorta affinis	-	Cushion	†	Apr-Oct
Corydalis juncea	-	Forb	†††	Jun-Aug
Gentiana phyllocalyx	-	Spreading	††	May-Aug
Geranium nakaoanum	-	Cushion	††	Jun-Aug
Hemiphragma heterophyllum	-	Spreading	†	Apr-Oct
Juncus thomsonii	-	Graminoid	†††	May-Sep
Pedicularis hoffmeisteri	-	Forb	††	Jun-Aug
Phaeonychium parryoides	-	Cushion	†††	Jun-Aug
Poa sp. I	'Booki'	Graminoid	†††	Apr-Oct
Poa sp. II	'Booki'	Graminoid	†††	Apr-Oct
Poa sp. III	'Booki'	Graminoid	†††	Apr-Oct
Potentilla coriandrifolia	-	Cushion	††	Jun-Sep
Potentilla microphylla	-	Cushion	†	May-Sep
Potentilla peduncularis	-	Forb	†	Apr-Oct
Primula primulina	-	Forb	††	Jun-Aug

*Preference ranking as cited by the villagers and also by personal observation (††† = most preferred, †† = medium preferred and † = least preferred).

Table 4.2 Number of species of each category of plant habit and preference levels of fodder species from forest, agriculture land of Yuksam and alpine and subalpine pastures along the Yuksam-Dzongri trail.

Habit/Preference	Number of species		
	Temperate forest	Agriculture land	Alpine/subalpine
Habit			
Tree	24	4	-
Shrub	11	6	-
Herb	4	-	17
Climber	3	-	-
Epiphyte	1	-	-
Total	43	10	17
Preference			
High	17	8	7
Medium	19	1	5
Least	7	1	5
Total	43	10	17

Table 4.3 Species wise fodder production in agriculture land on household basis at Yuksam. Data based on the basis of 52 households' survey.

Fodder species	Average number of trees per household	Dry weight forage production (kg tree^{-1} year^{-1})	Total forage production (kg household^{-1} year^{-1})
Brassaiopsis mitis	4	16.68	67
Ficus cunia	5	19.20	96
Ficus nemoralis	4	12.18	49
Ficus roxburghii	10	44.46	445
Saurauia napaulensis	7	19.38	136
Total	30	111.90	793

Fresh weight = 3.5 × dry weight

Table 4.4 Quantity of forage collected from the forest and the agriculture land at Yuksam village. Data on fodder are presented on fresh weight basis.

Parameters	Quantity
Total number of households	274
Number of fodder trees in the agriculture land (household^{-1})	30
Forage production from the agriculture land (kg household^{-1} year^{-1})	793
Total forage production from the agriculture land (kg year^{-1})	217282
Forage collected from the forest (kg household^{-1}day^{-1})	10.86
Forage collected from the forest (kg household^{-1} year^{-1})	3964
Total forage collected from the forest (kg year^{-1})	1086136
Total forage collected from the forest and agriculture land (kg year^{-1})	1303418
Forage contributed from the forest (%)	83.33
Forage contributed from the agriculture land (%)	16.67

Fresh weight = 3.5 × dry weight

Table 4.5 Bite rate, bite size, foraging hours and foraging days of livestock grazing animals in temperate and alpine pastures along the Yuksam-Dzongri trail (± standard error).

Pasture site/ Animal types	Bite rate (bite min^{-1})	*Apparent bite size (mg $bite^{-1}$)	Foraging hours (hours day^{-1})	Total foraging period (days $year^{-1}$)	*Forage intake rate (kg day^{-1})	**Forage intake rate (kg day^{-1})	*Total forage intake (kg $animal^{-1}$ $year^{-1}$)
Temperate							
Cow	49.7±6.2	102.3±0.35	11.2±2.5	365	3.43	16.46	1250
Dzo	51.5±2.5	105.6±0.5	11.9±1.7	185	3.88	18.62	718
Horse	50.1±3.5	100.0±0.75	11.7±2.5	265	3.52	16.90	932
Goat	42.6±1.2	53.0±0.15	9.3±2.5	365	1.28	6.14	469
Sheep	41.2±3.5	53.3±0.20	9.6±1.7	255	1.27	6.10	323
Alpine/subalpine							
Cow	56.5 ± 7.50	97.5 ± 0.25	10.8 ± 2.5	90	3.55	12.83	320
Dzo	59.5 ± 1.25	99.8 ± 0.20	11.3 ± 0.5	180	4.03	14.11	725
Yak	54.0 ±7.00	92.5 ± 0.15	11.1 ± 0.8	365	3.33	18.32	1214
Horse	54.0 ± 9.00	96.0 ± 0.14	11.5 ± 0.5	100	3.58	12.53	358
Sheep	48.5 ± 5.50	52.0 ± 0.20	7.8 ± 2.5	110	1.17	4.10	129

* dry weight, ** fresh weight

Table 4.6 Nutrient concentration of the common fodder species from forest and cropland farming system in Yuksam (dry weight basis)

Species	Nutrient concentration (%)						
	Crude fibre	Cellulose	Hemi-cellulose	Lignin	Total nitrogen	Total phosphorus	*Crude protein
Forest species							
Acer campbellii	19.73±1.02	37.32±2.12	17.21±2.11	32.66±0.96	2.21±0.06	0.101±0.021	13.81
Acer oblongum	17.23±1.29	32.81±1.03	13.45±0.09	35.89±1.13	2.02±0.06	0.132±0.028	12.63
Aconogonum molle	15.90±0.02	13.10±0.09	_	11.33±1.17	1.04±0.03	0.060±0.032	6.25
Bassia butyracea	13.34±0.06	33.21±0.08	_	32.92±0.79	1.32±0.08	0.076±0.031	8.25
Brachiaria sp.	18.40±1.03	16.70±0.09	26.90±1.23	16.37±0.83	3.01±0.06	0.203±0.045	18.79
Commelina benghalensis	8.55±0.08	19.56±0.06	_	12.56±0.92	1.96±0.06	0.219±0.037	12.25
Diplazium umbrosum	18.56±0.19	11.32±0.04	_	12.50±0.75	3.68±0.09	0.211±0.031	23.00
Elatostema sessile	14.21±0.11	15.11±0.04	_	12.66±0.39	2.01±0.06	0.159±0.028	12.56
Eupatorium cannabinum	11.20±0.08	22.56±0.13		12.92±0.86	2.40±0.12	0.173±0.023	15.00
Ficus clavata	19.45±0.09	11.85±0.12	_	20.75±0.97	1.41±0.07	0.088±0.021	8.81
Ficus foveolata	17.44±1.21	10.72±0.11	12.20±0.09	17.34±1.01	2.67±0.05	0.141±0.021	16.69
Ficus hirta	17.33±1.04	15.26±0.09	_	16.89±1.29	2.32±0.07	0.052±0.036	14.50

Hedychium ellipticum	26.31±1.23	19.20±2.11	17.80±0.08	13.87±0.39	2.92±0.12	0.229±0.023	18.25
Impatiens sp.	12.54±2.10	18.42±1.20	_	11.08±0.76	1.83±0.03	0.153±0.011	11.44
Litsaea polyantha	16.87±0.08	11.54±1.02	_	9.86±0.59	2.53±0.05	0.038±0.008	15.81
Pilea scripta	18.10±1.03	17.21±1.75	_	15.56±1.11	2.19±0.04	0.113±0.012	13.69
Pteris sp.	18.23±1.10	11.56±0.03	_	6.56±0.08	3.05±0.08	0.131±0.014	19.06
Silaginella sp.	14.61±0.09	7.30±0.03	16.30±1.24	11.30±1.03	2.63±0.07	0.224±0.012	16.45
Urtica dioica	30.43±0.09	14.00±0.05	_	12.55±0.27	2.63±0.06	0.135±0.013	16.44
Viola sp.	16.21±0.08	11.16±0.08	_	18.31±0.85	2.52±0.11	0.116±0.015	15.75
Vitex heterophylla	18.32±1.12	14.75±0.09	_	13.20±0.74	1.09±0.05	0.154±0.041	6.81
Agroforestry species							
Arundinaria maling	29.76±1.13	16.22±1.09	-	9.78±1.13	2.11±0.06	0.199±0.031	13.20
Brassaiopsis mitis	29.20±1.16	13.12±0.56	10.00±0.63	13.61±1.15	1.75±0.04	0.208±0.013	10.94
Ficus cunia	16.57±0.91	10.70±0.72	11.30±0.43	10.22±0.93	4.97±0.05	0.216±0.022	31.06
Ficus nemoralis	24.10±0.72	21.03±0.88	12.70±0.92	11.73±1.06	1.82±0.06	0.282±0.013	11.38
Ficus roxburghii	16.98±2.56	11.79±0.93	12.00±0.87	11.21±0.43	3.14±0.05	0.209±0.027	19.65
Prunus cerasoides	21.13±0.93	13.07±0.11	17.23±0.66	17.36±0.87	1.17±0.04	0.122±0.008	7.31
Saurauia napaulensis	28.70±2.80	27.90±1.20	6.00±0.33	12.23±0.25	1.69±0.18	0.185±0.011	10.58

Thysanolaena maxima	31.21±1.78	21.32±0.97	-	11.34±1.10	1.83±0.11	0.191±0.009	11.41
Alpine & subalpine species							
Poa sp. I	23.71±0.91	27.53±0.87	35.54±0.13	16.81±0.23	1.12±0.03	0.209±0.012	7.00
Poa sp. II	21.16±0.32	27.08±0.12	27.51±0.08	13.23±0.38	1.87±0.03	0.234±0.009	11.69
Poa sp. III	11.41±0.09	24.35±0.12	35.44±0.09	9.32±0.08	1.32±0.05	0.377±0.007	8.25
Potentilla peduncularis	28.45±0.19	12.65±0.11	24.28±0.13	26.72±0.09	1.32±0.07	0.209±0.022	8.25
Aletris pauciflora	14.27±0.37	33.19±0.11	27.43±0.32	11.31±0.11	1.06±0.03	0.185±0.013	6.63
Bistorta affinis	19.73±0.21	4.59±0.08	22.53±0.07	23.11±0.26	1.12±0.01	0.201±0.023	7.00
Hemiphragma heterophyllum	26.33±0.09	18.72±0.08	35.84±0.12	19.89±0.11	1.35±0.06	0.190±0.008	8.44
Potentilla microphylla	24.12±0.18	6.98±0.18	20.62±0.18	22.11±0.12	1.21±0.06	0.212±0.016	7.56
Potentilla coriandrifolia	16.38±0.35	5.17±0.15	19.71±0.25	16.23±0.11	1.35±0.09	0.213±0.011	8.44
Juncus thomsonii	22.46±0.31	26.18±0.08	26.74±0.32	18.72±0.09	1.63±0.06	0.226±0.019	10.19

* Crude protein (%) = Total nitrogen (%) × 6.25; This is based on the assumption that plant protein contains 16% nitrogen.