

Biomass availability and forage quality of *Eurotia ceratoides* Mey in the rangelands of Changthang, eastern Ladakh

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Rangeland conditions can be assessed based on the biomass availability and nutrient quality of major forage plants. While conducting ecological studies on the rangelands of Changthang, eastern Ladakh, we assessed the above-ground biomass and nutrient quality of *Eurotia ceratoides* Mey (Chenopodiaceae), a common shrub in the area, following standard methods. Its density, cover and biomass were highest in the lower slopes and sandy plains, while it was completely absent in the marsh meadows. Nutritive quality of *Eurotia* was found to be significantly ($P < 0.005$) higher compared to other dominant species. As expected, a seasonal variation in nutrients was found. Crude protein content decreased from 21% in summer to 12% in winter, whereas anti-quality factors increased during winter. Patterns and processes of *Eurotia* degradation and its implications for the management of rangelands are discussed.

RANGELANDS of Changthang (Figure 1a) which are a repository of forage support a number of livestock and wild ungulates in a resource limited environment (G. S. Rawat and B. S. Adhikari, unpublished report, 2002). In such an environment, few species that not only fulfil the needs of local people but also have high ecological values may be used as indicators of rangeland health². *Eurotia ceratoides* Mey (*Krascheninikovia ceratoides*), locally called 'Gyabshen', (Chenopodiaceae), is a common and widespread shrub of the Changthang plateau and has an important place in this cold and arid ecosystem. The plant has a woody root stock and aerial shoots bear woolly hairs as an adaptation to the prevailing cold and arid conditions. The seeds are covered with woolly hairs and easily dispersed by wind. The plant not only helps in soil stabilization, but also forms important forage for the wild and domestic ungulates of Changthang³. The Changpa herders (a nomadic community of Changthang that rears pashmina goat, sheep, yaks and horses) depend on the thick rootstock of this plant for their fuelwood requirements. They rate this species as the best forage for their livestock (Figure 1b), and it has often been linked to the quality of underwool (pashm, raw material for the famous pashmina shawls)⁴. Forage quality depends on the ratio of positive and negative (anti quality) nutrients. Positive nutrients include protein, carbohy-

drates, fat and minerals, while negative nutrients which reduce the digestibility of positive nutrients include fibre, cellulose, lignin, silica and secondary compounds⁵. A forage plant of good quality would be one with high crude protein content, high calorific value, low fibre, low lignin and low ash content⁶.

Thus, realizing the exceptional importance of *E. ceratoides* as a major forage and fuelwood species and its role in ecological stability of this fragile ecosystem, it can be regarded as one of the keystone species of the area. Recently, concerns have been raised regarding its degradation and its associated impacts on the rangeland⁷. The need for studying keystone species has been highlighted for the proper conservation and management of these rangelands⁸. Hence the present investigation was carried out in the Tso Kar Basin, Changthang plateau, with an aim to study the biomass availability and forage quality of *E. ceratoides*.

Tso Kar Basin that covers an area of about 400 km², represents the westernmost extension of the Changthang plateau. The characteristic cold and arid conditions of the Tibetan plateau prevail in the area and most of the precipitation occurs during winter in the form of snow, with the temperature going below -30°C. The basin that lies between 33°09'46"-33°28'57"N lat. and 77°53'51"-78°12'49"E long. (Figure 2) is surrounded by the Zaskar range in the south, Leh-Manali highway in the west, Polokong la and the Taklang la passes in the east and north respectively. Almost the entire area is above 4500 m asl. The basin with a diversity of landforms such as marsh meadows, sandy plains, higher slopes, lower slopes and alluvial fans, supports a diversity of fauna. Important ungulates of the area include Tibetan argali (*Ovis ammon*), kiang or Tibetan wild ass (*Equus kiang*) and blue sheep (*Pseudois nayaur*). Apart from these many small mammals, namely marmot (*Marmota himalayana*), pika (*Ochotona* spp.), voles (*Alticola roylei*) and Tibetan woolly hare (*Lepus oiostolus*) also depend on the biomass resources of the basin. The major carnivores of the area are snow leopard (*Uncia uncia*), Tibetan wolf (*Canis lupus chanku*) and lynx (*Lynx lynx*). In addition, the basin is seasonally (during winter) used by the Changpa herders, who also depend on the surrounding resources of the basin especially for fuelwood, while their livestock forage on the available plant biomass. About 6000 livestock use the basin. Recently, a change in the livestock composition has been observed. The number of pashmina goats has increased due to direct economic benefits derived from the sale of wool (pashm), whereas the number of yaks has decreased (G. S. Rawat and B. S. Adhikari, unpublished report, 2002). Apart from its inhabitants, tourists visiting the area for its famous lake and wildlife also use the biomass resources of the basin.

We followed stratified random sampling to quantify the distribution and biomass of *Eurotia* in the basin⁹. Various strata recognized in the Tso Kar Basin were marsh meadows, sandy plains, higher slopes, lower slopes and alluvial fans (Table 1). A total of 91 sites were selected in the basin to

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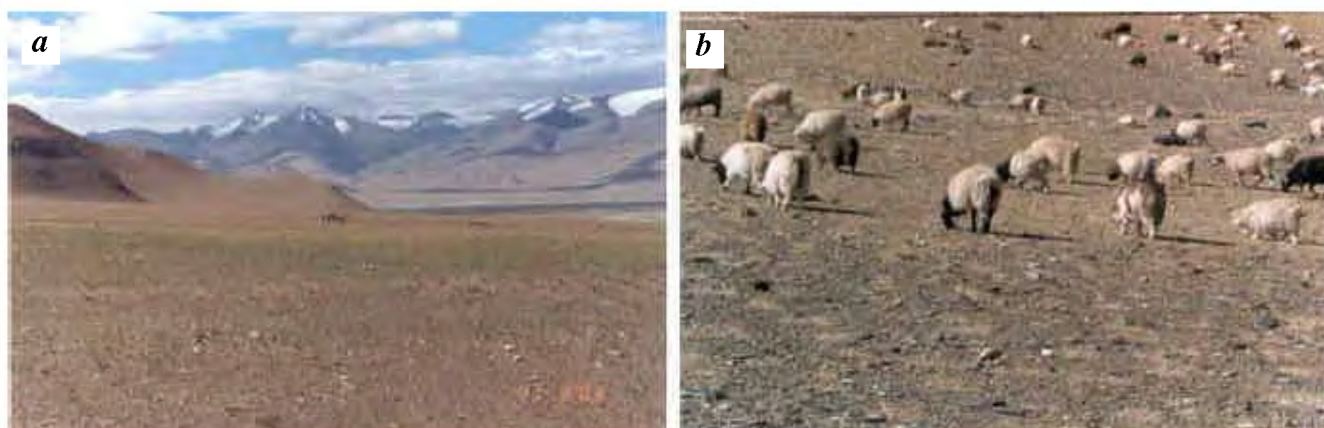


Figure 1. *a*, Changthang plateau in eastern Ladakh; *b*, Livestock herd feeding on *Eurotia ceratoides*.

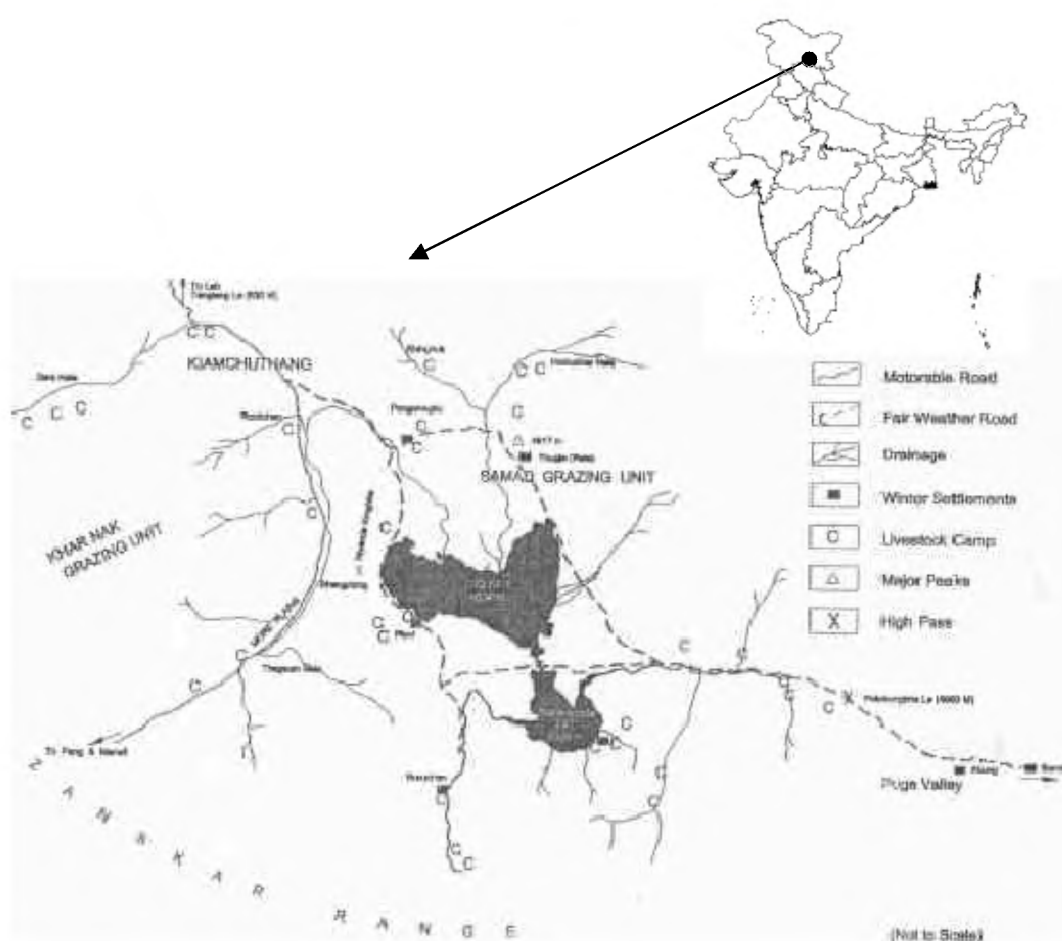


Figure 2. Map of Tso Kar Basin.

Table 1. Characteristic features of different landforms

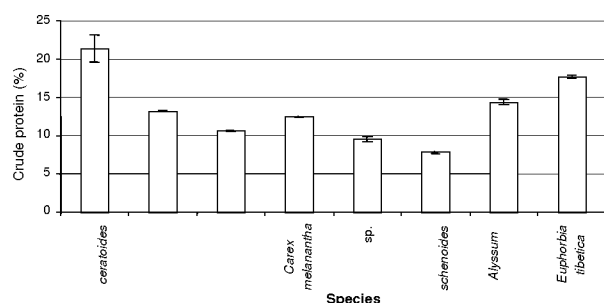
Landform	Characteristics
Alluvial fans	Rocky areas formed by washed-up deposits.
High slopes	Areas above 4900 m asl
Low slopes	Areas below 4900 m asl and above 4600 m asl
Sandy plains	Gentle and flat sandy areas generally about 4600 m asl
Marsh meadows	Moist/wet areas around lakes

get a representation of all the landforms. These sites were sampled using a 1×1 m quadrat ($n = 10$ at each site). We noted the number of individuals of *Eurotia* in each quadrat, while their cover in these quadrats was estimated by ocular cramming¹⁰. For above-ground standing biomass, harvest method¹¹ was adopted and every fifth plot at each site was harvested close to the ground. Fresh weight of entire aerial shoots was recorded in the field using 'Pesola' spring

Table 2. Distribution of *Eurotia ceratoides* in different landforms

Landform	Density (individual/m ²)		Dry wt (g/m ²)		Cover (%)	
	<i>Eurotia</i>	Overall	<i>Eurotia</i>	Overall	<i>Eurotia</i>	Overall
Alluvial fans	0.2 ± 0.05	48.5	7.69 ± 6.67	30	0.8 ± 0.25	5.29
High slopes	0.78 ± 0.15	35.3	7.04 ± 6.32	63	2.6 ± 0.82	9.84
Low slopes	2.05 ± 0.46	16.37	14.54 ± 5.01	215.68	7.65 ± 1.47	19.57
Sandy plains	1.53 ± 0.32	32.43	9.56 ± 2.52	37.47	5.13 ± 1.01	21.05
Marsh meadows	NA	622.47	NA	31.99	NA	75.96

±, Standard error.

**Figure 3.** *E. ceratoides* amidst *Caragana* bushes.**Figure 4.** Crude protein content in some important plant species of Changthang ($n = 3$).

balance. Later the shoots were oven-dried for dry weight measurements. Plant material thus collected from the different landforms in peak growing (August) and lean (November) seasons, were brought to the laboratory at Wildlife Institute of India (WII), Dehradun. The samples were ground for nutrient analyses.

Density and cover of *Eurotia* in different landforms were calculated¹¹. Dry weight of the species from different landforms was recorded for biomass measurement. Crude protein content was estimated using micro Kjeldahl method¹² and acid detergent fibre, cellulose, lignin and ash content were quantified using standard methods^{13,14}.

Abundance (density and cover) of *Eurotia* in the study area is shown in Table 2. This species was completely absent in the marsh meadows, which are dominated by few specialized plant species such as *Kobresia pygmaea*, *Kobresia royleana*, *Kobresia schoenoides*, *Carex sagaensis*, *Potentilla anserina* and *Carex melanantha*. The mean density of *Eurotia* in different landforms ranged from 0.2 to 2.05 individuals/m², while the cover and biomass ranged from 0.8 to 7.66, and 7.04 to 14.54 g/m² respectively (Table 2). The distribution of *Eurotia* in terms of density, biomass and cover was highest in the lower slopes followed by sandy plains, where it was mainly associated with *Stipa orientalis* and *Caragana versicolor*. *Caragana*, which is a common thorny plant of the area, provided shelter to the regenerating *Eurotia* plants (Figure 3) from browsing by livestock. However, these areas are also the ones which are most frequently used by Changpas for fuelwood collection and grazing by their livestock. When compared with the overall density, biomass and cover in different landforms, *Eurotia* contributed higher biomass and cover in sandy plains and density in lower slopes.

Nutrient quality of *Eurotia*, especially the crude protein content was highest (ca. 21% of the dry wt). It was significantly higher ($P < 0.005$) when compared to other important plants of the basin during summer (Figure 4). As the season progressed and phenology changed, the crude protein decreased by 41.55% in *Eurotia* (Figure 5a). On the other hand, anti-quality factors that reduce digestibility and palatability such as fibre, lignin and cellulose increased with the progress of season (Figure 5b). Lignin, which was negligible during summer, increased to ca. 0.1%. Still it was low in proportion to the crude protein content.

The widespread distribution, relatively higher biomass and significantly higher nutrient content reflect the importance of *E. ceratoides* for the Changthang ecosystem. In such a resource-limited environment, where both the quantity and quality of vegetation become an important factor for the survival of its inhabitants as well as the stability of the ecosystem^{15,16}, the importance of *E. ceratoides* increases manifold. The species is not only a preferred forage plant for the pashmina goats⁴, but is an important winter food for many wild ungulates³. The significantly higher crude protein content, lower anti-quality components such as fibre, lignin and cellulose in *Eurotia* in comparison to other dominant plant species, indicate its value as a highly nutritious forage. Seasonal

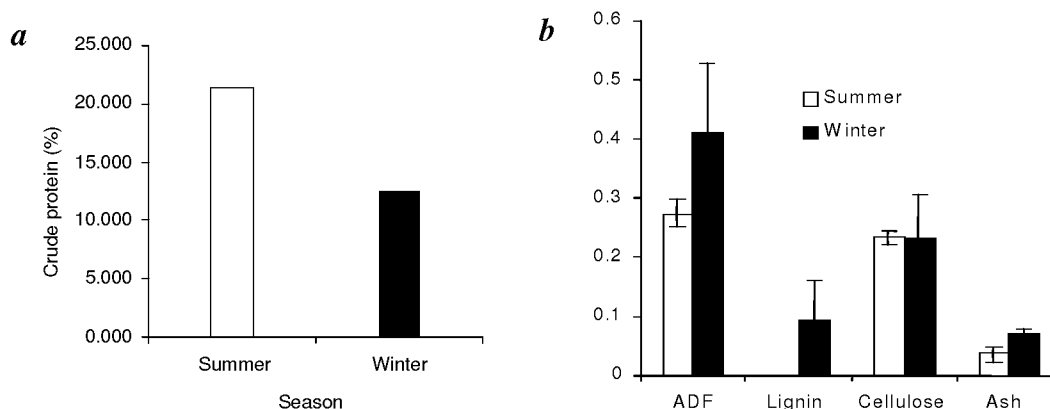


Figure 5. Crude protein content (a) and anti-quality factors (b) in *E. ceratoides* (n = 3).



Figure 6. Dried rootstock of *E. ceratoides* used as fuelwood.

variation in the nutrient contents of *Eurotia* paralleled those reported for other plants from similar regions^{17–19}. Although the crude protein content in *Eurotia* decreased by 41% during the lean (winter) period, it was higher compared to other species. As the nutritional quality of food during the peak growing season is an indicator of livestock and human survival during the remainder of the year²⁰, the value of *Eurotia* for the survival of dependent fauna, especially during winter season becomes self-explanatory. Winter season in Changthang is a crucial period for the survival of wild as well as domestic ungulates. Heavy snowfall, limited resources and lower biomass availability during this season have known to cause mass mortality of animals²¹ and also increase competition for food among wild and domestic ungulates²². *Eurotia*, having high nutrient quality, still forms an important part of their diet and is heavily browsed during winters (pers. obs.).

Besides being an important forage plant, the thick rootstocks of *Eurotia* are extracted by herders for fuelwood. Loads of *Eurotia* roots are collected and dried for winter season (Figure 6). Dual pressure (underground part extraction for fuelwood and above-ground parts heavily browsed) on *Eurotia* would not only affect its regeneration, but will

also reduce the available forage biomass. In a cold and arid environment, where it takes several years for a plant to grow, degradation of *Eurotia* would not only cause desertification²³, but will also lead to resource scarcity thus impoverishing the overall quality of rangelands. This may in turn lead to changed grazing habits of ungulates from selective to more opportunistic feeders²⁴. The altered diet composition may subsequently lower the nutritional status and fertility among them, as has been reported elsewhere²⁵. This holds not only for wild ungulates but also for the domestic livestock of the Changpa herders. The Changpas, whose mainstay of economy is based on the pashmina goats, may have to bear the impact of degrading pasture quality. Nutritional deficiency among pashmina goats may degrade the quality of underwool (pashm), while lower fertility may reduce their numbers thus increasing economic burdens on the pastoralists.

Hence, conservation of *Eurotia* becomes important not only for the stability of the ecosystem, but also for the long-term sustainability of pastoralism in Changthang. Studies on the regeneration and productivity of *Eurotia* are of immediate need for the conservation and proper management of this unique ecosystem.

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