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Carrying capacity of three grassland ecosystems in Bundelkhand region (U.P.), India

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Abstract
The carrying capacity (CC) of three grasslands differing in vegetation composition and biotic stress (fire and grazing) in Bundelkhand region (Uttar Pradesh, India) was assessed. Average carrying capacity, which express the ability of range unit to support adequately a constant number of grazing animals for a definite period without deteriorating its structure and function with respect to grazing value has been calculated on year-long basis. Dry sub-humid tropical grassland could carry 3.75 cow units ha^{-1} yr^{-1} as compared to 1.09 and 1.96 cow units ha^{-1} yr^{-1} at the temperate and alpine sites respectively. The higher carrying capacity at all sites was found with controlled grazing. Excessive grazing affected the CC adversely. Fire treatment also enhanced the CC of the grassland. Controlled grazing, firing and a reduction in livestock population are recommended to sustain the carrying capacity of the grasslands in Bundelkhand region.

Key words: Bundelkhand, Carrying capacity, Firing, Grassland, Grazing

Introduction

The grasslands of Bundelkhand region are subjected to uncontrolled and unregulated grazing pressure both by the nomadic livestock as well as local cattle. Intense grazing hampers regeneration and reduces productivity, and desirable species composition, leading to ecological degradation. The grasslands need to be managed for a balance between sustainable animal production and plant productivity by the application of ecological principles. The concept of carrying capacity (CC) is the guiding factor for the scientific management of pastures and grazinglands, which can be defined as the ability of rangeland unit to adequately support a constant number of grazing animals for a definite period each year without deterioration of rangeland forage resource. Carrying capacity is often expressed as number of livestock per unit area.

In Bundelkhand region, an average house hold has 5 animals. In addition, the livestock of the nomadic graziers that visit these grasslands from nearby area during the summer consist of about 20 animals per family (Kushwaha and Singh, 2011). This nomadic bovine population is over and above the pressure of animals owned by the sedentary population in this region. The assessment of the carrying capacity of these grasslands, including those along the migratory routes of nomadic graziers, was undertaken to assist in management and development of the area during 2008-2009. Such a study is important as the local economy is mostly dependent on livestock and their products and productivity of pasture is maintained by short growing season and short duration of grazing.

Materials and Methods

Study Area: The grasslands were selected at three different places, Kalpi, Konch and Orai of Jalaun district of Uttar Pradesh for estimating carrying capacity. These grasslands fall under tropical region and varied in exposure, topography, climatic factors and vegetational composition. The study sites lies in 25^0 59' N and 79^0 37' E and at 141.6 m above mean sea level in Bundelkhand region (Fig.1). It is confined along the banks of Yamuna river which represents the level of the ancient flood plain but at present is badly cut into deep ravines. However, the sites selected for the study has a plain topography. The common rocks found are sand stones, lime stones and shales. The soil is light olive brown in colour and sandy loam to loam in texture.

Climate: The climatic data of each site were recorded separately from July, 2008 to June, 2009. The average values of minimum and maximum temperature, rainfall, relative humidity and solar radiation are depicted in table 1. In general, the climate of the study sites was dry sub-humid and divisible into three seasons namely rainy (July-October), winter (November-February) and summer (March-June). The average annual temperature was uniformly high (over 25^0C) and the mean monthly values varied considerably (13.8 to 34.1^0C). The mean total annual precipitation was about 1160 mm of which 84% falls between July

to October. On the basis of climatic data recorded, there are four wet months (July-October) and eight dry months.

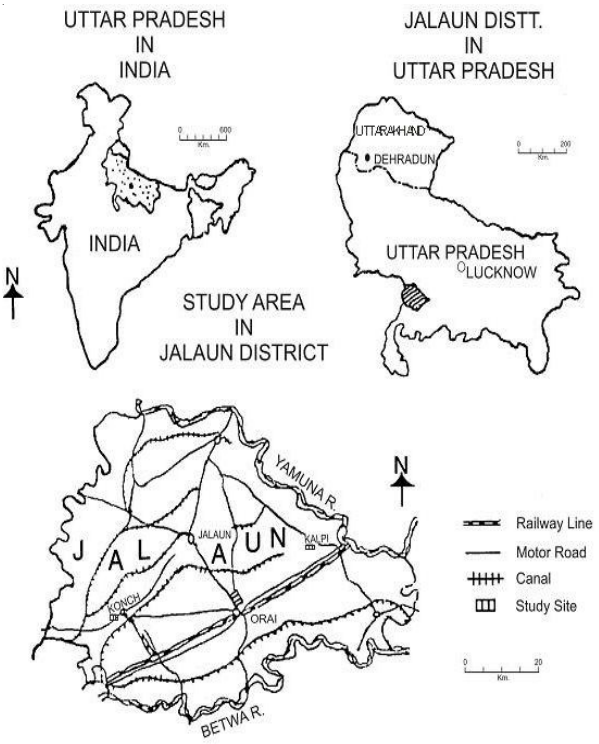

Fig 1. Location three study sites in Bundelkhand region at Jalaun district in Uttar Pradesh state of India

Methodology: Grassland study sites were located on flat topography. The grassland formation depends mainly on edaphic, topographic and biotic factors (Singh and Saxena, 1978). Grasslands located as various places were treated as control (no livestock grazing), controlled grazing and free grazing. Under controlled grazing, the cattle were allowed to graze for a week in two months. Fire treatment was also given to the control and grazed grasslands in January, 2009. All the grassland sites were fenced to protect them from biotic disturbances except the free grazing. 50x50 m was the minimum size of an experimental plot.

The carrying capacity of individual grassland was calculated following the formula of Brown (1954):

Carrying Capacity (CC) = Fr. k/Rq,

where, CC = carrying capacity (animals/hectare),
Fr = total forage production/hectare,
k = proper forage use factor and
Rq = Animal requirement.

The animal requirement is the dry matter consumption per animal per hectare. It was found to be maximum during August-September and this was taken as the standard requirement. The consumption per animal was estimated for each month using the estimate of bite size, bite frequency and grazing time.

A proper forage use factor was considered 50% of the total aboveground production as per findings for a controlled grazing experiment (Pandey, 1980). Total net production was computed as the sum of successive monthly biomass and litter increases plus monthly cattle consumption as described by Gupta (1986).

Measurement of dry matter production was done on "short-term harvest method" as described by Odum (1960, 1971). A sampling unit of size of 25x25 cm was used for estimating the aboveground biomass. Five quadrats at each site were chosen at random for investigation at one month interval. The plant material after harvesting were collected in polythene bags, transported to the laboratory and then dried at 80^{0}C for 48 hours and weighed. Litter was also collected and dried and weighed separately. The data were statistically analysed to obtain a reliable estimate of total net production.

Animals that visited the experimental sites were categorized into different groups that are sheep, goats, bullocks, buffaloes, cows, mules and horses. Different animal groups were standardized against the cow unit on the basis of dry matter consumption as shown below:

1 cow = 0.46 buffalo = 3.24 adult goat/sheep = 0.87 mule = 0.84 horses = 0.75 ox

* Standardization was done on cow basis because of its frequent occurrence in each family from the localities where research sites were located.

Results and Discussion

The carrying capacity (CC) estimated exhibited a considerable variations. Under controlled condition, with no grazing could support 1.44 cow units ha^{-1} yr^{-1}. This can be considered a high value as compared with the CC of temperate and alpine vegetation (Gupta, 1986). Singh and Misra (1978) also reported that grasslands at Chandraprabha sanctury, eastern Uttar Pradesh could support about 1.3 cow units ha^{-1} yr^{-1}. On the other hand, CC of native arid pastures under protection was estimated at 2.5 sheep ha^{-1} yr^{-1} on the basis of 60-70% utilization of herbage (Chakravarty, 1971). Das *et al*. (1963) estimated the average CC of grasslands of western Rajasthan of 5 sheep ha^{-1} yr^{-1}.

A marked increase in the CC of Bundelkhand grasslands under controlled grazing was observed over that of free

Table 1. Location of research sites and their climatic characteristics (average value of 12 months in Bundelkhand region during 2008-2009)

Research	Topography	Altitude (m)	Mean Temp.		Mean annual rainfall (mm)	Mean relative humidity (%)	Solar
			Max.	Min.			
Kalpi 25^0 59' N 79^0 37' E	Flat	141.6	31.07	19.24	1169.20	55.84	452.37
Konch 25^0 59' N 79^0 37' E	Flat	141.6	32.90	15.68	1186.20	49.66	466.90
Orai 25^0 59' N 79^0 37' E	Flat	141.6	34.11	18.37	1069.60	52.66	473.08

Table 2. Dominant species and carrying capacity (No. cow ha^{-1} Yr^{-1}) of grassland vegetation at different sites in Bundelkhand region during 2008-2009

Study site	Dominant species	Average carrying capacity			
		Control	Controlled grazing	Free grazing	Period of study
Kalpi (Jalaun)	*Heteropogon contortus* (Linn.) P. Beauv.	2.15	3.61	0.60	April
	Chrysopogon montanus Trin.	1.39 (2.19)	2.76 (3.10)	0.43 (0.46)	April March
Konch (Jalaun)	*Dichanthium annulatum* (Forsk.) Stapf.	1.08	2.16	0.22	April
Orai (Jalaun)	*Iseilema laxum* Hack.	1.22	2.46	0.33	April

Data in parenthesis indicate the effect of fire

grazing and control treatments. The values ranged from 2.16 to 3.61 cow units ha^{-1} yr^{-1} (Table 2). Free grazing resulted in a conspicuous decrease in plant productivity as compared to control and controlled grazing. The study of Kaul and Chakravarty (1968) supports these findings and indicated that grasslands could be maintained properly under light grazing in western Rajasthan. Upadhyaya *et al*. (1971) also found that *Cenchrus setigerus* gave highest CC (10.5 sheep ha^{-1} yr^{-1}) under controlled grazing.

Bhimaya and Ahuja (1969) recommended 20-31, 20, 17, 13 and 0-6 adult cattle per 100 hectares in excellent, good, fair, poor and very poor rangeland conditions respectively in tropical grasslands. Compared with these observations, the CC of grasslands of Garhwal Himalaya is quite high provided they are not opened up for uncontrolled grazing. However, a better future of these grasslands is apparent, when under controlled condition they are combined with the factors like livestock population, overgrazing and unavailability of the forage resources. The observations made and conclusions drawn by Gupta (1990) are almost in conformity with the findings of present investigation.

It is observed that grassland dominated by *Heteropogon contortus* and *Chrysopogon montanus* is fairly high in CC probably due to different species composition and the availability of other forages (shrubs) at the time of dormant period of grasses. This provides the grassland a rest period for vigorous growth in the next season. On the other hand, low CC on other two sites may be due to decreasing alternative fodder resources (shrubs) along with a high livestock population. With continued excessive pressure of grazing animals, the grasslands are either destroyed within the same grazing season or they are reduced in vigour with inadequate root reserve which affect the CC adversely.

In view of the above observations and extensive survey of Bundelkhand region in relation to socio-economic aspect, the following recommendations are made to increase the CC of these grasslands:

- Control and manage grazing and burning practices to improve primary production.
- Reduce the number of cattle to reduce the excessive pressure on these grasslands.
- Introduce other forage resources to assist the grasslands in areas of inadequate plant protection.
- Create hay banks to neutralize the imbalance caused by migratory animals.
- Involve, people by educating them the sense of conservation and its relevant consequences.

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