



GLOBAL JOURNAL OF SCIENCE FRONTIER RESEARCH
AGRICULTURE AND VETERINARY
Volume 13 Issue 5 Version 1.0 Year 2013
Type : Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

Botanical Composition and Herbage Mass Estimation in Relation to Quality Status of Mauma Kharka (*Rangeland*) in the Taplejung District, Nepal

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Abstract - A study was conducted in Mauma Kharka, Olang Chung Gola VDC of Taplejung district, Nepal during June, 2010 to November, 2010 to determine the status of available herbage mass at transhumance system. Accordingly, herbage biomass estimation was done in three different slope categories using RCB design (<4%- plain category; 5-10% gentle slope, and 11-16% steep slope), each replicated for five times. The total fresh and dry weight of herbage mass Was estimated three times (July, August and September), taking 90 days growth period along with the botanical composition. The sample from each slope category harvested during July was also analyzed to determine CP, ether extract, NDF, ADF, ADL, cellulose, hemicelluloses and total ash. Results showed that the proportion of forbs were highest (60%), whereas cyperoids and grasses were similar and lower in proportion at each slope categories. The total dried herbage mass was statistically similar ($p>0.05$) along the three slope categories, with the mean dried weight 1.8 t/ha, 3.6 t/ha, and 2.6 t/ha for July, August, and September, respectively.

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GJSFR-D Classification : FOR Code: 270499p



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Botanical Composition and Herbage Mass Estimation in Relation to Quality Status of Mauma *Kharka* (Rangeland) in the Taplejung District, Nepal

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Abstract - A study was conducted in Mauma Kharka, Olang Chung Gola VDC of Taplejung district, Nepal during June, 2010 to November, 2010 to determine the status of available herbage mass at transhumance system. Accordingly, herbage biomass estimation was done in three different slope categories using RCB design (<4%- plain category; 5-10% gentle slope, and 11-16% steep slope), each replicated for five times. The total fresh and dry weight of herbage mass was estimated three times (July, August and September), taking 90 days growth period along with the botanical composition. The sample from each slope category harvested during July was also analyzed to determine CP, ether extract, NDF, ADF, ADL, cellulose, hemicelluloses and total ash. Results showed that the proportion of forbs were highest (60%), whereas cyperoids and grasses were similar and lower in proportion at each slope categories. The total dried herbage mass was statistically similar ($p>0.05$) along the three slope categories, with the mean dried weight 1.8 t/ha, 3.6 t/ha, and 2.6 t/ha for July, August, and September, respectively. Likewise, the cumulative dried weight during 90 days growth period was 8 t/ha. The CP, NDF, ADF, cellulose, ether extract, and total ash content were not affected by slope categories ($p>0.05$), but ADL was significantly higher ($p<0.01$) in steep slope whereas hemicelluloses content was significantly higher ($p<0.05$) in gentle slope. The chemical composition of ten most abundant pasture species harvested during July showed that *Kobresia nepalensis* had the highest CP content (21%). Although the CP content was highest in cyperoids followed by forbs and grasses there was a dominance of forbs and cyperoids in the pastureland reflecting poor quality of herbage with its slowly deteriorating quality. Thus, findings of this study revealed that the alpine rangeland has more proportion of unpalatable forbs which ultimately hampers the quality of herbage mass.

Keywords : CP, cyperoids, forbs, grass, rangeland.

I. INTRODUCTION

Livestocks are the important component of Nepalese agricultural systems, as it contributes about 33% to the AGDP (CBS, 2001/2002). In the Agriculture Perspective Plan (APP, 1995), the future contribution of the livestock sector has been expected

to reach 45 % to the total AGDP (CBS, 2001/02) by 2015. Nepal is rich in livestock population and abundance among the livestock species found in Nepal, Yaks and their crossbreds are reared in the mountainous regions of Nepal, with their visible role in supporting livelihood of mountain people. People living in the high elevation zones of eastern mountainous regions of Nepal have supported by these livestock species to the people (herders and traders) since thousands of years (Barsila, 2008). Yak and Chauries in Nepal are managed under the he transhumance or the migratory livestock system, where livestock are moved from one place to another throughout the year (Tulachan and Neupane, 2000, Dong *et al.*, 2009) in order to exploit the vegetation of high alpine zones.

Rangelands are one of Nepal's most important resources, especially in the northern mountainous regions of the country. About 11% of Nepal's territory constitutes rangelands and most of it lies above the tree-line (Shrestha, 2001). It has been reported that rangeland ecosystems and their biological resources play a critical role in the region's overall economic development and in people's well being (Miller, 1997). However, rangeland as a cheaply available resource is depleted annually (Barsila, 2008), and therewith the rangeland productivity is declining mainly due to excessive stocking rate mostly in temperate pastures followed by subalpine and alpine pastures (Singh *et al.*, 1990; Miller, 1989 as cited in Barsila, 2008 and Devkota *et al.*, 2008). This raises a research question whether botanical composition differ to that of slope category so that appropriate management plan would be possible to formulate for improvement of rangeland resources. The major objective of this research was to identify most abundant pasture species and estimate general distribution of botanical composition across the three distinct slope categories in the selected rangeland of Taplejung district.

II. METHODOLOGY

The study was conducted during June, 2010 to November, 2010 (5 months) in a selected herd of Mr.

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Chungda Sherpa following a established transhumant route in the region. The selected pasture/rangeland has been situated at Mauma *Kharka*, (27° 46' 11" North latitude and 87° 48' 24" East longitudes, 4100 masl) of Olang Chung Gola VDC of the Taplejung district (10°15' to 27°56' North latitude and 80°32 to 88°15' East longitudes with 777 to 8598 masl elevations) of Nepal which is north-east facing rangeland, inside Kanchanjunga Conservation Area. Three different slope categories of rangelands (plain, gentle slope and steep slope), which were available in Mauma *Kharka*, at 4100 m above mean sea level were purposively selected for this study. The research site with defined quadrat area were fenced during the June 2010, before the herd arrived for grazing. Three slope category was determined by using a Clinometers (Suunto, Germany), whereas it has further verified slope was calculated by using the slope formula:

$$\text{percent slope} = \frac{\text{vertical distance}}{\text{horizontal distance}} \times 100$$

Where,

Vertical distance was measured as a difference in elevation between two points, and horizontal distance was the distance from one point to the other and calculated by measuring distance with a rural and by applying the map scale of a topographical map. Finally, the slope % was defined and adjusted to plain category (less than 4% slope), gentle slope category (5-10% slope) and steep slope category (11-16% slope) The experimental design was a Completely Randomized Block (RCBD); one factor with three treatments, each replicated for 5 times. The treatments were slope categories. Altogether there were 15 experimental plots for each month study.

Above ground herbage mass productivity leaving 50 mm above the ground was estimated by using quadrat cutting on 5th July, 2010. In each quadrat, 0.5m × 0.5m area was fenced. Meanwhile, for each treatment and replication, the botanical

composition was also determined under grasses, legumes, cyperoids, forbs, shrubs categories by separating individually for the harvested mass. The fresh re-growth from each treatment was also harvested twice at 30 days interval; each at 5th August, and 5th September, 2010. Likewise, individual herbage samples of ten most preferred pasture species were collected from the study site on the basis of herders experience and visual observation of grazed species and used for further the chemical composition determination by using proximate analysis. The harvested fresh herbage sample of most preferred pasture species were first sun-dried, and further oven dried at 60 °C for 48 hours at IAAS, Animal Nutrition laboratory. A proximate analytical method (AOAC, 1990) was used to determine the CP, NDF, ADF, ADL, EE, cellulose hemicelluloses and total ash. Different relevant government and non-government organizations such as NARC, DADO, DLSO, FAO, ICIMOD, IAAS were the source of secondary data for the study. Data obtained from the study was tabulated and analyzed by MS- EXCEL.

III. RESULTS

This section deals about the results of study conducted on distribution of botanical composition of herbage mass under three distinct slope categories in Mauma, Taplejung harvested at July, August and September and most abundant pasture species that were found in the selected rangeland.

a) Botanical composition of herbage at different slope categories

The botanical composition of herbage mass differed in terms of species composed. The percentage of forbs were highest with the similar proportion of cyperoids and grasses (Figure 1, 2, 3). Botanical composition within the slope categories remained almost similar for all three months.

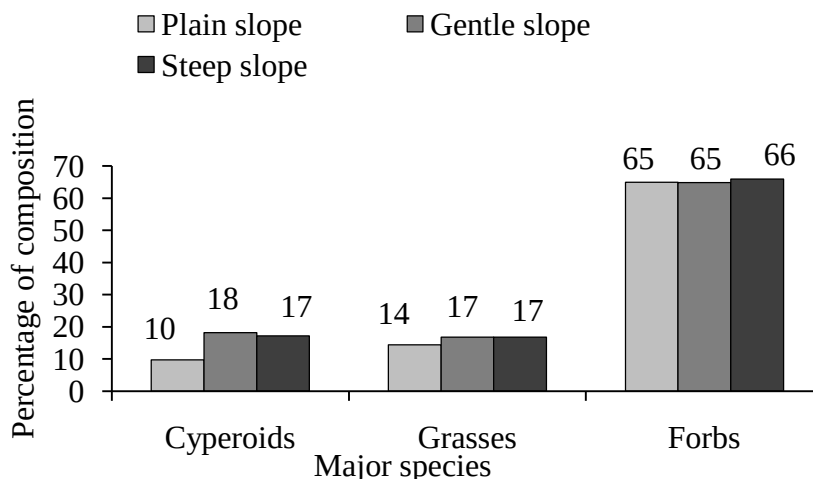


Figure 1 : Forage botanical composition at different slope categories (July, 2010) in Mauma rangeland, Taplejung

During July study, the proportion of cyperoids was 8% higher in gentle slope than the plain slope, but it was similar in gentle and steep slope. The proportion of grasses in gentle and steep slope was similar (17%) but was slightly higher than the plain slope. The proportion of forbs in all slope categories was similar which was about 50% higher than grasses and cyperoids. The highest percentage of forbs was 66% in steep slope.

During the study in August, percentage of forbs was higher that goes upto 61% (Figure, 2). Followed by the forb were grasses that contribute 37% in the plain slope whereas the proportion of grasses in gentle and steep slope was even lower than cyperoids. Likewise the percentage of cyperoids was somehow similar to grasses but slightly lower for plain slope (Figure 3).

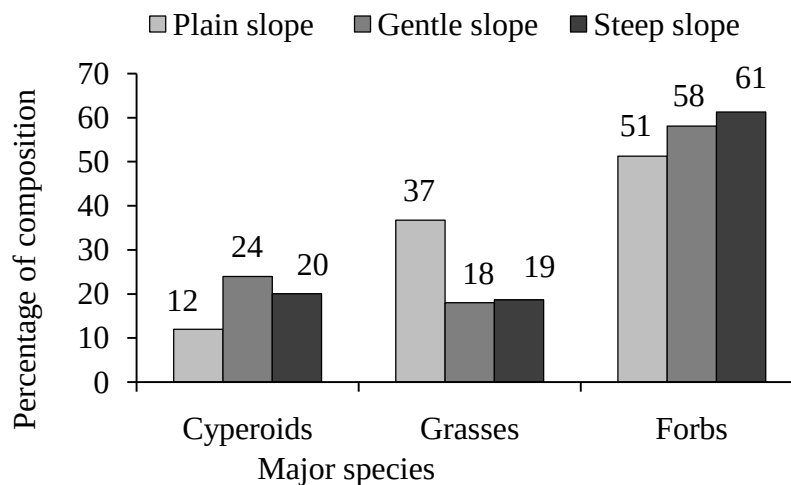


Figure 2 : Forage botanical composition at different slope categories (August, 2010) in Mauma rangeland, Taplejung

During September the proportion of forbs was highest that reached 73% for plain slope whereas percentage of forbs in other slope categories are exceeded 50% (Figure 3). Next to the forb was cyperoids to dominate 1 composition but only in gentle

and steep slope. The % composition of cyperoids ranged 13-20%. This situation of contribution of grasses as per different slope categories was similar to cyperoids.

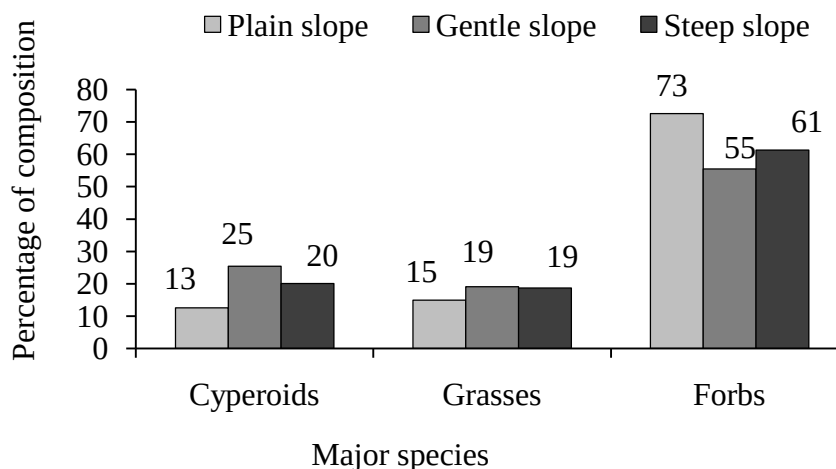


Figure 3 : Forage botanical composition at different slope categories (September, 2010) in Mauma rangeland, Taplejung

b) Chemical Composition of Most Abundant Pasture Species in the Experimental Area

The most preferred ten pasture species (on visual observation and herdes experiences) were

Kobresia humilis, *Poa alpina*, *Poa himalayana*, *Festuca* sp., *Agrostis tenuis*, *Carex* sp., *Plantago major*, *Ranunculus heterophyllus*, *Kobresia nepalensis*, and *Potentilla* sp. The Chemical composition of ten most

abundant pasture species has been reported in Table (1). Accordingly, the crude protein content was highest in *Poa alpina* (21.87%) with the lowest value for *Festuca species* (14%). Likewise, the ether extract was highest in *Kobresia nepalensis* (4.2%) and was lowest for *Agrostis tenuis* (2.4). The neutral detergent fiber (NDF) was highest in *Carax species* (68%) and lowest in *Potentilla species* (49.7%). The acid detergent fiber (ADF) was highest in *Festuca species* (58.7%) and lowest in *Poa alpina* (35.8%). Similarly, the acid detergent lignin (ADL) was highest in *Potentilla species*

(23%) and lowest in *Kobresia species*. In the similar way, the cellulose content was highest in *Festuca species* (48%) and lowest in *Potentilla species* (22%). The value of other species fell in between these two figures. Likewise, the hemicelluloses content was highest in *Agrostis tenuis* (17.5%) and lowest in *Potentilla species* (4.6%). The total ash content was also highest in *Kobresia species* with the lowest for *Agrostis tenuis* (7%).

Table 1 : Chemical compositions (%) of most abundant pasture species during July (2010) in Mauma rangeland, Taplejung

Species	CP	EE	NDF	ADF	ADL	Cellulose	Hemicellulose	Total Ash
<i>Kobresia nepalensis</i>	21.35	4.2	63.08	52.21	15.6	36.61	10.87	9.2
<i>Kobresia humilis</i>	20.78	2.9	52.39	37.98	7.13	30.85	14.41	11.5
<i>Poa alpina</i>	21.87	3.2	60.32	35.82	8.82	27	24.5	9.5
<i>Poa himalayana</i>	19.38	3.3	54.22	44.21	10.29	33.92	10.01	11.2
<i>Festuca sp.</i>	14	2.7	68.11	58.74	10.82	47.92	9.37	8.8
<i>Agrostis tenuis</i>	13.78	2.4	70.25	52.63	11.33	41.3	17.62	7.3
<i>Carex sp.</i>	18.55	2.7	68.08	51.85	12.67	39.18	16.23	9.3
<i>Plantago major</i>	18.55	3.4	50.31	42.08	19.46	22.62	8.23	9.9
<i>Ranunculus heterophyllus</i>	19.38	2.8	54.53	48.53	19.51	29.02	6	10.2
<i>Potentilla sp.</i>	20.65	3.6	49.68	45.04	23.17	21.87	4.64	8

c) Total Herbage Mass Productivity Across the slope categories

The total fresh herbage mass production at first harvest (5th July, 2010) remained statistically similar ($P>0.05$) for all three categories of slope. However, the highest fresh herbage mass was for gentle slope (4.76 t/ha) and with the lowest value for steep slope (3.5 t/ha). The total dried herbage mass at first harvest also followed the similar trend of fresh herbage mass (Table 2). Accordingly, the total dry herbage mass production was statistically non-significant ($P>0.05$), but having highest dried mass production at gentle slope (2 t/ha) and lowest for plain slope (1.52 t/ha). The mean dried weight of all three slope category was 1.84 t/ha.

At second harvest (5th August, 2010), there was again similar performance ($P>0.05$) for total fresh herbage mass production across the slope categories, but highest yield was harvested for gentle slope (8.6 t/ha) with the lowest value for plain slope (6.1 t/ha) (Table 2). Here again, the dried weight of herbage mass was also found non-significant ($P>0.05$) at second harvest. Nevertheless, the highest dried mass

was at gentle slope (4.1t/ha) with the lowest value for plain slope (1.7 t/ha). The average dried herbage mass for all three slope categories was to 3.6 t/ha in august.

At third harvest (5th September, 2010), the total fresh herbage mass production was again statistically similar, ($P>0.05$) but it was highest for gentle slope (12 t/ha) and lowest for plain slope (7 t/ha). The mean fresh herbage mass was 10 t/ha for all three categories of slope. Similarly, the dried herbage mass was also non-significant ($P>0.05$) as in the case of fresh herbage mass. Nevertheless the highest yield was for gentle slope (3 t/ha) with lowest value for plain slope (2.9 t/ha). The mean dry herbage mass of all three slope categories was 2.6 t/ha in September harvest.

The cumulated dried herbage mass of ninety days period from July to September was also non-significant ($P>0.05$) along different slope categories. Nevertheless the highest dried mass was for gentle slope (9.3 t/ha) with the lowest value for plain slope category (7.4 t/ha). The mean dried cumulated herbage mass of all three slope categories was 8 t/ha (Table 2).

Table 2 : The mean total herbage mass of mixed pasture species across the different slope categories (t/ha), in mauma rangeland, Taplejung (2010)

Treatments	First harvest (t/ha) (5 th July 2010)		Second harvest (t/ha) (5 th august 2010)		Third harvest(t/ha) (5 th September 2010)		Cumulated dried wt(t/ha)
	Fresh wt	Dry wt	Fresh wt	Dry wt	Fresh wt	Dry wt	
Gentle slope	2.26 (4.76)	1.6 (2.08)	2.980 (8.62)	2.14 (4.16)	3.5 (12.16)	1.880 (3.08)	3.06 (9.30)

Gentle slope	2.26 (4.76)	1.6 (2.08)	2.980 (8.62)	2.14 (4.16)	3.5 (12.16)	1.880 (3.08)	3.06 (9.30)
Steep slope	1.980 (3.50)	1.54 (1.92)	2.640 (6.52)	2.08 (3.84)	3.30 (10.70)	1.560 (1.90)	2.8 (7.66)
LSD(0.05)	0.4371	0.2799	0.5194	0.3602	0.595	0.4643	0.4558
SEM($\pm$)	0.1340	0.0858	0.1593	0.1105	0.182	0.1424	0.1398
F-probability	0.372 ^{ns}	0.294 ^{ns}	0.185 ^{ns}	0.069 ^{ns}	0.058 ^{ns}	0.295 ^{ns}	0.363 ^{ns}
CV (%)	14.0	12.7	13.1	12.4	12.8	18.2	10.8
Grand mean	4.19	1.84	7.09	3.65	10.15	2.65	8.14

Note: Figure in parenthesis are original value. The normally appeared figure are square root transferred value ($\sqrt{X}$ for value more than 10 and $\sqrt{X + 0.5}$ for for value less than 10). Mean followed by same letter (s) within the column are not significantly different by DMRT at 5% level of significance.

* = significant at 5% level of significance ($P < 0.05$)

** = significant at 1% level of significance ($P < 0.01$)

NS = No significance differences ($P > 0.05$)

SEM = Standard error of means

LSD = Least Significance difference of means at significance level $\alpha = 0.05$.

IV. DISCUSSION

The above ground herbage mass in alpine meadows are affected by factors such as air temperature, altitudinal aspects, slope aspects, soil organic matter, soil available N and P and environmental factors (Wang *et al.*, 2007). The total herbage mass productivity across the slope category in the present study was statistically similar ($P > 0.05$) for each month. This might be due to all slope categories selected in this experiment was in the north facing aspect. The primary productivity is depended upon spatial and temporal variation (Bouno *et al.*, 2010). North and north east aspect has the highest biomass in summer (Nikki *et al.*, 1980). Natural pasture yield in the north facing slopes was reported significantly higher than in the south facing slopes due to water availability (Gong *et al.*, 2008). Accordingly, biomass in the high alpine regions also reported highest in late rainy season mainly in July-August in Tibet (Long *et al.*, 1999b). Nevertheless August has the highest dry herbage mass productivity which is at par with Wang *et al.*, (2007). This results shows that slope would not be the determining factor in productivity of herbage but the time of grazing is important for the proper utilization of herbage mass. Biomass harvested in this experiment was comparatively higher than that reported by Devkota and Kolachhapati, (2010). Air temperature is crucial to be the single most important factor determining the biomass production of the alpine vegetation (Wang *et al.*, 2007), which might be favourable at July-August. The cumulated dried herbage mass was also found not significant ($P > 0.05$) across the slope categories and found higher than the herbage mass reported by Devkota and Kolachhapati, (2010). This might be due to longer growing period and due to more proportion of forbs in the rangeland and enough rainfall during experimental periods. The botanical composition of the rangeland in every month

and every slope slope categories shows that forbs are highly dominating,

The grazing management systems also affect the aboveground herbage mass and nutritive quality of pasture. The lowest dried weight yield in September at the present study might be due to the early withering of some of the early grown forbs succeeded by few species of *Potentilla spp.* and *Plantago major* which have lower NDF content but higher ADL content with the lowest cellulose content (Table 1).

The botanical composition of the rangeland in every month and every slope categories shows that forbs are highly dominating. In an abandoned pasture, the herbaceous forbs increased (Castro and Frietas, 2009). High forbs contribution in the herbage harvested would be due to the high grazing pressure in Mauma pasture (kharka), where the animals are freely grazed since the unknown past in the main pasture growing season. As majority of the pastures in Mauma rangeland are dominated by annual plants, forbs and sedges timely rainfall and snowfall are the critical factors for the growth of the good quality vegetation in the rangeland. Increase of number of invasive plants had been observed by Angassa and Oba (2010) in the pasturelands. Accordingly, high grazing pressure resulted high ADL content in pasture species (Glindemann *et al.*, 2009). These facts, somehow, resembles to the Mauma rangeland where forbs were dominating that showed visible and low quality herbage.

V. CONCLUSIONS

Botanical compositions of herbage like, cyperoids, grass forbs differed according to the slope categories. Forbs were in highest percentage cover in all slopes. Monthly distribution of herbage showed that cyperoids were distributed positively along slopes during each month but distribution of grasses and forbs were inversely related at gentle slope. Among the

pasture species *Poa alpinae* had the highest CP content (21.8), *Carex sp.* had the highest NDF content (68) and *Festuca sp.* had the highest cellulose content (47.9). Although the CP content was highest in cyperoids followed by forbs and grasses. There was a dominance of forbs and cyperoids in the pastureland reflecting poor quality of herbage with its slowly deteriorating quality.

ACKNOWLEDGEMENT

We would like to extend our sincere gratitude to Swaris Scholarship fund (with the Courtesy from Mr. S. Barsila, (Ph.D. Scholar) for providing financial support for this research and Directorate of Research, IAAS, for other technical supports.

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