VARIATION IN PRODUCTIVITY ALONG THE ALTITUDINAL GRADIENTS IN CENTRAL KARAKORUM NATIONAL PARK (CKNP), PAKISTAN

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Abstract

The study was carried out in the Hushe Valley, CKNP region, Pakistan, during summer 2012. Sampling was performed along altitudinal gradients in rangelands of CKNP area Hushe. Five quadrats were laid on each of line transects (25m) in four dimensions at 5 meters' intervals, on alternate sides of transect line. Biomass productivity and carrying capacity were estimated by using 1-m² quadrats (N=20 by site; total N = 60). The average standing biomass and carrying capacity was 48 Kg ha^{-1}and 55.67 ha^{-1}AU^{-1}5 mo^{-1} respectively. Furthermore, cumulative standing biomass of shrub, grass and forb at each altitudinal gradient of upper, mid and lower was estimated at18, 60 and 66 Kg ha^{-1}, respectively. The carrying capacity for the forb category was 16 months'ha^{-1}AU^{-1}/5 months^{-1} at the lower elevation, whereas at mid elevation the carrying capacity for the shrub category was 23 ha^{-}1AU^{-1}5 mo^{-1}. The assessment of soil organic matter at each site was highest (1.5%) at the high elevation, while P (27.9 mgkg^{1}) and K (260 mgkg1) concentrations were highest at mid elevation. The study highlighted low production which also vary along altitudinal gradient. This is an alarming situation for the livestock farmers and wild ungulates under present and predicted climate change scenarios. Therefore, the results of the study would be beneficial for the policy makers and managers in the planning of rangeland of CKNP.

Key words: Standing biomass, Rangeland, Carrying capacity, Ecological zones, CKNP, Gilgit-Baltistan.

Introduction

Rangelands are large tracts of natural vegetation that are inappropriate for cultivation due to physical characteristics. These stretches of land are important sources of wood products, water and forage for livestock (Miller & Craig, 1997). Rangelands have historically been the backbone of pastoral livelihoods (Tastad *et al*., 2010). They play a pivotal role in the livelihoods due to many direct and indirect services provide to society and for maintaining the composition of the environment including all natural resources (Ahmad & Ehsan, 2012). Range management and improvement is always difficult due to complex interactions of various environmental, biological and social factors. Many factors that influence rangelands degradation are shift in species composition, reduction in vegetation cover, above ground plant productivity and soil erosion (Ahmad & Ehsan, 2012). In the alpine pastures average forage production recorded was 700 kg ha^{-1} in Gilgit-Baltistan, Pakistan. The average carrying capacity is 5 haAU^{-1} for a well-managed area (Khan, 2003). Due to centuries of over grazing, rangeland productivity in Gilgit-Baltistan has been adversely affected. Biomass for different alpine communities in the Indian Himalayan alpine rangelands ranges from 112 to 396 g/m². Shoot production for different alpine communities' ranges from 114 to 490 g/m² (Ram & Singh, 1994). The alpine grassland is mainly utilized for summer grazing from June to August by large herds of sheep, goat and horses. The sub-alpine and alpine rangelands of Pakistan produce only 10-50% of their potential productivity and provide only 60% of the required herbage (Shah and Rafique, 1991). The relationship between gradients is the basic key to investigate the vegetation community in any area (Ahmed *et al*., 2014; 2006). The soil physico-chemical properties effect the distribution of vegetation both in positive and negative aspects (Ahmed *et al*., 2005; Ahmed & Shaukat, 2012; Akbar, 2013). Vegetation communities are dependent on environmental gradients in respect to the growth and biomass (Akbar *et al*., 2014a, 2014b, 2011). The grazing and collection pressures along with elevation are also the most important factors influencing the distribution and abundances of the species (Rahman, 2020). The soil characteristics are correlated with the flora in Balochstan agricultural fields (Agha, 2020).

Rangelands in Pakistan covered 28.5 million ha (32.4 %) out of the total land area of 88 million ha in Pakistan (Govt. of Pakistan, 2010). However, previous reports showed that it was 50.88 million ha, accounting for58% of the country's landmass out of 88 million hectares (Mohammad, 1989). There is small area lies in the Alpine pastures with high-rainfall (1.68 million ha) and grazing lands of the Himalayas (0.67 million ha), while the remaining area situated in arid and semi-arid regions of Pakistan (Afzal *et al*., 2008). According to a new land cover map of Gilgit-Baltistan by WWF-Pakistan (2012), using satellite images and GIS techniques, the area under rangelands is 2.34 million hectares, i.e., about one-third (33%) of the total land area of Gilgit-Baltistan.

The productivity, carrying capacity and soil parameters are important parameters to know the rangeland health and the information about biomass and carrying capacity in Alpine rangeland of Gilgit-Baltistan is very scarce. Therefore, the present study was designed to assess biomass productivity, carrying capacity and soil parameters of three potential range sites at varying altitudinal gradients in alpine of Hushe CKNP. This study would helpful to formulate the improvement of alpine pastures and management of Park in the Karakorum range.

Map of study area

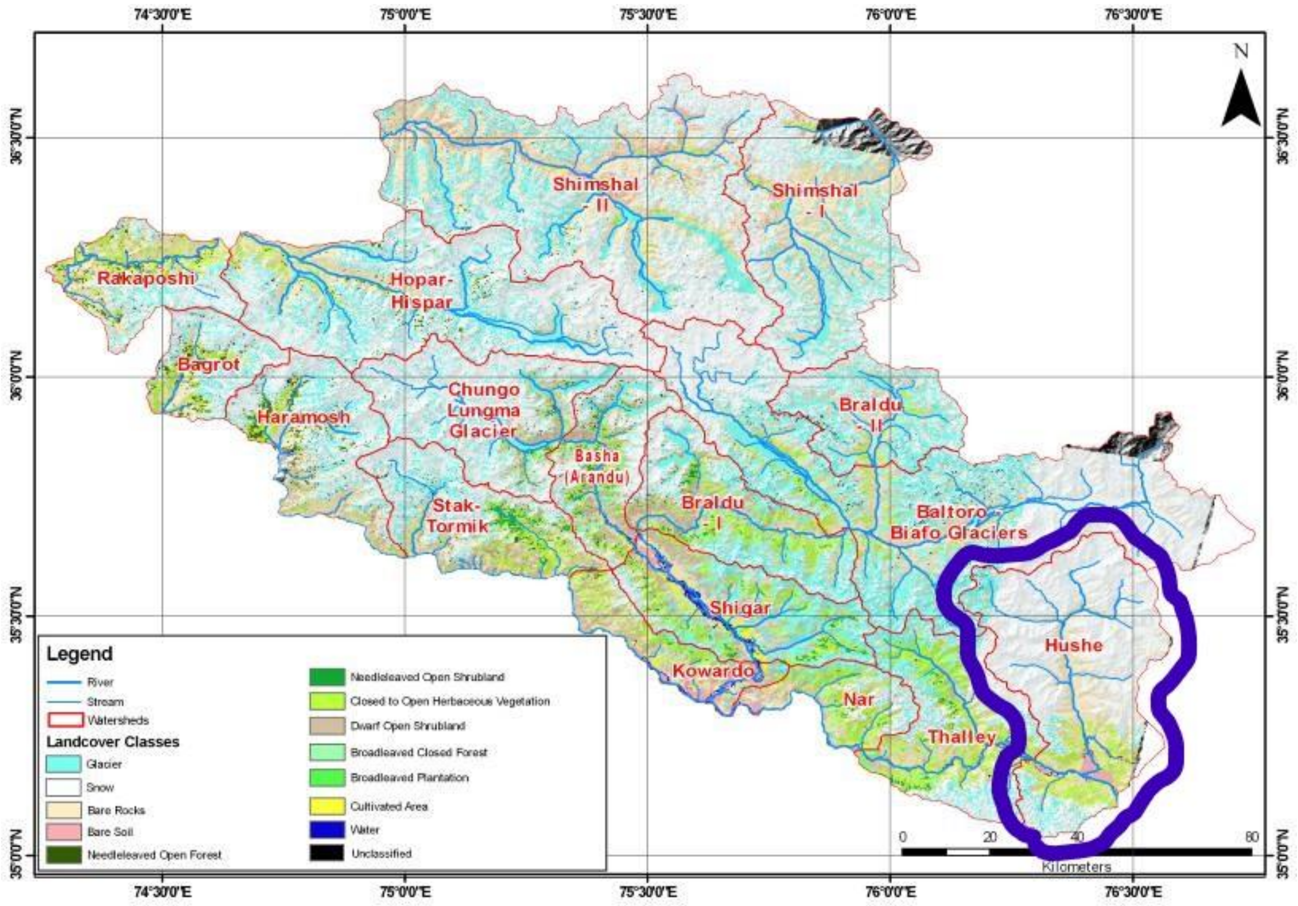


Fig. 1. Study area Hushe Valley, (Source CKNP office Directorate Skardu).

Material and Methods

Study area: Gilgit-Baltistan (35–37° North; 73–78° East) is situated in the (Fig. 1) northern part of Pakistan. The Hushe Valley is considered as most popular valley because of foreign tourism and several peaks such Mashabrum, and Ghodoghoro la. The valley is also popular because of their livestock and pastures. The mean precipitation during 2012 in Hushe Valley was 46.08 mm and temperature was 13.83°C.

Data collection: Selection of samples was carried out along three varying altitudinal gradients in the valley. Field visits were conducted during the summer 2012. To record productivity five quadrats were laid on each transect line (25meters) in four dimension with 5-meter interval on alternate side of transect line (Fig. 2). Biomass productivity was estimated by using 1-m² quadrats (*N*=20). The above-ground plant biomass for each plant growth form group was cut and weighed at fresh and after drying for 24 h in an oven at 85°C. The dry matter was calculated by converting g/m^2 into kg ha^1, following Kent & Kent, (2012) and Mueller-Dombois & Ellenberg, (1974). Altitude and geographical coordinates at each site were recorded through the Global Positioning System (GPS, Model-E. trex.30). There were three (3) range sites, from each range sites three (3) replicate of soil samples were collected on four dimensions which makes a twelve (12) samples on every range sites. In total there were thirty-six (36) sample on three elevations (N=36). Soil physico-chemical properties were carried out at Punjab Agricultural Research Center Rawalpindi. The soil electrical conductivity (EC) and pH was carried out by method of McKeague, (1978) and Mclean (1982). Soil texture was carried out by the method of Gee & Bauder (1986), organic matter was carried out by the method of Walkley & Black (1934). The potassium (K) was calculated by Smith & Mathew (1957) and Richard & Bates (1989). The available phosphorus (P) was determined by Olsen (1954) method.

The carrying capacity was calculated by considering one cow weighing 350 kg as one animal unit (AU) that requires 9 kg dry matter forage / day as per established criteria (Ahmad *et al*., 2012; Stoddart *et al*., 1975). Carrying capacity was calculated in terms of number of hectares required for sustainably supporting one AU for 5 months, as the pasture is only available for grazing for five months in the study area.

Data analysis

The range productivity and carrying capacity were analyzed to check altitudinal variation among potential ranges and LSD test was performed after ANOVA. The data were analyzed for descriptive statistics and ANOVA was performed by using software package Statistic 8.1, SPSS 16 and MS Excel 2007.

Fig. 2. Field sampling and biomass estimation.

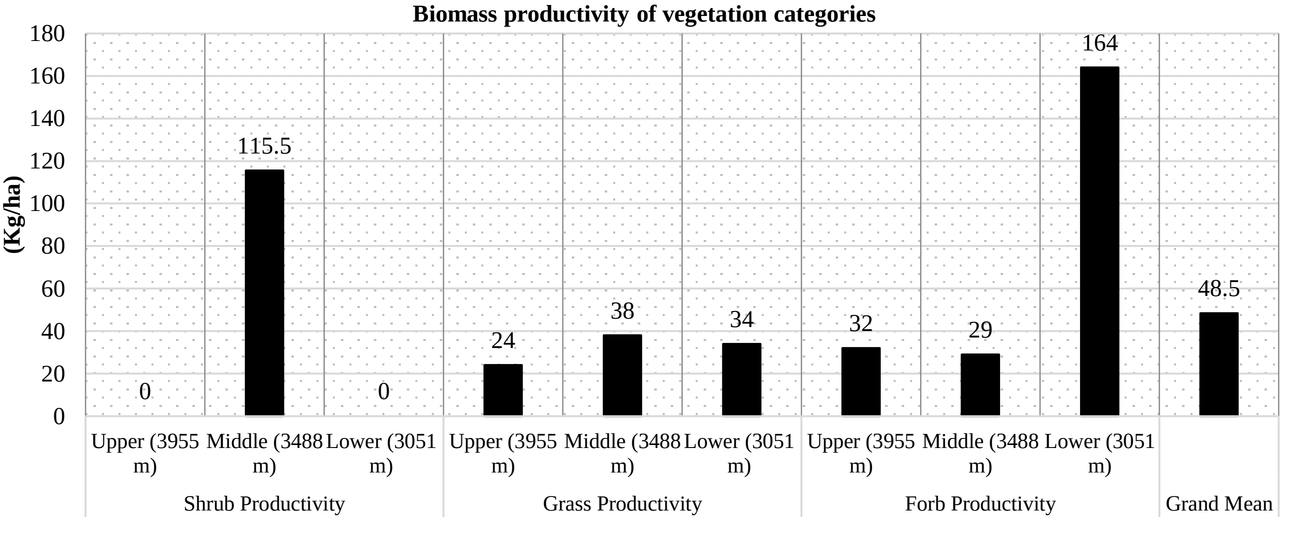
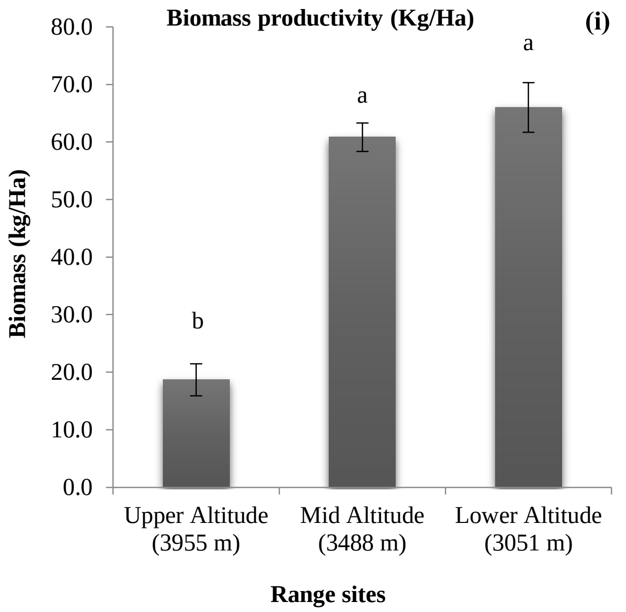


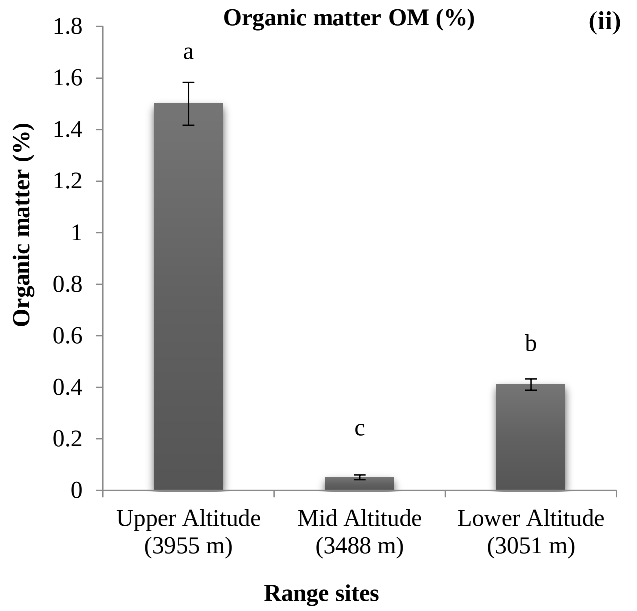
Fig. 3. Biomass productivity for vegetation categories at three altitudinal gradients in Hushe 2012.

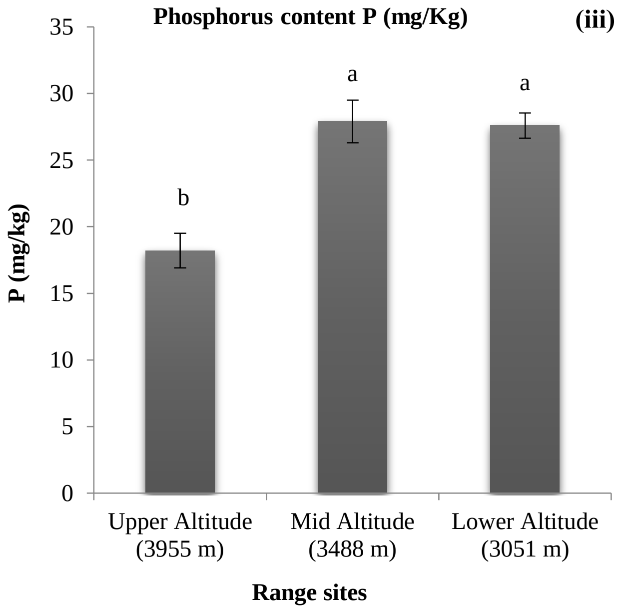
Results

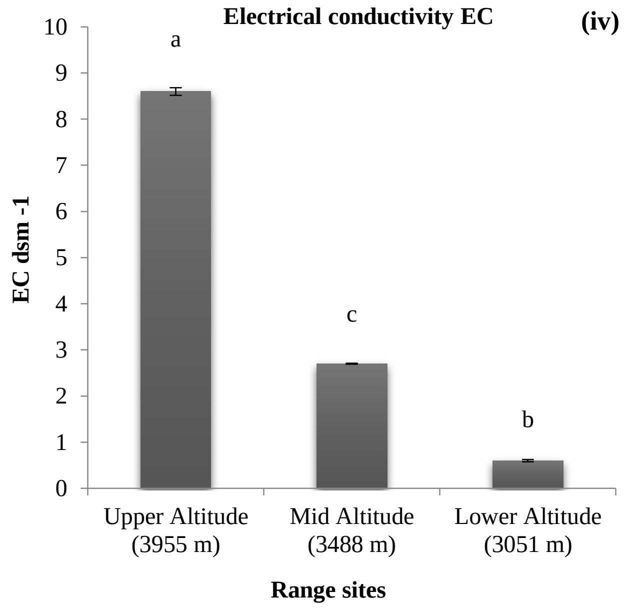
The cumulative standing biomass of shrub, grass and forb at each altitudinal gradient of upper, mid and lower altitude was found as 18, 60 and 66Kgha^{-1}, respectively. The plant growth form related to biomass such as for forb category, productions was recorded highest 164 Kgha^{-1} at lower altitudinal range site (Gambabramachan) followed by shrub 115 Kgha^{-1} in mid altitudinal ranges site (Jonfong) (Fig. 3). Standing biomass production for grass category was very low 38 Kgha^{-1}at mid-range followed by 34 Kgha^{-1} in lower altitudinal rang site and 32 Kgha^{-1}at upper altitudinal range site (Brumbrama). Statistically significant differences were observed between range sites of higher altitude with upper/mid and lower altitudes at $p<0.05$ (Fig.4 (i)). Similar trend was also observed for P content (Fig. 4 (iii)). However, for organic matter there were significant differences among all range sites ($P=0.05$) showing lowest organic matter at mid altitude (Fig. 4 (ii)). There was significant difference for electrical conductivity (EC dsm-1) on three altitudes (Fig 4 (iv)). However, there was no significant difference for potassium (K) on three elevations (Fig 4 (v)). The grand mean for standing biomass production in three ranges of study area was 48 Kgha^{-1}. (Fig. 3).

Carrying capacity at all three range sites showed that it was higher at upper (65.5 ha/AU/ 5 months) as compared to other range sites. There was significant difference between upper and lower altitude for carrying capacity (Fig. 5).









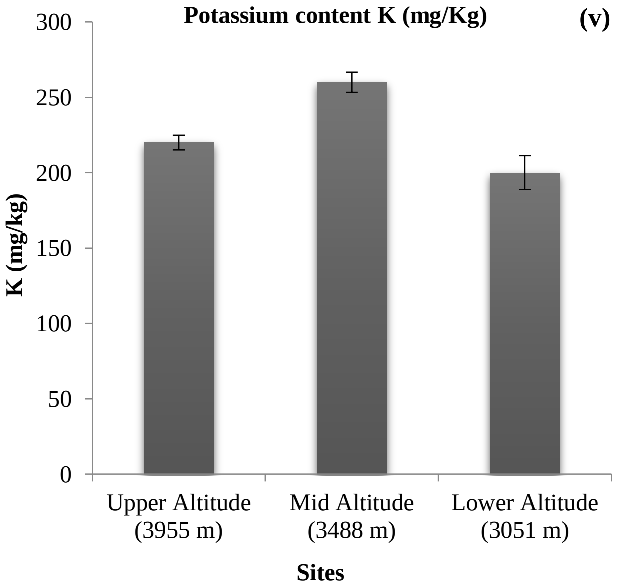


Fig. 4. (i) ANOVA effect of altitude on biomass productivity (Kg/ha) same letters sharing in each graph are statistically non-significant differences at $p<0.05$. (ii) ANOVA effect of altitude on organic matter (%), Same letters sharing in each graph are statistically non-significant differences at $p<0.05$. (iii) ANOVA effect of altitude on Phosphorus (mg/kg) Same letters sharing in each graph are statistically non-significant differences at $p<0.05$. (iv) ANOVA effect of altitude on EC (dsm-1) Same letters sharing in each graph are statistically non-significant differences at $p<0.05$. (v) ANOVA effect of altitude on EC (dsm-1) same letters sharing in each graph are statistically non-significant differences at $p<0.05$.

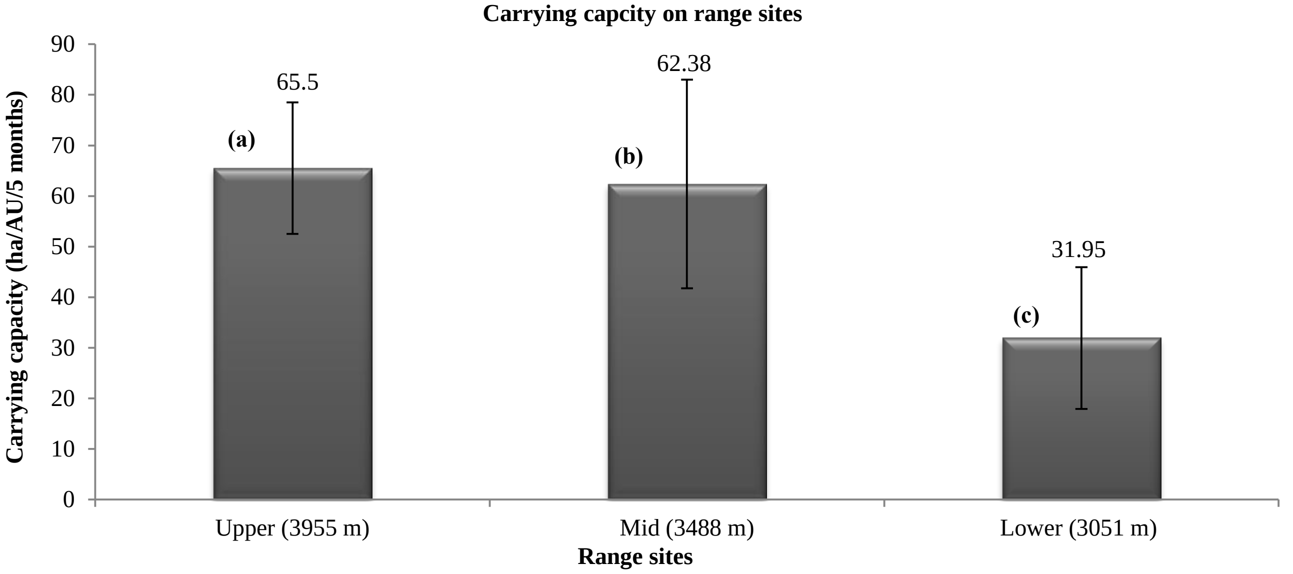


Fig. 5. Carrying capacity of three selected range sites in the study area, Same letters sharing in each graph are statistically non-significant differences at $p<0.05$.

Discussion

In the present study, the standing biomass production was measured in three elevation ranges (upper, mid and lower altitudes) of Hushe valley. Cumulative biomass of shrub, grass and forbs at each gradient of upper, mid and lower was found as 18, 60, 66 Kg ha-1 respectively. Major factors influencing range productivity include stocking rate, grazing system, type of forage species, types of animals and season of use (Durrani *et al*., 2005). This poor biomass production may also be linked with considerable number of wild ungulates population in the study area (Hussain, 2014). Recently, Austrheim *et al*., (2014) showed effect of herbivore density on plant biomass (above-ground) in an alpine grassland ecosystem stating that herbivores may increase or decrease aboveground plant productivity depending on factors such as herbivore density and habitat productivity.

The vegetation wise production for forb category, was recorded highest 164 Kg ha-^{1} at lower altitudinal range site (Gambabramachan). The shrub category was highest (115 Kg ha^{-1}) in mid altitudinal ranges site (Jonfong) The grass category was highest (38 Kg ha^{-1}) at mid-range. Similar findings have been observed for decreasing above ground biomass production with increasing altitude under various climatic zones (Kira & Shidei, 1967; Maruyama, 1971). Nevertheless, the differences of lower biomass production at higher altitude may also be attributed to the short growing period and traditional grazing mechanism of livestock as the local communities graze their domestic livestock in upper alpine pasture during summer (Khan, 2003). The grand mean for standing biomass production in three ranges of study area was 48 Kg ha^{-1}. Similar findings have also been reported from rangelands of Baluchistan producing 50 Kg ha^{-1} biomass categorized as poor, medium category (60 Kg ha^{-1}) and high potential range category (190 Kgha^{-1}) (Anon., 1995).

The overall average carrying capacity of three range sites was calculated as 55 ha/AU/5 months. This means more hectares are required to feed one animal unit. This status of carrying capacity can be improved by reseeding with potential forage species (Chaudhry *et al*., 2010). Carrying capacity for different forage categories was different at each altitude. This carrying capacity also changes with vegetation types. Our results for carrying capacity are in agreement with the rangelands of Ziarat and Kalat regions of Baluchistan with the findings of (Ahmed & Shaukat, 2012). Varying carrying capacity for forage categories (grass, shrub and forb) in selected sites may be linked with plant traits (Mysterud, 2006). The physico-chemical parameters of range sites showed comparatively low soil organic matter at lower altitude. This may be attributed due to grazing mechanism of livestock at higher altitude during summer (Khan, 2003). The continuous grazing of rangelands may result in decreasing organic matter content; which is in agreement with Kotzé *et al*., (2013). The data also showed higher biomass production with P contents. Similar findings have been reported by Wang *et al*., (2007), who has reported that Phosphorus and environmental factors affecting plant-species diversity and productivity of the alpine meadows. This required for plants to maintain growth and a key production factor for biomass (Hackenberg *et al*., 2012; Nesme *et al*., 2014). There are many factors, such as relative elevation, types of soil and climatic variations, affecting productivity and vegetation of rangelands (Khan, 2003; Peer *et al*., 2007). Similar findings have also been reported from dry alpine rangelands of Ladakh, western Himalaya for phytomass along the altitudinal gradients (Namgail *et al*., 2012). The climatic variables like temperature and rainfall are considered as major driving factor for ecosystem productivity and stability in rangelands, because they influence on soil moisture regimes and nutrients pools (Eldridge *et al*., 2011). Decreased biomass production in the region may be associated with low rainfall in the study area (Hussain, 2014). This has been supported by previous studies for biomass production in various rangelands (Durrani *et al*., 2005; Muhammad, 1989).

Conclusion

The result may be linked with poor soil organic matter, overgrazing and climatic conditions. The results of the study are very helpful for the policy makers and mangers in the planning of rangeland improvement programmes in the alpine area of Karakorum and for park management.

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