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Effects of Grazing Pressure on Plant Species Composition and Diversity in the Semi-Arid Rangelands of Mbulu District, Tanzania

C. Mligo
Department of Botany, University of Dar es Salaam, P.O. Box 35060,
Dar es Salaam, Tanzania

Abstract: The study was carried out in the semi-arid rangelands of Mbulu District that have been used for livestock grazing since the 18th C. The study assessed the effects grazing pressure on plant species composition, diversity and distribution. It was found that, grazing pressure negatively affected the species composition, diversity and resulted into uneven distribution of the common semi-arid plant species in the rangelands and land degradation and erosion were the consequences. However, similarities in plant species composition among the study sites ranged between 0 and 0.566 with the highest coefficient of similarity between Dongobesh and Maretadu since they were in close proximity, hence suffered similar level of effects of grazing pressure. Species diversity ranged between 4.067±0.217 (from Dongobesh) with moderate grazing pressure and 1.07±0.0586 (from Tlawi) with the maximum level of grazing pressure. DCA ordination showed the highest effects of grazing pressure on plant species distribution where as at the first two axes (axis1 and axis 2) 64.7% counted for the samples of species variation. DCA resulted into the three clusters showing the different levels of grazing pressure (the highest intensity of grazing, moderate grazing and the lowest) with increasing gradient in an ordination space. Plant species such as *Themeda triandra, Hyperhenia filipendula* and *Panicum maximum* were absent in overgrazed areas and survived in areas with the lowest level of grazed due to being palatable to livestock. On the other hand, the better performing vegetation which was essentially composed of *Hypoestes forskalii*, *Tragus beternonianus*, *Ageratum conyzoides* and *Solanum incanum* existed in overgrazed areas as they were not palatable to domestic livestock.

Key words: Composition, diversity, grazing intensity, palatable, semi-arid grasslands

INTRODUCTION

Mbulu District is located in Manyara Region, northern Tanzania between latitudes 3^0 28'S and 4^0 14'S and longitudes 34°53'E and 35° 46'E and at the elevation of 1500 to 2400 meters above sea level. The district has two major climatic zones *viz*, a semi-arid zones receiving between 300 and 700 mm of rainfall annually and sub-humid zone with an annual precipitation ranging between 700 and 1200 mm[1]. The temperature ranges from 12.6°C to 30.2°C[2], which is a characteristic semi-arid climate. The semi-arid areas of Mbulu District are part of the thorny woodlands of a Tropical Africa. The areas cover about 66% of the District that supports more than 96% its population, which is mainly comprised of the pastoral communities that uses them as rangelands for their domestic livestock[2]. This means that since the 18th century the semi-arid areas of Mbulu District has been occupied by domestic herbivores that might have preferentially grazed upon the palatable plant species, trampled upon the non-palatable ones and, as a consequence, disturbed the plant species composition, diversity and distribution. On the other hand, variation in number of grazing and browsing species as well as grazing pressure may result in variation in species diversity. Despite the importance of the effects of grazing pressure on the plant species diversity in the study area, little was known about the effects of varying grazing intensity on plant species diversity in the rangelands of Mbulu District. But with such scanty information, it was not easy to tell whether the plant species diversity in the area is decreasing as a result of grazing pressure or not. Further more, it was not easy to recommend the level of grazing intensity that are optimum for the maintenance of level of species necessary for the maintenance of ecological stability. Halting the decrease in plant species diversity resulting from grazing pressure must be central to rangeland conservation and management for sustainable production In the view of the fact that there was scanty information regarding the effects of varying of grazing intensity on the diversity of plant species in the semi-arid areas of Mbulu District, it was considered

important to undertake the present study as a means of augmenting the data that would help in formulating policies and practices for the conservation and management of the rangelands.

MARERIALS AND METHODS

A reconnaissance survey was first carried out to identify various vegetation segments present in the study area. On the basis of the results of the preliminary survey, the study area was divided into six more or less homogeneous vegetation segments. Four rectangular quadrats were randomly laid out in each vegetation segment with the long axis of each quadrat cutting across any perceived banding in the vegetation in terms of species cover. The size of each quadrat was determined using the minimal area technique[3] and a plot measuring 20 m x 30 m was satisfactory as a representative sample area of the vegetation under investigation. The plant species were identified to species level in the field whenever and wherever this was possible. Plants that were not easily identified in the field were identified through comparison with preserved plant specimens in the herbarium in the Department of Botany, University of Dar es Salaam. Each quadrat was subdivided into 0.5 m x 2 m sub-quadrats to facilitate the easy identification of the herbaceous species present. The intensity of grazing pressure in each of the quadrats also was assessed and recorded on a 6-point scale as described in Table 1 Rulangaranga[4].

Determination of plant species diversity: The plant species diversity was determined from the raw data by using the species diversity index[5] according to the formula given below: -

Where pi = ni/N, the number of individuals found in the ith species as a proportion of total number of individuals found in all the species.

$$\text{Diversity index } (H!) = -\sum_{i}^{\infty} pi \ln pi$$

In = Natural logarithms to base e

The variation in species diversity between study sites was compared by using the analysis of variance (ANOVA)[6].

Ordination analysis: The ordination analysis method was used to assess the effects of grazing and grazing related activities on composition change (distribution) in the semi-arid areas of Mbulu District. The vegetation data matrix for canonical analyses was generated using Microsoft Excel spreadsheets. These data were exported direct to the canonical community ordination (CANOCO) programme using the canoimport program and then subjected to Detrended Correspondence Analysis (DCA) an indirect gradient analysis technique Noy-Meir and Whittaker[7]; Ter Braak[8]. The technique was selected on the assumption that species composition and their distribution patterns are determined by grazing pressure according to the single response model[8] Ter Braak. DCA was attempted to cluster the sampling units according to different levels of grazing pressure. This was selected so as to provide an effective approximate solution to the ordination for the unimodal response model in two dimensions on the assumption that the data were reasonably representative of the major underlying grazing intensity gradient.

Table 1: Grazing intensity classes and their interpretation Rulangaranga[4]

Grazing Intensity Class	Interpretation
0	No grazing
1	11 – 20% of the quradrat grazed
3	21 – 40% of the quradrat grazed
4	41 – 60% of the quradrat grazed
5	61 – 80% of the quradrat grazed
6	81 –100% of the quradrat grazed

Table 2: The czekanowski coefficient of similarity in species composition among the study sites

	Masieda	Tlawi	Maretadu	Dongobesh	Yaeda Chini	
Masieda	0					
Tlawi	0.2269	0				
Maretadu	0.158	0.220				
Dongobesh	0.157	0.367	0.566	0		
Bashay	0.3048	0.326	0.1638	0.32	0	
Yaeda Chini	0.3259	0.125	0.1327	0.261	0.2237	0

RESULTS

Similarity in floristic composition between the different study sites in mbulu district: The similarities was the highest between Maretadu and Dongobesh, there was a higher coefficient of similarity ($S_{c=}$ 0.566) than with other areas. The species composition in Dongobesh was also to some extent similar to the plant species composition of Tlawi (Sc = 0.3668) but was slightly different from the species composition recorded at Masieda (Sc = 0.157). Likewise, the vegetation recorded at the Tlawi study area was more similar in species composition to that of Bashay (Sc = 0.326) and had a slightly different species composition when compared with the vegetation recorded at Maretadu, Yaeda Chini and Masieda (Table 2).

The effect of grazing intensity on species diversity in the semi-arid mbulu district: The results showed a significantly different in plant species diversity between study sites on the basis of analysis of variance (ANOVA), ($F = 24.596$, $p<0.0001$). The correlation analysis also showed negative effects of grazing pressure on plant

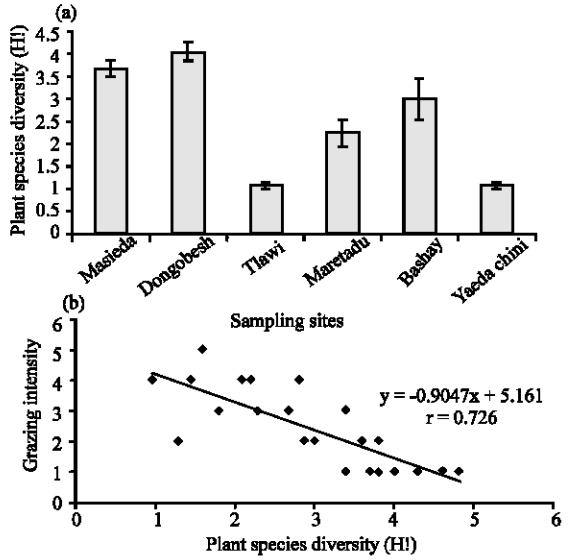

Fig. 1: Variation in species diversity with grazing intensity between sites.
(a). Variation in species diversity.
(b). Correlation between species diversity and Grazing Intensity in Mbulu District

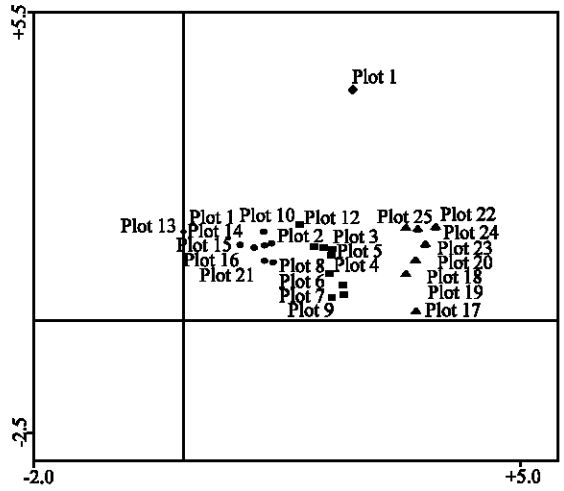

Fig. 2: The DCA ordination results for the effect of grazing pressure of various areas of the semi-arid Mbulu District. ▲ Low level of grazing, ● moderately grazed and ■ intensively grazed

species diversity in the semi-arid rangelands of Mbulu District, r = 0.72 Fig. 1. Dongobesh recorded the highest species diversity (4.067±0.217) with the lowest grazing pressure. Grazing pressure was very high at Tlawi resulting in the lowest species diversity, i.e. (1.07±0.0584). At Yaeda Chini was 1.1±0.059 which was also very low due to unknown factors that were not related with grazing. Furthermore, species diversity values at Masieda (3.667±0.185), Maretadu (2.25±0.325) and Bashay (3±0.47) at comparatively intermediate levels presumably because these areas were subjected to intermediate grazing pressure Fig. 1.

Variation of grazing pressure on the plant species distribution in semi-arid rangelands of mbulu district (dca-ordination analysis): The results in DCA ordination analysis showed that plant species composition change and distribution in Mbulu rangelands is determined primarily by grazing pressure Fig. 2 and 3.

The main clusters or groupings of samples of species in the DCA ordination showed that, the first two axes (axis1 and 2) counted for 64.7% of the samples of the plant species variation Fig. 2. These were the most useful and significant in the analysis. At the DCA-axis 1, 42.6% counted for by the influence of grazing intensity on species distribution, where as at axis 2, 22.1% counted for by the cutting of thorn woody plant species for grazing related activities, such as for construction of enclosures of their compound and kraals for grazing units where the pasture in the communal land is not sufficient during the dry seasons. Although this could not bring high dispersion of sampling units and plant species in an ordination diagram, the combination of variations at DCA axes 3 and 4, 4.53% counted by other environmental factors apart from that caused by pastoral activities, which were not measured in the present study. However these contributed a very little percentage in the species distribution and hence were not very meaningful to the present analysis and interpretation. The gradient among sites was indicated by the DCA axis 1, which shows three important clusters with different levels of grazing pressure. The first cluster from the left of the canodraw (ordination diagram) was from areas (plots 17-20 and 22-25) in which grazing pressure was very low. They scored the highest gradient at DCA axis 1 among all the sites Fig. 4. The second cluster (Plots 2-9 and 12) at the middle in the canodraw was from areas that were overgrazed with the average gradient at the DCA axis 1.

The third cluster (Plots 10, 11, 13-16 and 21) was from areas that were moderately grazed with the lowest gradient in an ordination space. On the other hand all the species with preference to the environmental optimum variables are well explained by DCA axis 1 which makes plots to be grouped together as a single cluster different from the other and scoring different gradient at DCA axis 1 and as well as at DCA axis. Such plant species preferences reflect the influence of environmental variables on the general vegetation characteristics in the study area. Plot 1 is a control for the assessment as it had the highest species richness and diversity the no grazing intensity.

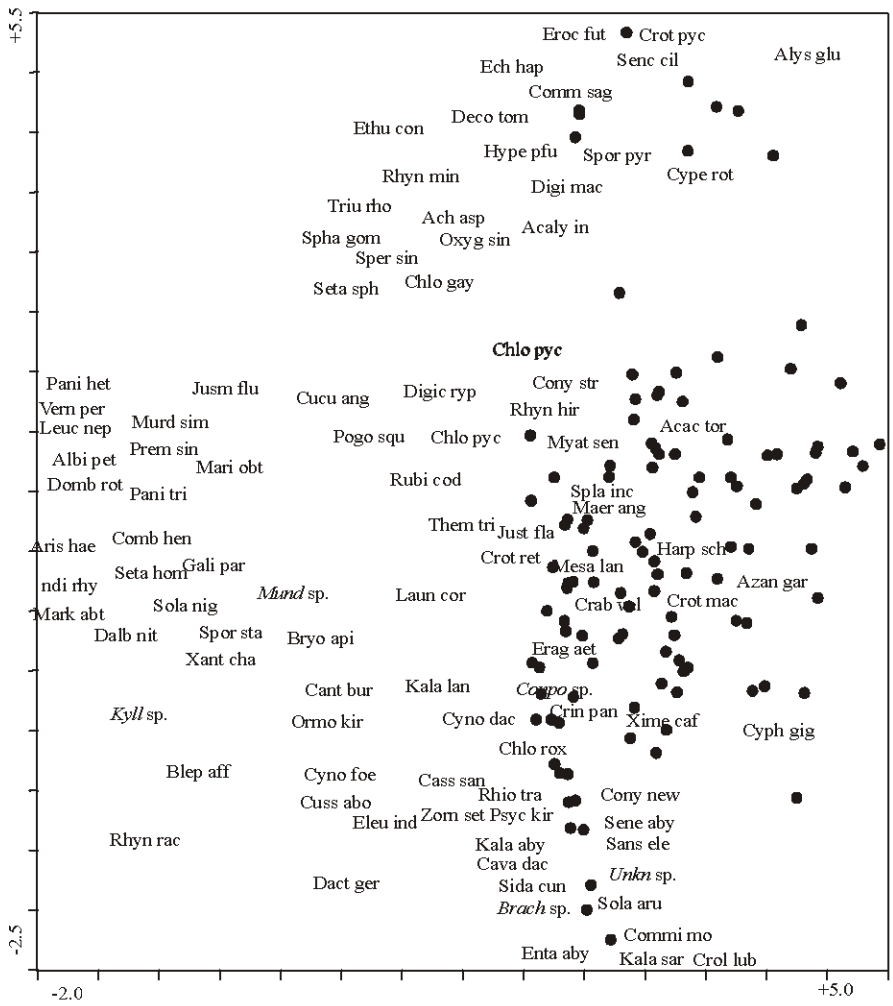

Fig. 3: The variation in plant species abundance using eigen distance for the first (DCA 1) and the second (DCA, axis. Species names appear in seven characters i.e. four letters for the genus name and three letters of the species

DISCUSION

Similarity in floristic composition between study sites: grazing pressure by both domestic and wild ungulates results into changes in plant species composition in an area as the selectively graze upon them. Increased in grazing pressure on palatable plant species may result into dominance of unpalatable plant species in an areas and hence the composition changes. Therefore, variation in grazing intensities results into variation in plant species composition. The results showed that grazing pressure resulted into variation in plant species composition in different study sites of the semi-arid grassland of Mbulu. Maretadu and Dongobesh, had high coefficient of similarity because these two sites were in close proximity to each other and hence the chances of having more or less similar vegetation composition with more or less the same cover abundance was higher than it was with other study sites. Also, Tlawi is closer to Dongobesh and therefore the chances of having somehow similar effect of grazing pressure on plant species compositions is greater than Masieda site.

Effect of grazing pressure on plant species diversity different areas of mbulu district: Grazing intensity is the major factor affecting species diversity and distribution in the semi-arid ecosystem of Mbulu District Fig. 1 and 2. The clusters of samples in Fig. 2, showed different levels of grazing pressure. Some areas were highly grazed with very low diversity, others moderately grazed and in some areas were at the lowest level grazing Fig. 2.

The Masieda and Dongobesh had a very high plant species diversity compared to Tlawi, Bashay and Maretadu where grazing was very high Fig. 1. High species diversity in these areas with dominance of *Panicum maximum*, *Themeda triandra*, *Acacia nilotica*, *Acacia robusta*, *Acacia seyal*, *A. tortilis*, *Dichanthium annulatum* and *Heteropogon contortus* which implies

high palatability to both domestic and wild herbivores. Hence, their occurrence in high richness is an indicative of moderate or little grazing intensity.

According to Naithani, *et al*.,[9] and Sabernwal,[10] grazing intensity maintains low species diversity in an area. Grazing animals decreases species diversity through the removal of palatable plant species[11] or trampling by the hooves, soil compaction, urination and dung deposition. Grazing animals selectively grazed on the palatable grass species in the study area. The palatability of some plant species attracted large herds of domestic livestock to forage on its tissues. Selective foraging on palatable plant species by domestic herbivores led to the dominance of the plant community by relatively few unpalatable species with concomitant reduction in species diversity with increasing grazing intensity. Since both areas have been grazed upon, the effects of grazing and browsing pressure cut across in almost all the semi-arid grasslands of Mbulu District in that, none of the areas was found to be unaffected by grazing. Species diversity is high when disturbance is maintained at an intermediate level[12]. Under moderately intensity of grazing pressure resulted into increased species diversity. This is due to the fact that some plant species especially the rare ones may favoured thereby resulting in relatively higher species diversity. According to Moen *et al*.[13] intermediate-grazing pressure can maintain relatively high species richness by preventing any of the plant species from gaining dominance. Plant species can be prevented from gaining access to light by canopies of the dominant palatable plant species. Grazing on the dominant and palatable plant species may result in many of the sub-ordinate plant species becoming exposed to light and even the seeds in the seed bank may receive sufficient light to stimulate their germination thereby increasing diversity of the vegetation in such areas.

The increased in environmental stress favours plants that are stress tolerant and are long lived in these overgrazed areas and hence are morphologically implastic and are well adapted to the harsh conditions by having relatively faster growth rates when favourable moisture condition set in under high grazing pressure. Also grazing intensity may favour species diversity by promoting invasion of non-indigenous species[14] or colonizing species with high growth rates or high dispersal rates[15] that may result into high species diversity.

The situation with regard to loss of plant diversity in Mbulu District is particularly alarming in most of the village areas where the data were collected. Inspite of the aridness of the areas, it was found to have very high livestock populations. Great number of livestock populations has caused a very high degree of vegetation disturbances through both overgrazing and trampling. This resulted in the loss in plant species diversity and consequently reduction in the overall productivity of the vegetation community in the area. Since the plant community productivity is dependent on increased in plant diversity[16], the reduction in plant species diversity will inevitably lead to massive deaths of livestock due to reduced amount of forage resulting in starvation. This has resulted into negative economic consequences for pastoralists, since nothing was done before to reduce the high livestock numbers present in the area. Due to overgrazing and the scarcity of forage in the pasture, the animals currently present in the pastures have become very weak and vulnerable to diseases due to poor health. As a result, their market value has been reduced, thereby providing low income to the pastoralists.

Effects of gazing pressure on plant species distribution patterns in the semi-arid mbulu district: The vegetation community in most of the areas was dominated by *Acacia* sp. which are the characteristic semi-arid and arid species. These species are used by domestic herbivores as forage resource in all the year round resulting into uneven plant species in the ecosystem. Some palatable grass species such as *Themeda triandra, Hyperhenia filipendula* and *Panicum maximum* performed better during the rainy seasons under high grazing pressure but failed completely during the dry season and hence overgrazing due to being palatable to grazing animals. On the other hand, the better performing vegetation which was essentially composed of *Hypoestes forskalii*, *Tragus beternonianus*, *Ageratum conyzoides* and *Solanum incanum* that were not palatable to grazing animals were reduced to a low carpet through trampling. It appears that the area has been subjected to long term grazing such that all the palatable plant species have been selected against and the existing plant species were not preferred by the grazing animals and hence they have been afforded a chance to be the dominant species in the area.

The vegetation in Masieda and Dongobesh were essentially dominated by Panicum maximum, Themeda triandra, Acacia nilotica, Acacia robusta, Acacia seyal, A. tortilis, Dichanthium annulatum and Heteropogon contortus with a very low grazing pressure. On the other hand, Tlawi, Bashay and Maretadu areas were dominated by Digitaria macroblephara, Tragus berteronianus, Dactyloctenium aegyptium, Mellinis repens, Plectranthus barbatus, Chloris roxburghiana, Harpachne schimperi, Microchloa kuntii, Aristida barbicolis, Croton pseudopulchellus, Ageratum conyzoides, Bidens schimperi, Hyperrhenia pfundii and Hypoestes forskalii and Hypoestes forskalii of which most of these are herbaceous species. Therefore, the predominance of these plant species is indicative of high level of grazing pressure. Hence these plant species were regarded as unpalatable to livestock. With an exception of

the Yaeda Chini study site where *Commiphora africana, Grewia haploclada* and *Acacia mellifera* were the most abundant forming woodland vegetation

The results have revealed that, grazing intensity is the major factors influencing vegetation distribution in the semi-arid ecosystem of Mbulu District Fig. 2. There is an excessive livestock grazing throughout the studied areas and its effect has significantly affected the vegetation cover in this area. Due to widespread grazing, it was difficult to ascertain the potential distribution of pristine vegetation because ungrazed land was extremely rare. The observation in the present study, showed that, almost all the vegetation (except woody species that have survived from browsing and fire) was considered to be secondary. High grazing intensity and low levels of green forage were noted everywhere and virtually all the green materials available had been eaten by the domestic grazing animals. Consequently there was very little available forage remaining anywhere in the pasture at the end of the rainy season and the forage shortage was very severe during the dry season.

The results presented in Fig. 2 have shown a clear pattern in the relationship between the vegetation samples and grazing pressure. This made clusters of plots with similar level of grazing pressure as one group different from the other. The overall outcome of the combined effects of the presence of cattle, goats and sheep is that, in areas where there were high population densities of these herbivores, there were high intensities of grazing and browsing. This decimated the palatable plant species. It has been argued that, grazing enhances the establishment of woody species by reducing the grass cover so that light conditions can be favourable for seedling establishment[17]. However, woodland regeneration can be prevented by selective browsing of seedlings or by the effects of disruption of plant species associations[18]. In the semi-arid areas of Mbulu District, the cattle are responsible for grazing the grasses while the goats and sheep selectively browse on woody plants and their seedlings[9]. This shows that none of the plant species in the ecosystem can be given a chance to grow without being attacked by livestock as both grazers and browsers have considerable effects on the vegetation of the semi-arid areas. Their effects are highly aggravated by the severe shortage of seasonal rains particularly in the dry season through trampling when animals cluster together in the limited forage resource.

Conclusively; livestock grazing is the most widespread land management practice in Mbulu District. The present study recognized that, grazing by domestic livestock has been the most influence on the indigenous ecosystems of the semi-arid grasslands. Such grazing primarily by cattle, goats and sheep has been nearly ubiquitous throughout the semi-arid areas. Most of the semi-arid areas including all the grasslands, bush-lands and bushed grasslands were found in the present study to be heavily grazed in such a way that, the vegetation is appearing in mosaics and there are bare patches in between where the land is exposed to various agencies of erosion. The frequency of grazing and the number of livestock reduced plant species evenness diversity and community organization in the areas due to non-selectivity of the grazing process and trampling by hooves as the livestock frequently pass around the rangelands during grazing periods. On the other hand pastoralists inhabiting the study area have used domestic animals to modify the pristine ecosystems in a bid to acquire more products for their consumption and survival. The present study however has found that the modification is beyond irreparable damage to the semi arid ecosystem.

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REFERENCES

1. Mendertsma, J.D. and J.J. Kessler, 1997. Towards better use of environmental resources. Planning document of Mbulu and Karatu Districts, Tanzania; Netherlands Economic Institute (NEI).
2. Ngalason, P.K., 1996. Population pressure and overgrazing in Mbulu District. A case study in Isale and Ayamaan village. An unpublished MA dissertation. Univerity of Dar-es-salaam.
3. Mueller-Dombois, D. and H. Ellenberg, 1974. Aims and Methods of Vegetation Ecology. John Wiley and Sons, New York.
4. Rulangaranga, Z.K., 2000. Obstacles to the sustainable utilization of the vegetations of the semi-arid area of Mbulu District for animal Husbandry. Paper presented at a workshop on current initiatives in sustainable management of dry land Biodiversity held in Arusha, Tanzania.
5. Shannon, C.F. and W. Weiner, 1948. The Mathematical Theory of Communication. University of Illinois Press, Urbana: In Razida, A., Joshi, S. P. and M. M. Srivastava (1980) Composition and Vegetation Diversity in Alpine Grasslands in the Garhnal Himalaya. Tropical Ecology, 39: 133-141.
6. Zar, J.H., 1984. Biostatistical Analysis; 2nd Edn. Prentice-Hall, Inc. Englewood Cliff's, New Jersey.

7. Noy-Meir, I. and R.H. Whittaker, 1977. Continuous multivariate methods in community analysis. Some problems and developments. Vegetatio, 74: 9-32.
8. Ter Braak, C.J.F., 1998. The analysis of vegetation-environmental relationships by canonical correspondence analysis. Vegetatio, 69: 69-77.
9. Naithan, H.B., J.D.S. Negi, R.C. Thafliyal and T.C. Pokhriyal, 1993. Valley of flowers: Needs for conservation or preservation. Indian forester, 118: 371-378.
10. Saberwal, V.K., 1996. Pastoral politics, gaddi grazing, degradation and biodiversity conservation in Himacal Pradesh, India. Conservation Biol., 11: 741-749.
11. Gibson, C.W.D. and V.K. Brown, 1992. Grazing and vegetation changes deflected on modified succession. J. Applied Ecol., 29: 120-131.
12. Connel, J.H., 1978. Diversity in tropical rainforest and coral. Sci., 199: 131-302.
13. Moen, J., P.A. Lundberg and L. Oksanen, 1993. Learning grazing on snow bed vegetation during a population peak, Northern Norway, Articles on Appl. Res., 25: 130-135.
14. Keel, J.E., 1994. Ecological Costs of livestock grazing in Western North America. Conservation Biol., 8: 29-644.
15. Moshi, G.Y., 2000. The influence of disturbance on the status and Regeneration rate of selected Forests in the Udzungwa mountains, Tanzania. An unpublished M.Sc. Thesis, University of Dar es salaam.
16. Tilman, D. and Pacala, 1996. The Maintenance of Species Richness in Plant Communities. Species Diversity in Ecological Communities. Eds. R.E., Ricklefs and Schluter, D University of Chicago Press, Chicago, pp: 13-25.
17. Belsky, A.J., 1992. Effects of grazing competition disturbance and fire on species composition and diversity in grassland community. J. Vegetation Sci., 3: 187-200.
18. Olf, H. and M.E. Ritchie, 1998. Effect of herbivores on grassland plant diversity. Trends Evolution Ecology, 13: 261-265.