Impact of Grazing Pressure around a Watering Point on Natural Pasture Quality in the Rangeland of North-Eastern Ethiopia

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Abstract: Livestock production in the Afar Regional State of Ethiopia is constrained by both quantity and quality of forage produced and consumed. Poor grazing management, in particular around watering points, result in degradation of large areas of productive grazing lands. The forage quality along a stratified grazing gradient around a watering point in a semi-arid rangeland in North eastern Ethiopia was investigated for two growing seasons. Forage quality was investigated by analysing forage samples for neutral detergent fibre, acid detergent fibre, crude protein, lignin, in vitro dry matter digestibility, phosphorus and calcium content. The forage showed a decrease in neutral detergent fibre and acid detergent fibre content and an increase in crude protein content in areas close to the watering point in both seasons. Differences in phosphorus content were not significant but there was an increasing trend towards areas further away from the watering point. Contrary to this, calcium concentration was significantly higher in areas closer to the watering point. Thus the study confirmed changes in forage quality at increasing distances from the watering point. Management options to utilize and in doing so, improve the condition of the degraded areas are discussed.

Key words: Degradation Gradient • Digestibility • Nutrient Content • Range Land Management

INTRODUCTION

Rangeland is the primary source of livestock feed in the Afar Regional State of Ethiopia, but livestock production is constrained by both quantity and quality of forage produced and consumed. Knowledge of the nutrient quality trends of range forage as well as seasonal fluctuations will assist to indicate the optimal time of utilization of the range, as well as help to predict the animal nutritional status and to indicate supplementation requirements.

Apart from the natural characteristics of the soil and plant species contributing to low quality forage, overgrazing can be instrumental in causing a decline in forage quality because the impact of grazing causes changes in botanical composition [1]. This is due to the fact that animals selectively graze palatable perennial plants repeatedly and impair the vigour of the plant causing a lower production of herbage [2]. This ultimately favours the emergence of poor quality forages, which are less palatable or unpalatable species [3]. This can happen in areas where watering points are available resulting in degraded areas near the watering point. Forage quality measurements indicate whether the forage will provide the animal’s requirements of protein, energy and minerals [4].

This study was initiated with the objective to quantify the change in forage quality caused by the effect of grazing around a watering point in the Allaidege rangeland in the southern Afar region of Ethiopia.

MATERIALS AND METHODS

The Allaidege rangeland is situated in the southern part of the Afar regional state of Ethiopia 270 km northeast of Addis Ababa. Geographically the rangeland is located between the coordinates of 9° 35’ 17.170” N; 40° 11’ 4.161” E, 9° 35’ 12.996” N; 40° 29’ 6.947” E, 9° 3’ 16.271” N; 40° 10’ 58.144” E and 9° 3’ 12.33” N; 40° 28’ 58.83” E, east of the main highway that leads to the neighbouring countries of Eritrea and Djibouti. The
rangeland has a semi-arid climate (mean annual precipitation approximately 560 mm) where the mean monthly minimum and maximum temperatures range between 14.8 °C and 37.9 °C (Werer Agricultural Research Centre, unpublished data).

The experiment was conducted for two seasons in a communal grazing land around a watering point in the Allaidege rangeland. Two watering points supplied by water from boreholes were initially selected in the rangeland. However, before the study was initiated mechanical failure of the pump on one of the boreholes, which was not repaired by the authorities during the study period resulted in only one watering point being included in the study. With the assistance of livestock owners from the community the grazing area was stratified into four grazing categories: severely degraded (SD), moderately to severely degraded (MSD), moderately degraded (MD) and lightly degraded (LD) areas. The classification was based on subjective visual rating of the grazing area by the livestock owners and researcher taking into account plant density and species composition. The distance of each degradation area from the watering point was recorded as 0 to 1 500 m for the SD, 1 500 to 3 600 m for the MSD, 3 600 to 5 150 m for the MD and 5 150 to 6 250 m for the LD areas. A 1.2 km transect was laid out perpendicular to the direction of the grazing gradient, more or less in the middle of each of the degradation areas. On each transect, five 30 m x 30 m sample plots were laid out at 300 m intervals, resulting in a total of 20 plots in the experimental field.

Samples were collected by randomly placing three 2 m x 2 m cages in each plot in each degradation area. In year 1, forage samples were collected at seed setting stage (first week of October) from a 1 m x 1 m quadrate inside the cage. The samples were cut at ground level by means of a sickle. A total of 60 sub samples of 300-400 g was taken from the 20 sampling plots (five in each degradation area) and dried in an oven at 65°C for 72 h[5]. In year 2, samples were collected in a similar manner but earlier on first week of September (late flowering stage) taking into account the grazing trained of the community around. The forage samples were harvested from a 1 m x 1 m quadrat at late flowering stage using a sickle and were sorted into groups (palatable, intermediate and other species). The samples were oven dried as described above to calculate the dry matter yield contribution of each species. After that sample groups of the same plot were mixed in order to get 60 sub samples to prepare for chemical analysis. All the collected samples were ground through a 1 mm sieve using a Wily mill to obtain a 300 g sample from each sample plot and stored in labeled airtight bottles until chemical analyses were performed.

The samples were analyzed for nitrogen (N) by means of the Kjeldahl method, according to the AOAC [6]. Crude protein was calculated by multiplying the N content with 6.25. Fiber analysis (acid detergent fiber (ADF) and neutral detergent fiber (NDF)) and lignin was done according to Van Soest [7] and in-vitro digestibility according to Tilley and Terry [8]. The mineral Ca was analyzed by means of an Atomic Absorption Spectrophotometer (AAS) and P was analyzed by means of the Auto-analyzer method of the AOAC [6].

Repeated measures of ANOVA (using the Statistic 7 package) were used to compare forage quality between different degradation areas over two years.

RESULTS AND DISCUSSION

No significant (P > 0.05) interaction between year and degradation gradient was observed for crude protein (CP). Over the two years the mean CP content of 7.83% in the SD area was significantly higher than the CP percentages of 5.8, 5.49 and 4.68 in the MSD, MD and LD areas respectively (Table 1). The mean CP content of 6.8% in year 2 was significantly higher than the mean CP content of 5.0% in year 1 (Table 2).

The statistically significant higher CP levels in year 2 throughout the gradient was attributed to the delayed development (maturity) of the plants due to low rainfall [5] as well as the fact that the plants were harvested almost 30 days earlier than in year 1. In year 2 the precipitation recorded was 55.6 mm less than in year 1.

The SD and MSD areas met the 6-7% CP dietary requirements (pooled data for the 2 years) level of livestock suggested by Milford and Haydock [9] probably due to the large contribution of annual grasses and forbs that dominated in these grazing areas. However, the low forage production attained from these areas is a constraint exacerbated by the large communal livestock population in the area. This can only be rectified by urgent corrective measures such as de-stocking of animals. This can be achieved by creating greater awareness of the problem and the establishment of enough convenient linked market outlets. The MD and LD areas dominated by tufted perennial grasses had a slightly lower range of CP levels of 5-5.5%, similar to native hay in Ethiopia highlands [10].
Fig. 1: Mean neutral detergent fibre (NDF) content of forage samples collected from a degradation gradient in year 1 and year 2 in the Allaidege rangeland (SD = severely degraded area, MSD = moderately to severely degraded area, MD = moderately degraded area and LD = lightly degraded area).

Table 1: The effect of a degradation gradient on various quality parameters of the vegetation in the Allaidege rangeland (mean of year 1 and year 2 data) (SD = severely degraded area, MSD = moderately to severely degraded area, MD = moderately degraded area and LD = lightly degraded area) *(Values in a row followed by the same letter does not differ at the \( P = 0.05 \) level.)*

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<thead>
<tr>
<th>Parameter</th>
<th>Degradation</th>
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<tr>
<td></td>
<td>LD</td>
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<tr>
<td>CP (%)(^1)</td>
<td>4.68 b</td>
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<tr>
<td>IVDMD (%)(^2)</td>
<td>41.6 a*</td>
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<tr>
<td>Phosphorus (%)</td>
<td>0.098 a</td>
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<tr>
<td>Calcium (%)</td>
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A similar result was reported by [11] where he indicated that most feeds sampled from natural pasture were below 7% which is the critical CP level.

The acid detergent fiber (ADF), neutral detergent fiber (NDF) and lignin values all showed significant \( (P < 0.05) \) interactions between season and degradation area. Since the trends displayed by the interactions of the different parameters had a similar appearance, only the data of the NDF parameter will be shown. The probable cause of the interaction was due to the contrasting NDF levels in the MSD area in year 1 and year 2 (Figure 1). The year 1 NDF levels in the MSD area were significantly \( (P < 0.05) \) higher than year 2 in the same area. There were no significant differences between the two years in any of the other degradation gradients, but the year 2 NDF levels were generally lower than the year 1 values, indicating a better quality fodder in year 2 in terms of digestibility.

The higher NDF and ADF levels in year 1 compared to year 2 were most probably due to a 30 days delay in harvest in year 1 resulting in increased structural carbohydrates (cell wall) and reduced leaf- stem ratio. In both seasons, the grazing gradient revealed a decrease in NDF and ADF content close to the watering point.

The NDF, ADF and lignin trends observed in this study may be due to the abundance of annual legume species and the dominance of the annual grass,
Setaria verticillata in the SD area [12]. The annual legumes exhibit lower levels of cell wall components [4] and S. verticillata has a relatively good nutritional status and retains its nutritional value even when mature and dried out Van Oudtshoorn [13]. Further away from the watering point the annual grass component decreased and perennial grasses, which are more fibrous at maturity, as was revealed in the NDF and ADF contents, dominated.

The reciprocal relationship between CP and CF content reported by McDonald P Edwards and Greenhalgh [14] and Frost and Smith [15] were confirmed in this study. This is however in contrast with what Nsiamwa, Moleele and Sebego [16] has found. These authors found an initial increase of CP and CF with distance away from the watering point up to 400 m away and from there both CP and CF declined with distance away from the water point.

In terms of In vitro dry matter digestibility (IVDMD), there was no significant (P > 0.05) interaction between year and degradation gradient. When the data of the two years was pooled, there were also no significant (P > 0.05) difference between the IVDMD values in the different grazing gradients (Table 1) but there was a clear decreasing trend in IVDMD with increasing distance from the water point. The findings in this study agreed with those of Frost and Smith [15]. Simultaneously there were no significant (P > 0.05) differences between years although the mean IVDMD over all grazing gradients was a little bit higher (47.5%) in year 2 compared to 43.8% in year 1 (Table 2).

Digestibility of grasses is also one of the main factors determining nutritive value of forage [14]. From the 2 years pooled average data, the IVDMD percentage was high for the SD area. This is linked to the low fiber and lignin contents of the forage species close to the watering point. The areas far from the watering point had low IVDMD percentages attributed to high fiber and lignin contents of the perennial grass species dominating in the area [12].

There was no significant interaction (P > 0.05) between year and degradation gradient in terms of P and Ca content. The 2 years pooled average P content of the forages showed no significant (P > 0.05) differences along the degradation gradient (Table 1) but the seasonal effect caused significant (P < 0.05) differences of P levels from 0.07% P in year 1 to 0.15% P in year 2 (Table 2).

Calcium content displayed significant within-treatment differences for gradient and season (P < 0.05). The Ca concentration was significantly higher in the SD area compared to areas further away from the watering point (Table 1). The Ca concentration in year 1 (1%) was significantly higher than in year 2 (0.85%) (Table 2).

Phosphorous levels in the different degradation areas closely resembled the P levels observed in the soil [17] with no clear trends emerging. The two-fold higher P concentrations recorded in year 2 could be attributed to the decreased maturity of the vegetation that was harvested 30 days earlier.

Contrary to P levels, Ca occurred in higher concentrations in the SD area compared to the other areas. High concentrations of cations occurred in the experimental site in general and in particular in the SD area [17]. Additionally, in the SD area the herbaceous species composition, consisting predominantly out of annual grasses and forbs, could play a role. The high Ca content of edible forbs (Ca concentration of Ipomoea sinensis 2.22%) compared to grasses was evident from the analyses made in the study. The Ca levels over the whole grazing gradient were higher than the dietary requirement level whereas P levels were below the required dietary level of 0.24% [18].

Currently the grazing utilization of the SD and MSD areas by the community takes place early in the rainy season at an early growth stage. This is a deliberate strategy to exploit the lush green vegetation of the area dominated by annual grasses and annual legumes relative to the grazing areas further away to achieve better performance of the animals. Late in the season, when the area has been completely over utilized, animals are moved to areas further away from the watering point. The varying species composition and nutritive value contents of the different grazing gradients should be considered in planning an alternative grazing system. It could be better to graze the LD and MD areas early in the season after the first rains have occurred because the quality of the perennial grasses dominating in these areas will then be higher than later in the season. The SD and MSD areas can then be rested during the rainy season to enable seedlings to establish and mature plants to produce seed to replenish the soil seed bank for better vegetation cover and restoration of the degraded areas. Thus range condition can be improved and developments of a denser, more palatable perennial plant cover are enhanced to come out. Otherwise the degradation will aggravate and the existing species will wiped out leaving the grazing area without vegetation cover.

This system should allow the provision of relatively high quality fodder to the animals throughout the year whilst it will also allow the recovery of the degraded areas.
Recovery of the degraded areas may also be accelerated by applying reclamation actions described by Kidane Gebremeskel and Pieterse [19].

In conclusion, the study showed that there were differences in rangeland forage quality over the degradation gradient. In most quality parameters (CP, IVDMD, CF) the nutritive quality of the range forage close to watering point was better than forage further from the watering point. Therefore the results of this study emphasized the importance of regular rangeland condition monitoring and proper management of rangeland around watering points in communal rangeland areas because the effect of grazing pressure may vary in different areas. Grazing systems such as the one mentioned above should be investigated to determine the best system to provide a satisfactory fodder flow whilst at the same time improve the condition of the degraded range areas.

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REFERENCES