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# Species and Chemical Composition, Productivity and Utilization of Grazing Lands in Bako-Tibe District, West Shewa, Oromia

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**Abstract:** This study was conducted to assess the holdings at household (hh) level, yield, species and chemical composition and utilization of grazing lands in Bako-Tibe district of West Shewa Zone, Ethiopia. A total of ninety-nine household's: sixty four from the lowland and thirty-five from the mid-land were randomly selected after stratified random sampling. Twenty representative enclosures (10 from each altitude) were selected equally representing virgin and fallow grasslands. A total of 24 herbs were identified from the private grazing lands of the study area; of these 16 were grass species (4 annuals and 12 perennials), 3 legumes, 1 sedge and 4 weed species. About 89% of the household's in the lowland and 97% of the mid-land owned their own private grazing lands. The average grazing land holding of the lowland hh (0.28±0.36ha) was comparatively similar ($P$>0.05) with that of the mean holding of the mid-land (0.37±0.05ha). The overall mean herbage yield of the study area was 2.59 t /ha. The crude protein (CP), neutral detergent fiber (NDF), acid detergent fibers (ADF), acid detergent lignin (ADL) and ether extract(EE) contents of selected herbs differed significantly ($P$<0.001) among species. But differences between the two agro-ecologies were not significant ($P$>0.05). The overall mean compositions of CP, NDF, ADF, ADL and EE were 12.4, 60.9, 29.2, 7.8 and 1.4%, respectively. The grazing systems practiced in these areas include extensive grazing and paddock feeding and to a lesser extent cut and carry (17.7%) system. Hay making practice was low and it was practiced only by about 12.5% of the lowland and 17.1% of the respondents of the mid-land. Grazing lands were decreasing from time to time mainly because of expansion of cropland, expansion of towns, investment and increased use of land for settlement and social purposes. This requires appropriate intervention strategy that might involve improvement in the productivity of the existing grasslands and working towards the effective utilization of other feed resources like adoption and utilization of improved forages.

**Key words:** Chemical Composition・Fallow-Land・Grassland Species・Grazing Land・Herbage

## INTRODUCTION

Range lands globally constitute over 50% of the terrestrial land cover and support about 75% of the forage used by livestock [1, 2] and about 31% is grassland (including grasslands, shrub lands and savannah) [3]. Grasslands cover 41% of Earth's land surface and provide livelihoods for nearly 800 million people, as well as forage for livestock, wildlife habitat, valuable ecosystem services and locations for recreation and tourism [4, 5]. Grasslands on every continent have been degraded due to human activities, with about 7.5% of grasslands having been degraded because of overgrazing [6] consequently leading to poor productivity of the lands. Studies have shown that population growth has resulted in a substantial reduction in land holdings per family (<0.5ha) which in turn has inevitably led to encroachment onto communal grazing lands for

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cultivation. Livestock numbers on the other hand have almost remained unchanged and this has led to overstocking of the few areas left [7].

With nearly 60 million cattle, Ethiopia is estimated to be home to the largest livestock population in Africa [8, 9]. However, the productivity of the largely local breeds that accounts for over 98% is said to fall below the continent average in milk production [9]. Fall in production is constrained by several technical factors. Feed problem is the leading constraints of livestock production in Ethiopia [10, 11]. The availability and quality of these feed resources particularly that of grazing lands fluctuate from time to time and hence do not meet the maintenance requirement of livestock. During wet season, grazing lands stand first in contributing to the livestock feed resource in different altitudes of Ethiopia [12]. However, severity of grazing (over use) and demand for cropland may affect the status, utilization and holdings thereby affecting the productivity of grazing lands. This phenomenon could hold true for Bako-Tibe district, where livestock production is an essential part of the land use system. However, there is no up to date information providing comprehensive evidence on the status of grazing lands in the district. This study was therefore, conducted to investigate the grassland holding, yield, species and chemical composition and utilization of grazing lands in the district.

## MATERIALS AND METHODS

**Characteristics of the Study Area:** The study was conducted in Bako-Tibe district of West Shewa Zone in the Oromia Regional State, western Ethiopia. The district is located at 250km west of Addis Ababa at an altitude of 1650m above sea level. The district receives mean annual rainfall of 1200mm in a bimodal distribution, 80% of which falls from May to September. The area has a mean relative humidity of 59% and a mean minimum and maximum temperature of 13.5 and 27°C, respectively. The district has 32 '*Kebeles'* (the smallest administrative structure in Ethiopia) where agro-ecologically, Lowland makes about 50%, mid-altitude 37.5% and the highland constitutes about 12.5% of the total area of the district.

### Data Collection on Feed Resources

**Selection of Respondents to Collect Survey Data:** The '*Kebeles'* were selected first from the district by stratified random sampling. Then, ninety-nine households (64 from lowland and 35 from mid-land) were selected randomly to participate in the survey. A semi-structured questionnaire was used to obtain data on: background information of the respondents' land holding and animal feed resources data. Group discussions and key informants' interviews were also used to generate necessary data on grazing land types, holdings and utilization. The group discussions focused on available feed resources, feeding and grazing systems, status of grazing land and feed conservation practices. In addition, secondary data were collected from the reports of the district Office of Agriculture and Rural Development and Livestock Agency to complement the primary data. The households were selected to generate the data on the assessment of the status of grazing land and grazing management using the previously suggested formula by Yamane [13] as follows:

$$n = \frac{N}{1 + N(e^2)}$$

where; n is sample size computed; N is the total households in the study area and e is the error term (0.1).

**Estimation of Herbage Yield and Species Identification of Grassland:** The study on grassland was conducted in September and October, as these months were appropriate to notice features in early flowering of the pasture and hence, easing species identification in the study areas; and the time is also the expected time when pasture reaches good stand to harvest for yield (biomass) and chemical composition [14].

**Herbage Estimation:** Twenty representative enclosures, 10 from each altitude (5 sites each from virgin and fallow grasslands for both altitudes) were selected by knowledgeable farmers and extension workers. Then three samples at quadrat size of 0.5m×0.5m were taken from the selected grazing lands diagonally at 10 meter interval for each altitude category and both types of grasslands. Thus, a total of 60 samples were taken for biomass yield estimation. The samples were harvested by hand using sickle at approximately 2cm above the ground [15]. For estimating biomass yield, fresh samples were dried at 105°C for 24hours. Then the dry matter (DM) obtained from different sites were used for extrapolation of the total dry matter obtained from hectare of land; and grass, legume and weeds and/sedges composition were calculated following the method described by Tothil *et al.* [16];

$$T_{fw}\ of\ grass\ or\ legume = \frac{T_{fw}\ of\ grass\ or\ legume}{S_{fw}\ of\ grass\ or\ legume} * S_{dw}$$

where:
$T_{fw}$ = total fresh weight
$S_{fw}$ = sub- sample fresh weight
$S_{dw}$ = sub- sample dry weight
$T_{dw}$ = total dry weight

Then, the DM yield per hectare was calculated by multiplying the dry matter yield of the sample area and convert to hectare.

**Species Identification of Grassland and Laboratory Analysis:** While harvesting samples for herbage yield estimation, harvested samples which were common and known were identified as grasses, legumes and weeds and/or sedges in the field. While taking samples for biomass yield, samples of herbs were harvested for laboratory analysis. Harvested samples were immediately weighed fresh using sensitive balance (0.01g sensitivity) on the field and then taken to laboratory for drying. Fresh sub samples were dried at 65°C for 48 hours and milled by whilley mill with sieve size of 1mm. Representative ground samples were taken for each of the two sites separately and kept in closed container for chemical analysis at Jimma university nutrition laboratory.

**Statistical Analysis:** The qualitative data obtained through the survey were analyzed using descriptive statistics. Testing for the relationship between holdings of surveyed households Spearman's rank correlation analysis was performed independently for each agro-ecology using the General Linear Model (GLM) of the SPSS 16.0 statistical computer software. A two-way variance analysis was carried out to see mean differences between two altitudes, between virgin and fallow grassland and their interaction through a 2×2 factorial arrangement for herbage (biomass) yield and chemical analyses. The statistical model used for the analysis of variance for the effect of altitude and types of grassland (virgin vs fallow) on biomass yield of grassland and chemical composition was the following:

$$Yijk = \mu + \alpha i + \beta j + (\alpha\beta)ijk + \varepsilon ijk$$

where,
Yijk = Response variables (estimated yield, chemical composition)
μ = overall mean
αi = altitude effect
Bj = effect of $i^{th}$ types of grassland (Fallow and Virgin)
(αβ)ij = The interaction effect between altitude and type of grassland
εijk = Random error

## RESULTS AND DISCUSSION

**Natural Pasture and Grazing Management**

**Types and Size of Grazing Lands Possessed by the Households:** The types and holdings of grazing lands of the surveyed households of lowland and mid-altitude areas of Bako-Tibe district are shown in Table 1. Two categories of grazing lands were recognized. These include communal and private grazing lands. Because of factors like competition with cropping purpose and others that impose pressure on communal grazing lands and due to exhaustion of the remaining communal grazing lands due to over utilization, majority of the households own private grazing land. The study showed that majority (89%) of the households in the lowland and the vast majority (about 97%) of the households of mid-altitude owned their own private grazing lands. The overall average households possessing private grazing land in the study area was 91.9%. Among the studied households, about 67.2% of the lowland and 80% of the mid-altitude possess grazing land that they fallow part of their cropland. That is, only 32.8% of the lowland and 20% of the assessed households of the mid -land agro-ecology possess virgin grassland (Table 1). The average grazing land holding of the lowland respondents (0.28±0.36ha) was comparatively similar ($P$>0.05) with that of the mean holding of the mid-land respondents (0.37±0.05ha). The respondents of the study area relate the relatively small grazing land holding per household, to the general shortage of the land that they ought to first suffice their need in food crop production for their household members and to the ever diminishing grazing land.

Table 1: Grazing land holding of the surveyed households of the study area

| Description | Lowland N (%) | Mid-land N (%) | Overall N (%) |
|---|---|---|---|
| Private grazing land | | | |
| Own | 57 (89.1) | 34 (97.1) | 91 (91.9) |
| Mean size (ha) | 0.28±0.36 | 0.37±0.05 | 0.31±0.03 NS |
| Not owning | 7 (10.9) | 1 (2.9) | 8 (8.1) |
| Type of grazing land | | | |
| Virgin | 21 (32.8) | 7 (20.0) | 28 (28.3) |
| Fallow | 43 (67.2) | 28 (80.0) | 71 (71.7) |
| > 1ha | 3 (4.7) | 5 (14.3) | 8 (8.1) |
| < 1ha | 61 (95.3) | 30 (85.7) | 91 (91.9) |

N = number of respondents, Figures in parenthesis indicates percentage of the frequencies (observations); NS = non-significant

The overall mean grazing land holding of the surveyed households (0.31±0.03ha per family) is similar with the values reported for Diga and Jeldu districts which were 0.3 and 0.4ha, respectively by Bedasa *et al*. [17]; but is smaller than the holding (0.73ha/hh) that was reported by Kassahun [18] for Horro and Guduru districts. The virgin grazing lands in the mid-lands of the study area are found mainly adjacent to the croplands of the respective owners. Holders of those croplands have full control over such grazing lands which they also call '*Gataa'* and thus *Gataa* is accessed only by the owners of those nearby croplands mainly during the wet season. Nonetheless, such grazing lands could be accessed by the whole community during dry season when the herbage of the land exhausts. If protected for longer, these lands may form bushy encroachment/trees and may serve as source of fire wood or construction items. In the lowlands of the surveyed households however, the virgin grazing lands also prevail more widely at valley bottoms and at the outskirts of the towns of the study district and may be accessed by the community during both wet and dry seasons. The communal grazing lands were regulated by the *kebele* leaders who develop and implement the by-laws where also elders of the *Kebeles* contribute in resolving any pertinent conflict. Very few of the respondents (8.1%) of the study area, possessed one or more than one hectare of grazing land. Only about 4.7% of the lowland respondents and 14.3% of the mid-land households had more than one hectare.

**The Status of Grazing Lands:** The status of the grazing lands of the current study for the low and mid-land agro-ecologies is shown in Table 2. The assessment reveals that grazing lands are decreasing from time to time. Expansion of agricultural land for crop cultivation, expansion of towns, investment and increased use of land for settlement and social purposes are the leading causes for the decline in the size of grazing lands. Majority of the respondents (96.9% of the lowland and 91.4% of the mid- altitude) indicated their agreement that expansion of agricultural land was the first cause for the diminishing in the size of grazing lands. Land allocation for investment and expansion of towns follow as constraints for the decrease in grazing lands in the study area. The current study is consistent with that of Ahmed *et al*. [19] and Kassahun [18] who similarly reported that expansion of agricultural land was the main cause for the decrease in size of grazing lands in Bosona district and Horro and Guduru districts, respectively. Alemayehu *et al.* [20] also indicated that crop production has expanded due to increase in the amount of land devoted to this activity at the expense of grazing land.

It was recently shown that cropland increased (0.4% year -1) while grazing land reduced (3.5% year -1) under contrasting dynamics and competitive changes according to Wuletaw *et al*. [21]. Tadesse and Solomon [22] similarly reported in their study that grazing land was found to decline drastically by 30.52% with cultivated lands rapidly increasing by 11.65%. Kassa *et al*. [23] and Yayneshet [24] also indicated that the progressive conversion of grazing lands into crop fields was the main cause for the decline in grazing lands in northern Ethiopia. But others argue that croplands have been rather converted to woodlots [25] after keeping away from cultivation. In the latter, it may be because of less population and livestock pressure leading to less competition. Another argument was reported from the southern rangelands that drought, shortage of rain and bush encroachment are the leading causes of shortage and poor productivity of grazing lands by Alemayehu *et al*. [26]. This may indicate that factors leading to shrinkage of gazing land depend on the existing local environment.

With regard to the quality of the grazing lands, nearly all the studied households of both altitudes agree that the quality of the grazing land is deteriorating (Table 2). Disappearance of nutritious and palatable species, expansion of toxic and unpalatable invasive plants and exhaustion of soil fertility due to over use and erosion were listed to be the chief causes for the decrease in quality of the pastureland in that order of importance. For example, invasive and toxic plants like *Parthenium hysterophrus* were mentioned (observed) to be the most common invader. These invasive weed species are known to impair health of the animal, animal products and human health. It was observed to be abundantly prevailing and appearing green even during the dry season of the year at the outskirt of Bako town when other palatable pasture species fade away (Fig. 1) below. This is in agreement with the basic principle that the excessive over utilization of grazing lands may lead to the invasion of unpalatable and alien weeds and non-herbaceous plants eventually leading to remaining with poor and unproductive pasture lands reported by Alemayehu [26, 27]. In a similar way, Auken [28] reported that extended grazing and over exploitation of grazing lands would ultimately lead to alteration of species composition and reduction in grass yield particularly following exhaustion of the soil.

Table 2: Causes for the quantitative and qualitative deterioration of the grazing land as prioritized by the respondents of the district

| | | Ranked causes for the diminishing size of pasturelands | | | | |
|---|---|---|---|---|---|---|
| Agro-ecologies | Causes | 1st N (%) | 2nd N (%) | 3rd N (%) | 4th N (%) | Index |
| Lowland | Arable farming | 62 (96.9) | 2 (3.1) | - | - | 0.402 |
| | Expansion of towns | - | 10 (15.6) | 38 (59.4) | 16 (25.0) | 0.193 |
| | Investment | - | 31 (48.4) | 18 (28.1) | 15 (23.4) | 0.228 |
| | Settlement & social | 2 (3.1) | 15 (23.4) | 10 (15.6) | 39 (60.9) | 0.177 |
| Mid-land | Arable farming | 32 (91.4) | 3 (8.6) | - | - | 0.407 |
| | Expansion of towns | - | 2 (5.7) | 7 (20) | 26 (74.3) | 0.143 |
| | Investment | - | 18 (51.4) | 15 (42.9) | 2 (5.7) | 0.267 |
| | Settlement & social | 3 (8.6) | 4 (11.4) | 11 (31.4) | 17 (48.6) | 0.183 |
| Lowland | | Prioritized causes for the decline in quality of pasturelands | | | | |
| | Disappearance of better species | 50 (78.1) | 8(12.5) | 6 (9.4) | - | 0.447 |
| | invasive plants | 6(9.4) | 44 (68.8) | 14 (21.9) | - | 0.312 |
| | Soil degradation | 8 (12.5) | 13 (20.3) | 43 (67.2) | - | 0.242 |
| Mid-land | Disappearance of better species | 21 (60.0) | 10(28.6 ) | 4 (11.4 ) | | 0.414 |
| | invasive plants | 8 (22.9) | 17 (48.6) | 10 (28.6) | | 0.330 |
| | Soil degradation | 6 (17.1) | 8 (22.9) | 21 (60.0) | | 0.257 |

N = number of respondents; Figures in the parenthesis are holding percentage values

(a) (b)

Fig. 1: A green *Parthinium hysterophrus* invading along the roadside near Bako town (a & b)

(a) (b)

Fig. 2: Expansion of arable land (a) and towns (b) putting pressure on the grazing land near Tibe town of Bako-Tibe district Species Composition of Pasture Land

Indeed, overgrazing affects the botanical composition and species diversity by depressing the vigor and presence of dominant species, which then enables colonization by grazing tolerant plant species [29].The invasive plants are not only less palatable for grazing and/or browsing but may also contain toxic chemicals which can be hazardous to the health of the animals and humans. Other authors also indicated that in arid and semi-arid ecosystems, loss of microbiotic crusts as a result of overgrazing can have detrimental long-term effects [30, 31]. Another finding reported by Lu *et al*. [32] also revealed that overgrazing decreased above ground biomass (47.15%), soil organic carbon (12.41%), soil total nitrogen (12.75%) and microbial biomass carbon by about 9.42% thereby affecting species composition and productivity of grazing lands.

Table 3: Species of herbs identified in the study area

| Ref. no | Local name | Botanical name | Family name | Occurrence Low-land | Occurrence Mid-land | Life form |
|---|---|---|---|---|---|---|
| A | Grass species | | | | | |
| 1 | Chokorsaqala | *Cynodon dactylon* | *Poaceae* | X | X | P |
| 2 | Unknown | *Eragrostis paniciforms* | *Poaceae* | X | X | P |
| 3 | Unknown | *Loliumm ultiflorum* | *Poaceae* | X | X | A |
| 4 | Xaafiisinbirroo | *Eragrostis tenuifolia* | *Poaceae* | X | X | P |
| 5 | Migira | *Pennisetum sphacelatum* | *Poaceae* | | X | P |
| 6 | Muujjaa | *Snowdenia polystachya* | *Poaceae* | X | X | A |
| 7 | Margaqallaa | *Digitaria abyssinica* | *Poaceae* | X | X | P |
| 8 | Waratii | *Eleucine jagrie* | *Poaceae* | X | X | P |
| 9 | Daggoo | *Eleusine floccifolia* | *Poaceae* | X | X | P |
| 10 | Muriyyii | *Sporobolus pyramidalis* | *Poaceae* | X | X | P |
| 11 | Sardooharree | *Eleusine indica* | *Poaceae* | X | X | A |
| 12 | Ballammii | *Andropogon abyssicus* | *Poaceae* | X | X | A |
| 13 | Migrasareeadii | *Penniseturn polystachion* | *Poaceae* | X | X | P |
| 14 | Migrasareediima | *Penniseturn thunbergi* | *Poaceae* | X | X | P |
| 15 | Sardoo | *Pennisetum clandestinum* | *Poaceae* | X | X | P |
| 16 | Daggala | *Hyparrhenia rufa* | *Poaceae* | X | X | P |
| B | Sedges | | | | | |
| 17 | Qunnii | *Cyperus rotundus* | *Cyperaceae* | X | X | P |
| C | Legumes | | | | | |
| 18 | Siddisadhalaa | *Trifolium rueppellianum* | *Fabaceae* | X | X | A |
| 19 | Siddisakormaa | *Medicago polymorpha* | *Fabaceae* | X | X | A |
| 20 | Ataraquruphee | *Vicia* spp | *Fabaceae* | X | X | A |
| D | Weeds | | | | | |
| 21 | Tuufoo | *Guizotia scabra* | *Asteraceae* | X | X | P |
| 22 | Keelloo | *Bidens biternata* | *Asteraceae* | X | X | A |
| 23 | Kortobbii | *Plantago lanceolata* | *Plantaginaceae* | X | X | P |
| 24 | Chuqqallaa | *Uebelinia abyssinica* | *Caryophyllaceae* | X | X | A |

Where: P = perennial, A = annuals

The types of herbaceous plants identified in the current study area are enumerated in Table 3 below. A total of 24 herb species were identified from grazing lands of the study area. Of these, 16 were grass species (4 annuals and 12 perennials ), 3 legume species, 1 sedge and 4 weed species were identified in both agro ecologies except one grass (*Pennisetum sphacelatum*) which was only observed in mid altitude area. The most common grass species identified in the study area were *Cynodon dactaylon, Pennisetum clandestinum, Eragrostis tenuifolia andropogon abyssinicus, Digitaria abyssinica, Eleusinejaegeri, Pennisetum thunbergii* and *Sporobolus pyramidalis;* whereas *Trifolium rueppellianum, Medicago polymorpha* and *Vicia sativm* were the identified legumes. One sedge spp: *Cyperus rotundus* was also identified. The current result is similar with those reported for central plateau of Ethiopian highland and general report for highland Ethiopia by Bedasa *et al.* [17], Alemayehu [27], Yeshitila *et al*. [33] and Zewudie *et al.* [34]. Plant diversity decreases with increasing grazing intensity. For example, about 115 plant species were reported in lightly grazed parts of the montane forests of Mount Kilimanjaro by Imani and Mligo [35] which is much higher than the heavily grazed parts of the same area and the current study.

**Estimated Herbage Yield and Composition of Pasture Land:** Table 4, shows the estimated herbage yield and composition of enclosed private grasslands of lowland and mid-land areas of Bako-Tibe districts. The herbage yield of the grassland did vary significantly ($P$<0.001) between the low and mid-land agro-ecologies. But there was no interaction effect ($P$>0.05) observed between type of grassland and agro-ecology on the estimated average herbage DM yield (t DM/ha) of the study area. Hence, 2.78t DM/ha of estimated mean herbage recorded for the lowland altitude was significantly higher than 2.40t DM/ha estimated for the mid-land agro-ecology. Similarly, difference in the grassland type significantly ($P$<0.001) affected the total herbage yield in both agro-ecologies. It was higher for the virgin grasslands (2.81t DM/ha) than the fallow lands (2.38t DM/ha). The overall grassland herbage mean yield was 2.59t DM/ha (Table 4) for the study area. The current finding reveals that, the mean herbage yields of 2.98 and 2.47t DM/ha were obtained for virgin and fallow grasslands of the lowland altitude, respectively and 2.53 and 2.29t DM/ha average biomass for the virgin and fallow pasturelands of the mid-land altitude, respectively.

The 2.08t DM/ha grass yield at the lower altitude was significantly ($P$<0.001) higher than that of the mid-land agro-ecology; which was observed to be 1.66t DM/ha. This similarly holds same for the average harvested grass yield in the type of grass lands which was 2.10 and 1.64t DM/ha for the virgin and fallow pasture lands, respectively appearing significantly ($P$<0.001) higher for the virgin grassland. In terms of the appearance in the respective agro-ecology, the estimated harvested grass yield of the virgin land (2.31t DM) was significantly ($P$<0.001) higher than the estimated yield of fallow lands (1.85t DM/ha) in the lowland altitude. The 1.89 and 1.42t DM/ha of grass biomass for the virgin and fallow lands, respectively of the mid-altitude also varied significantly ($P$<0.01). The lower the biomass yield observed for the fallow lands of the current study is probably due to the previous exposure of the arable lands to repeated tillage that might in turn have led to exhaustion of the grass species from such lands and hence, necessitating longer recovery time. The higher the grass biomass yield obtained in the lowland agro-ecology is probably associated to the higher the temperature and better freedom from disturbance by tillage that might facilitate abundant growth of the grass particularly where soil moisture is adequate.

On the other hand, while difference in agro-ecology did not significantly ($P$>0.05) affect the harvested legume DM yield (t/ha), the type of pastureland significantly ($P$<0.01) affected the legume DM yield of the pasturelands in the study area. Thus, the 0.71t DM/ha estimated legume DM yield of the fallow land was significantly higher than that of the virgin land yield (0.62t DM/ha). There was no interaction effect between the altitudes and the types of pasturelands on the composition of legumes. The higher in composition of the legumes on the fallow grazing lands could be because of the presence and better rejuvenating ability of *Trifolium* spp. on the fallow grazing lands following tillage. Generally, there is a tendency towards increase in the composition of legumes as one move from the lower to mid and higher altitudes due to the appearance of these species of legumes. Similar trend in the appearance of legumes was reported by Alemayehu [27].

The average estimated yield of weeds/sedges (t DM/ha) was significantly ($P$<0.001) higher for the mid-land altitude. But this did not show significant ($P$>0.05) variation between virgin and fallow grass lands; also with no interaction effect between ago-ecology and types of grazing lands. But the tendency to have higher numerical advantage of weeds and/sedges on fallow lands is probably due to the quicker restoration potential after exposure to previous tillage. The effect of both agro ecological variation and the type of grassland has shown significant ($P$<0.001) difference in overall herbage yield of the grassland in the study area. The overall estimated mean herbage yield (2.59t DM/ha) reported for the study area in the current survey is relatively higher than herbage yield 1.7-2.4 ton/ha reported for Menesibu district of West Wellega by Diriba *et al*. [36]. On the contrary, Bedassa *et al*. [17] reported higher values (3.54 and 3.4 tons) per hectare for Digga and Jeldu districts of West Shewa zone, respectively. Likewise, the currently observed value is also less than 5.4t/ha reported for North West lowlands of Ethiopia by Bilatu [37] and Isaias *et al*. [38]. The current finding is consistent to previous conclusions by Stypinski [39] who documented that low production of sward can only produce about 2-3 tons of dry matter (DM) per ha/annum, in contrast, high producing herbage can yield as much as more than 10t DM under good grazing land management conditions. The differences may be attributed to climate, soil, species composition of pasture and history of previous grazing. Overgrazing has been reported to be one of the primary contributors to grassland degradation and poor productivity around the world, through reduction in vegetation cover, degradation of topsoil, causing soil compaction as a result of trampling, reduction in soil infiltration rates and enhancement of the susceptibility of soil to erosion [40, 41]. It was similarly reported that changes in vegetation composition from productive and palatable grasses and sedges to less palatable forbs due to heavy grazing in northwest China by Sun *et al*. [42], in Libya by Zatout [43] and in South Africa by Koerner and Collins [44].

Table 4: Herbage yield (t DM/ha) by species and type of pastureland in BakoTibe district

| | Lowland | | Mid-land | | | | P-value | | |
|---|---|---|---|---|---|---|---|---|---|
| Species | Virgin | Fallow | Virgin | Fallow | Mean | SE | Agro | Type | Agro*Type |
| Grass | 2.31 | 1.85 | 1.89 | 1.43 | 1.87 | 0.06 | *** | *** | NS |
| Legume | 0.61 | 0.68 | 0.65 | 0.73 | 0.67 | 0.02 | NS | ** | NS |
| Weeds | 0.03 | 0.031 | 0.037 | 0.038 | 0.034 | 0.001 | *** | NS | NS |
| Total | 2.98 | 2.47 | 2.53 | 2.29 | 2.59 | 0.079 | ** | *** | NS |

Agro= agro-ecology (altitude), SE= standard error

Table 5: Chemical composition (%) of selected herbaceous grasses and legumes from the lowland and mid-altitudes

| Lowland | DM% | Ash% | CP% | NDF% | ADF% | ADL% | EE |
|---|---|---|---|---|---|---|---|
| Cynodon dactylon | 94.8 | 9.2$^{b}$ | 11.8$^{b}$ | 64.4$^{a}$ | 29.1$^{b}$ | 6.9$^{b}$ | 2.1$^{a}$ |
| *Digitaria abyssinica* | 93.7 | 13.8$^{a}$ | 12.2$^{b}$ | 65.1$^{a}$ | 31.2$^{a}$ | 11.7$^{a}$ | 1.7$^{b}$ |
| *Trifolium* spp. | 95.1 | 9.6$^{b}$ | 17.2$^{a}$ | 56.5$^{b}$ | 24.1$^{d}$ | 6.8$^{b}$ | 1.3$^{c}$ |
| *Andropogon abyssicus* | 94.9 | 8.8$^{b}$ | 11.4$^{bc}$ | 54.2$^{b}$ | 26.9$^{c}$ | 5.6$^{c}$ | 0.9$^{d}$ |
| *Eleucine floccifolia* | 96.2 | 7.0$^{c}$ | 9.1c | 67.1$^{a}$ | 31.8$^{a}$ | 8.5$^{ab}$ | 0.8$^{d}$ |
| Mean for the lowland | 94.9 | 9.6 | 12.3 | 61.5 | 28.6 | 7.9 | 1.38 |
| SE | 0.1 | 0.08*** | 0.07*** | 0.07*** | 0.06*** | 0.07*** | 0.03*** |
| Mid-land agro-ecology | | | | | | | |
| *Cynodon dactylon* | 93.7 | 8.9$^{b}$ | 12.1$^{ab}$ | 66.1$^{a}$ | 31.6$^{a}$ | 7.2$^{b}$ | 1.8$^{b}$ |
| *Digitaria abyssinica* | 92.9 | 12.7$^{a}$ | 12.4$^{ab}$ | 67.4$^{a}$ | 32.3$^{a}$ | 11.9$^{a}$ | 2.3$^{a}$ |
| *Trifolium* spp. | 94.8 | 9.2$^{b}$ | 17.9$^{a}$ | 58.2$^{ab}$ | 25.2$^{b}$ | 7.4$^{b}$ | 1.2$^{c}$ |
| *Andropogon abyssicus* | 93.6 | 7.9$^{c}$ | 11.8$^{b}$ | 55.6$^{b}$ | 30.5$^{ab}$ | 6.3$^{bc}$ | 1.1$^{c}$ |
| *Sporobolus pyramidalis* | 95.7 | 10.1$^{ab}$ | 8.7$^{c}$ | 54.7$^{b}$ | 29.4$^{ab}$ | 5.8$^{c}$ | 0.7$^{d}$ |
| Mean for mid-land | 94.1 | 9.8 | 12.6 | 60.4 | 29.8 | 7.7 | 1.42 |
| SE | 0.09*** | 0.07*** | 0.06*** | 0.14*** | 0.08*** | 0.04*** | 0.05*** |
| Overall mean (low & mid) | 94.5 | 9.7 | 12.4 | 60.9 | 29.2 | 7.8 | 1.39 |
| Lowland VS Mid-land (SE) | 0.1 | 0.24 | 0.12 | 0.83 | 0.3 | 0.2 | 0.04 |
| Significance | NS | NS | NS | NS | NS | NS | NS |

Means in a column with different superscripts are significantly different ($P$<0.05). DM = dry matter; CP = crude protein; NDF = neutral detergent fiber; ADF = acid detergent fiber; ADL= acid detergent lignin; EE = ether extract

In addition to problems with grass land productivity, despite the possible danger of bloat in ruminants, grass land with legume composition of around 20% is said to suffice optimum livestock production [45]. In fact, the legume composition of the study area is close to this threshold. Hence, such grass lands can be used to meet the optimum livestock production principle provided that attentive care is in place while grazing during the lush growth of the pasture. The comparatively lower herbage yield registered for the mid-land (Table 4) is probably due to high stocking rate on the private grazing lands because of limited communal grazing lands, the moderately lower temperature that may not as such favor rapid herbage growth and possible subjection to heavy erosion because of the nature of topography that might have in turn led to poor growth of plant species.

**Nutrient Composition of Selected Herbs:** DM yield alone could not satisfy livestock feeding objectives. The bottom line is to have a balanced ration with all the required nutrients in a daily ration for optimum production. So as to accomplish such tasks, adequate information should be available on nutrient composition of feeds to do ration formulation using the available feed ingredients. For this purpose, analyses of nutrient composition have been carried out for some of the selected grass species of the study area. Thus; the chemical composition of selected herbaceous plant sample is presented in Table 5. The mean dry matter (DM) content of selected grassland species of the low land altitude was 94.9%, the highest DM content (96.2%) was recorded for *Sporobolus pyramidalis* and the lowest (93.7%) was recorded for *Digitaria abyssinica* for this altitude; whereas in mid-land, the mean DM content was 94.1%, ranging from 92.9% for *Digitaria abyssinica* to 95.7% for *Sporobolus pyramidalis*. There was no significant difference ($P$>0.05) in DM content among species in the lowland and mid-land areas. This could be because of similar time of harvesting and procedures and tools used during the sample drying. The mean ash content of selected pasture species didn't show significant ($P$>0.05) difference between the two agro-ecologies. But highly significant ($P$<0.001) variation was observed among species. The mean ash contents were 9.6 and 9.8% for the low and mid-altitude, respectively with the overall mean of 9.7% for the study site.

The average crude protein (CP) content of the selected species of grasslands of the lowland differed significantly ($P$<0.001) from 9.1% for *Eleusin ejagrie to* 17.2% for *Trifolium* species with the overall mean of 12.4%. Likewise, the CP content of the selected pasture species of the mid-land varied significantly ($P$<0.05) from 8.7% for *Sporobolus pyramidalis*to 17.9% for *Trifolium* spp. The CP content of all the selected species was above the maintenance requirement (>7%) meeting the optimum rumen microbial function documented by Van Soest [46]. The mean CP contents of selected species of natural pasture of the lowland and mid altitude didn't show significant variation ($P$>0.05) and it was 12.3 for the lowland and 12.6% for the mid altitude, with the overall mean of 12.4%. This is comparably close to the values of 12.1% and 13.1% reported by Zinash and Seyoum [47] and Solomon [48], respectively. Close value of CP (11.5%) to the current finding that ranged from 8.95% for *Cynodon* spp. to 14% for *Pennistetum* spp. was also reported by Megersa *et al*. [49]. However, the CP value obtained in the current study is higher than other previous values reported to be 5.03-8.1% for the selected species of natural pasture harvested from Menesibu district in western Ethiopia by Diriba *et al*. [36]. Such discrepancies may be due to difference in time of harvesting, difference in species composition of the grassland and differences in procedures of sample drying and analysis. The overall mean CP content of the pastureland in the two agro ecologies is within the acceptable normal level of the grassland herbs (8-18%). Protein content of forages is a determining factor affecting the feeding value and it was evidenced that forages with CP content of below 8% are considered to be of poor quality [50] consequently leading to reduced feed intake, poor digestibility and eventually poor utilization of the feed. Thus, the mean CP content of grassland vegetation harvested could meet animal requirement for moderately producing livestock. That is, the analyzed CP value complies with the basic principle that forages which contain at least 10-12% CP or more appear to be satisfactory for animal production [51]. The mean NDF content of the selected herbs harvested from the grasslands differed significantly ($P$<0.001) among species in both altitudes. Yet, altitudinal variation did not affect the mean NDF content of the harvested herbages ($P$>0.05) from the two altitudes. This is probably due to the similarity of stage of harvesting, selected species and similar grazing systems exercised in the two agro-ecologies. The mean NDF content of the selected herbages of the lowland grasslands was 61.5% with values ranging from 54.2% for *Andropogon abyssinicus* to 67.1% for *Eleucine floccifolia* and the variation observed among species was significant ($P$<0.001) while, in mid altitude, the mean NDF content of the selected herbage materials was 60.4% ranging from 54.7% for *Sporobolus pyramidalis* to 67.4% for *Digitaria abyssinica.*

The overall mean NDF content (60.9%) of the selected herbage species of the study agro-ecologies is lower than NDF values of 72.7% to 77.8% reported for herbs harvested from Menesibu district by Diriba *et al.* [36]. It is also lower than 75.37% average value reported for the sampled grasslands in Gambella by Megersa *et al*. [49]. According to Singh and Oosting [52], roughage feeds containing NDF values of less than 45% are categorized as high, those with values ranging from 45% to 65% as medium and those with values higher than 65% as low quality. Therefore, the result of analysis of NDF content of the selected species of the natural pasture indicates that the herbage materials of the grassland harvested at flowering stage have medium quality and it is within the acceptable standard level (45–65%) reported for grass hay by Lemus [53]. Furthermore, Norton [54] showed that the NDF content that ranges from 67% to 78% to be high and would limit DM intake and digestibility; nonetheless, the finding by Nyamangara and Ndlovu [55] in goats feeding on natural vegetation with NDF contents ranging from 59% to 79%, has shown that this fiber component in the foliage could be adequately degraded, which may also be the case for the current finding. This may imply that ruminants may differ in fiber utilization. Stage of plant maturity, proportion of plant parts (stem-leaf) and species composition of the pastureland may all affect the NDF content or other nutrient composition of the herbs.

Acid detergent fiber (ADF) is a sub-fraction of fiber composition after removal of the hemicellulose and it only contains cellulose and lignin and is useful for prediction of digestibility and energy value of forages. This fiber material varied ($P$<0.001) from 24.1% (*Trifolium* spp) to 31.8% (*Eleusine flaccifolia)* for the lowland altitude and 25.2% (*Trifolium* spp) to 32.3% (*Digitaria abyssinica*) in the mid altitude. The result showed that there is significant ($P$<0.001) difference among herbage species within the same agro-ecology in both study altitudes and the variation was not significant ($P$>0.05) between the two altitudes. The overall mean ADF content of 28.6%

reported for the selected herbage materials of the natural grassland of the lowland and 29.8% reported for the mid-altitude are in the category of good quality forage as demonstrated by Kellems and Church [56] who previously reported roughages with ADF less than 40% are of high quality while those with higher than 40% content are classed as poor quality ones.

The mean ADL content for the lowland pasture species was 7.9% varying from 5.6-11.7% and the mean ADL for the mid-land was 7.7% again varying from 5.8-11.9%. The observed mean ADL content was comparable ($P$>0.05) between the two agro-ecologies but significant ($P$<0.001) variation was observed among pasture species within the same altitude in both agro-ecologies. ADL represents an indigestible portion of roughages and forms complexes with nutrients particularly, cellulose and hemicellulose constituents through lignification thereby impairing microbial digestion according to Kellems and Church [56] and McDonald [57]. As stated earlier by Raj and Kumar [58], forages with lower ADL content (<10%) are considered to be of superior quality, 10.01 to 19.99% as moderate and those containing higher than 20% are low quality with lower feeding value. Therefore, samples of harvested and analyzed herbage species of the current study are possibly in the category of moderate quality forage and thus conforming to the previous reports for hay harvested at optimum time as documented by Crowder and Chemeda [59]. The average composition of EE also varied significantly ($P$<0.001) among the species analyzed in both altitudes.

**Managements of Grazing Lands**

**Grazing Systems of Pasture Land:** Grazing system of pasture land is shown in Table 6. Grazing on natural pasture (grazing land) is the most common livestock feeding system in both low and mid-land altitudes of the study area. Yet, the grazing systems practiced in these areas differ based on season, size and type of grazing land and size of individual livestock. Extensive grazing and paddocks feeding and to a lesser extent cut and carry system were the common grazing methods in the two agro ecologies. In addition, tethering is practiced by the households whereby the owners tie the few numbers of livestock on the road side and/ the peripheral parts of their farmland during the crop growing seasons. Extensive grazing system was the most common one and practiced by all of the respondents of the lowland and mid altitudes of the study district. It is mainly practiced on communal grazing land during both the wet and dry seasons including the time of feed shortage. This method of grazing mainly targets the communal grazing land in order that they first fully exploit the available pasture materials; and because of the very weak control and management system on the communal pastures, farmers graze on the communal grazing lands first and keep their private pasture for the later use (during feed scarcity), when the vegetative growth of pasture is well maintained. Continuous stocking is the traditional grazing method intended for keeping livestock on a single pasture for a protracted use or throughout the grazing season. Consequently, such grazing system may lead to the weary of palatable species due to over use; hence, the grassland declines in palatability. Such plants may also fail to recover quickly and they are observed to be less productive during wet season too.

On the other hand, paddocking is mainly practiced on private grazing lands. At the start of the rainy season, both private grazing lands (PGL) and communal grazing lands (CGL) were allowed for extensive grazing for short time. Then, following the full cultivation of the croplands for food crops, private grazing lands get to be protected from grazing until they fully restore with optimum biomass, especially early autumn. Until then, animals are limited to graze on the exhausting CGL, grazing lands along the road sides and peripheral areas adjacent to individual crop lands. After the establishment of crops, these privately owned pasture plots are used for paddock grazing and cut and carry. This starts in the middle of September and proceed to November. However, such grazing lands are prioritized for their animals particularly for plough oxen, milking cows and calves in order of importance. The paddock feeding system is common and practiced by about 61% of the lowland and 68.6% of the surveyed households of mid-land agro-ecology. This type of grazing system is common and reported for other parts of the country by Solomon *et al*. [60] and Ahimed *et al*. [9].

The practice of cut and carry system was poor and practiced only by about 14.1% of the lowland and 25% of the surveyed households of the mid altitude mainly for sick, lactating cows and equines particularly mule. In general, natural pasture supports livestock for about 7 months (May to November) with relatively better herbage until cultivated crops are harvested and the croplands become open for grazing. In the lowlands, crops are harvested earlier and crop lands could start supporting livestock as of October or earlier. The current finding is in agreement to the overall report that natural pasture is among the leading feed resource of livestock in the country documented by Alemayehu [27], Ahimed *et al*. [9] and CSA [61].

Table 6: Grazing systems in the low and mid-altitude of BakoTibe district

| | Cut and carry | | Paddock | | Continuous grazing | |
|---|---|---|---|---|---|---|
| Agro-ecology | Yes | No | Yes | No | Yes | No |
| Lowland (N=64) | 9 (14.1) | 55 (85.9) | 39 (61) | 25 (39) | 64 (100) | - |
| Mid- land N=35) | 8 (22.9) | 27 (77.1) | 24 (68.6) | 11 (31.4) | 35 (100) | - |
| Overall (N = 99) | 17 (17.7) | 82 (82.8) | 63 (63.6) | 36 (36.4) | 99 (100) | - |

N= number of respondents

Table 7: Forage conservation practices and use methods

| Descriptions | Lowland (N=64) | Mid-land (N=35) | Overall |
|---|---|---|---|
| Enclosing | 40 (62.5) | 30 (85.7) | 70 (70.7) |
| Conserve as hay | 8(12.5) | 6(17.1) | 14 (14.1) |
| Conserve as silage | - | - | - |
| Fencing pasture land | 16(25) | 7(20) | 23(23.2) |

N=number of respondents, Figures in the parenthesis are percentage

**Forage Conservation Practices and Use Systems:** Forage conservation practice and forms of use from the grass lands of the study area is indicated in Table 7. Livestock feeds may not be adequately and evenly found throughout the seasons. Thus, in order to well feed the animals and obtain better performance as a reward, it is expected that the relatively adequate feed resources in a particular season shall be secured for the season of feed scarcity. This is also the case for the livestock keepers of the study area. Here, 62.5% of the surveyed households of the lowland and 85.7% of mid-altitude respondents use enclosure for their land to use it later. Out of this, only 25% the lowland and 20% of the mid-land use fencing. The remaining majority simply use croplands as a protecting opportunity for their pastureland keeping the visiting livestock away from entering the pasture land that is situated in the middle of croplands during the crop growing season. In addition, since individual households watch over their own herd during crop growing seasons and this eases concern of fencing their private grazing lands.

Hay making practice in the study area was very poor. Only 12.5% of the lowland and 17.1% of the mid-land respondents were reported to practice intermittent hay making. This totally makes only 14.1% of the study households had experience of hay making. In agreement to this, Megersa *et al.* [49] reported that feed conservation as hay was almost nonexistent in their study area conducted in Gambella Peoples Regional State. The current finding is also closely consistent with the report of Kassahun [18] who reported that 16.7 and 29.3% of the highland and mid-land households, respectively of Horro and Guduru districts were known to practice hay making. This scenario may also remind that the contribution of hay (conserved forage) to the national livestock feeding is as low as 2.8% [8]. This observation nonetheless, is so deviating from other previous results of Azage [62] and Gebreegziabher and Tsegay [63] who reported that about 75% and 66% of the households in their findings, respectively used to practice hay making. Also, Yayneshet [24] debatably reported that considerable amount of land (at least 0.25ha) was allocated for hay making in many districts of Tigray Regional State. Such differences may be attributed to awareness, availability and productivity of private grazing lands.

There was no observation of silage making in both altitudes of the study district. Therefore, majority of the grazing land is used for paddock grazing where the owners of the land systematically divide the plot and use for grazing purpose by shifting portions after fully grazed. Grazing fields are prioritized based on age and level of production. Thus, the fields are grazed first by plough oxen, milking cows and calves and then the already exhausting field would be later grazed by dry cows and other mature cattle and livestock. In similar survey, Megersa *et al.* [49] came with similar report that the respondents under their investigation had no experience of silage making.

## CONCLUSIONS

The current study revealed that natural pasture was the leading feed resource of livestock in the study area during wet season particularly from early May to November. Majority of the respondents had experienced allocating grazing land to their livestock that they mostly fallow part of their cropland. Extensive grazing and paddock feeding were the two identified grazing systems in the study altitudes. The former one is commonly practiced on the communal grazing land through all seasons; while the latter system is employed on private grazing lands during the crop growing season. Cut and carry system was poorly practiced. Hay making was practiced to a limited extent. Use of pasture in the form of enclosure was rather the most commonly in the study area. The study shows the decline in grazing land and herbage yield and invasion of grazing land by invader weeds were among the major threats to pasture land.

Twenty four pasture species were identified in the study area, out of which grasses took the majority. The result showed the estimated grass yield was higher for the lowland. It was also higher for the virgin grasslands than the fallow lands. On the other hand, the estimated average composition of legumes was higher for the fallow lands than the virgin; while, no difference was observed between the two agro-ecologies. The average estimate for weed composition was higher for the mid altitude. The study generally indicated that the higher overall mean yield of the grassland herbage was recorded for the lowland than the mid-land and for the virgin land than the fallow land.

The percent composition of CP, NDF, ADF, ADL, EE, per kg of DM of the selected species of the grassland showed significant variation among the species in both altitudes with as such no altitudinal influence was recorded on the variation in chemical composition. Generally, the mean nutrient compositions of selected species of pasture have shown that they were of medium to high quality category. Thus, the selected species could meet the basic nutritional need of livestock if harvested at early flowering stage coupled with proper management; and combining conservation of grassland herbage which was observed to be poor in the study area.

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