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Research Article

Dry Matter Yield and Nutritional Composition of Natural Pasture in East Gojjam Zone, Amhara Region

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Next to crop production, rearing livestock in Ethiopia is essential for the community's food and nutrition security. However, a major obstacle to global livestock production, particularly in Ethiopia, is a shortage of high-quality and sufficient livestock feed. Designing development plans and intervention options for both improving natural pasture and rearing livestock would require an evaluation of the natural pasture yield and nutritional composition. As a result, the purpose of this study was to evaluate the nutrient content and dry matter yield of natural pasture in the study areas. The study area was divided into highland, midland, and lowland agroecologies, and from each agroecology, protected and communal grazing areas were selected randomly. The results showed that the average dry matter yield, crude protein (CP), and neutral detergent fiber (NDF) of natural pasture varied across agroecologies and between grazing sites. The average dry matter yields of natural pasture in highland, midland, and lowland agroecologies were about 1.60, 3.02, and 1.96 t/ha, respectively. The average dry matter yield in protected and communal grazing areas of natural pasture was about 2.70 and 1.69 t/ha, respectively. The crude protein content of the natural pasture was 7.12, 7.63, and 6.90% in the highlands, midlands, and lowlands, respectively. The crude protein content of the natural pasture in protected and communal grazing areas was 6.69 and 7.73%, respectively. In general, the dry matter yield and crude protein contents of natural pasture were low, which would have an effect on livestock productivity, and the overall NDF content of natural pasture was 65.9%, which is classified as low-quality feed and thus would have an impact on feed intake, digestibility, and livestock productivity.

1. Introduction

Ethiopia has the largest livestock resources in Africa, placing it first in terms of livestock population [1, 2]. Despite the large number of livestock in the nation, the industry has not developed, and its potential is not effectively utilized because of problems like insufficient feed, the poor genetic potential of native animals, farmers' lack of knowledge about husbandry techniques, and the prevalence of diseases [1–3]. The absence of feed in terms of quantity and quality for sustainable livestock production in Ethiopia is one of these obstacles, and it is also the main one [4]. Livestock lose body condition because of a lack of feed, especially during the dry season. This insufficient availability and quality of feed resulted in delayed puberty onset, low conception rates, long parturition intervals, low milk and meat production, and poor overall life-cycle reproductive performance [5].

In Ethiopia, natural pasture is the major feed resource for animals which is characterized by high spatial and temporal variability in rainfall [6, 7]. In the country, natural pasture made up primarily of herbaceous species is the main source of feed for livestock production. There is seasonal fluctuation in the availability and quality of natural pasture [8, 9]. The nutritional value and biomass yield of natural pasture are key indicators of the ecological and management processes that are taking place on the natural pasture [10]. Also, it is used to determine the carrying capacity and condition of natural pasture [9]. However, the size, dry matter yield, and nutritional composition of natural pasture are influenced by overgrazing, agroecology, continued cropland expansion, the spread of aggressive weeds, and soil erosion [11–14]. Therefore, pasture management techniques like adjusting stocking levels, removing invasive weeds, replacing them with high-yielding forage crops, particularly legumes, and enclosing the grazing land could be used to enhance biomass production and the nutritional content of natural pasture [6, 9, 11].

For more efficient utilization of natural pasture and sustainable livestock production and productivity, evaluation should be done on the dry matter yield and nutritional composition of natural pasture. Because it is critical to have access to such information when developing intervention options for natural pasture management and livestock production. More studies on the dry matter yield and chemical composition of natural pasture were investigated in the lowland dry and semiarid areas [13, 15–17] and highland parts of Ethiopia [18, 19]. The biomass production of natural pasture in the east Gojjam zone was the subject of a small number of studies [4, 12]. However, in the study areas, the palatability and nutrient composition of the natural pasture was not determined.

Therefore, this study seeks to (1) quantify the dry matter production of natural pasture, (2) evaluate the nutritional composition of natural pasture, and (3) determine the palatable and unpalatable forage species in the east Gojjam zone, northwestern Ethiopia.

2. Materials and Methods

2.1. Description of the Study Area. The study was carried out in the East Gojjam zone of Amhara National Regional State, Ethiopia. The zone is found in Ethiopia's northwestern highlands between the latitudes of 10°1′46″ and 10°35′12″N and the longitudes of 37°23′45″ and 37°55′52″E (Figure 1). It is located 305 and 251 kilometers from Addis Ababa and Bahir Dar, respectively. There are 18 districts in the East Gojjam zone, each with a different elevation and, thus, an individual agroecology. The districts' elevation ranges from 1500 to 3577 meters above sea level. The average annual rainfall is from 900 to 2000 millimeters, while the average minimum and maximum temperatures are 7 to 15 and 22 to 25 degrees Celsius, respectively. According to the East Gojjam Agricultural Office, sheep, goats, and cattle, as well as pack animals (donkeys, horses, and mules), chickens, and bees, were produced in the zone.

Figure 2 shows the contribution (%) of agroecology in each sampled district based on information gathered from the east Gojjam Zone Agriculture and Rural Development Office. Machakel District's agroecology is classified as frost, highland, midland, and lowland, with respective values of 2, 59, 39, and 0% while the agroecology of Sinan District's frost, highlands, midlands, and lowlands are roughly 2, 75, 23, and 0%, respectively. Frost, highland, midland, and lowland agroecologies, respectively, make up about 0, 3, 81, and 16% of the Aneded District. In the Enemay District, the proportions of frost, highland, midland, and lowland agroecologies are around 0, 7, 88, and 5%, respectively. Frost, highland, midland, and lowland agroecologies make up about 0, 0, 46, and 54%, respectively, of the Basoliben district. Frost, highland, midland, and lowland agroecologies, respectively, make up approximately 0, 0, 47, and 53% of the Debre Elias District.

2.2. Sampling Techniques and Sample Size. The east Gojjam zone was divided into highland, midland, and lowland agroecologies in order to evaluate the dry matter yield and nutritional content of natural pasture. Two districts from each agroecology—Sinan and Machakel, Aneded and Enemay, and Debre Elias and Basoliben—were selected purposively to represent the zone's highland, midland, and lowland agroecologies, respectively. Protected and communal grazing areas were randomly selected from each district to reflect the three agroecologies. Protected grazing areas were selected and utilized as a benchmark site on the presumption that those areas are protected from grazing, relatively have low grazing intensity and consequently produce more fodder. Grazing locations that are communally owned, that have been grazed all year, and where a high level of grazing intensity is anticipated are known as communal grazing areas.

2.3. Forage Species Identification. The herbaceous species in each quadrate were identified in the field, and those species that were difficult to identify were transported to Addis Abeba National Herbarium for identification. By conducting in-depth interviews with local residents about each identified species in relation to the intensity of grazing and cross-referencing with the list of forage species from the literature, forage species in the study area were classified according to their palatability into highly palatable, less palatable, and nonpalatable categories. According to the succession theory [20], highly desirable species with highly palatable forage are likely to diminish under strong grazing pressure; less palatable forage is likely to increase with heavy grazing pressure; and undesirable species are likely to invade under heavy grazing pressure and rise in number.

2.4. Estimating Dry Matter Yield of Natural Pasture. To estimate the dry matter yield of natural pasture, ten (0.5 m × 0.5 m) quadrats were placed randomly in each grazing site. Consequently, 130 quadrates in total were taken to quantify the dry matter yield of natural pasture (Table 1). All the herbages inside the quadrat were harvested at the ground level, instantly weighed using a sensitive balance, and the weighted subsample was placed in plastic bags. To determine the dry matter yield of the natural pasture per hectare, the gathered herbage was subsequently placed at 65°C for 72 hours. The following formula was used:

$$\mathbf{TDWs} = \frac{\mathbf{TFWs} * \mathbf{SDWs}}{\mathbf{SFWs}}, \quad (1)$$

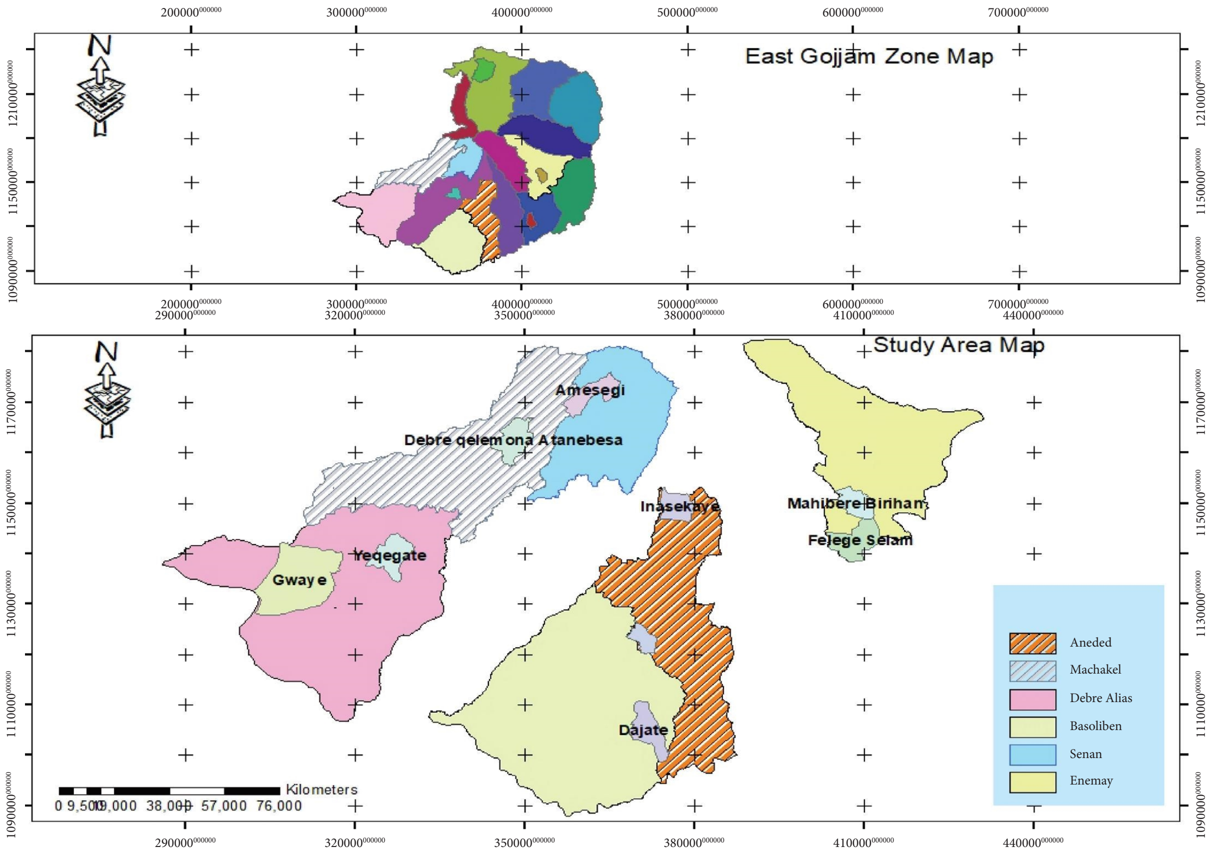

Figure 1: Location map of the six study area districts.

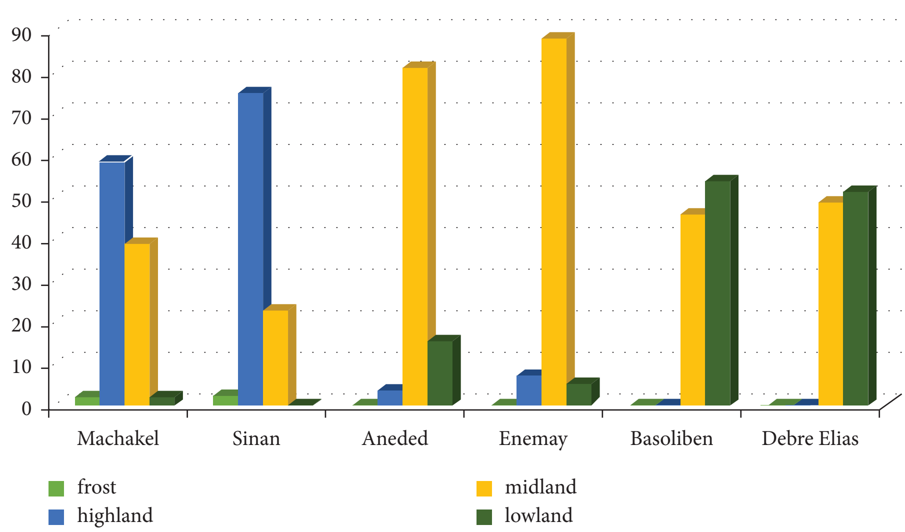

Figure 2: The contribution of (%) of agroecology in six sampled study districts.

where TDW is the total dry weight, TFW is the total fresh weight, SFW is the subsample fresh weight, and SDW is the subsample dry weight.

2.5. Chemical Analysis of Feed Samples. In order to determine the nutritional composition of natural pastures, samples were taken from every selected grazing site in every district. Samples were harvested and weighed using an electrically sensitive balance before being placed into a paper bag with the appropriate label. The samples were ground in a Willey mill to pass through a 1 mm sieve screen after being dried in an oven at 65°C for 72 hours. The forage samples were delivered to the Debre Birhan Agricultural Research Center for nutritional analysis. DM, ash, and CP were determined from feed samples using the AOAC method [21].

Table 1: Total sampled grazing sites in the three agroecologies.

Agroecology	Grazing sites	Total
Highland	Protected	2
	Communal	2
Midland	Protected	3
	Communal	1
Lowland	Protected	3
	Communal	2
Total		13

The method of [22] was used to analyze the neutral detergent fiber (NDF), acid detergent fiber (ADF), and acid detergent lignin (ADL).

2.6. Statistical Analysis. Software from SPSS (version 25) was used to analyze the data. The data were analyzed using a general liner model technique, and LSD mean comparisons were employed. Henry Garrett's approach was used to rank the main feed sources. Respondents were asked to rank each feed resources using this method, and the results of those rankings were then transformed into a score value using the following formula:

$$\textbf{percent position} = \frac{\textbf{100}\,(\textbf{Rij} - \textbf{0.5})}{\textbf{Nj}}, \tag{2}$$

where Rij is the rank given for the *i*th variable by *j*th respondents and Nj is the number of variables ranked by *j*th respondents.

The percent position estimated is translated to scores with the use of Garrett's table. The individual scores for each element were then totaled, and the sums of the scores as well as the mean scores were determined. The most significant element was determined to be the one with the highest mean value.

3. Results and Discussion

3.1. Major Livestock Feed Resources. The top five sources of livestock feed resources in the study area, according to respondents' rankings, were natural pasture, crop residues, stubble grazing, agroindustrial byproducts, and cultivated forage crops (Figure 3). This is in line with the reports of [4], in the Amhara region, and [23], in the Bench-Maji zone, which claimed that the primary sources of feed for livestock were natural pasture, crop residues, stubble grazing, agroindustrial byproducts, and cultivated forage crops. In all agroecologies of the study areas, natural pasture and crop residue ranked as the top two feed sources for livestock, which is similar to the findings of [24], who found that this was also the case in the majority of developing countries. Additional studies in Hadiya zone [25], in the central highlands of Ethiopia [26], in Lalo Kile District of Kellem Wollega Zone [27], and in Burie Zuria District reported that natural pasture and crop residue were the main livestock feed sources.

According to the respondents, the third form of feed resource in all agroecologies was crop stubble that was grazed for two to four months. This was similar to the reports of [28], which describe the practice of grazing animals for two to three months on stubble in mixed crop-livestock farming systems. However, the length of feeding on crop stubble is influenced by cropping intensity and the ratio of livestock to crop stubble size [29]. Improved forage crops, agroindustrial byproducts (such as wheat bran and Niger seed cake), and byproducts from local breweries (such as attela and brint) are rarely used as sources of feed for livestock in the study areas. This is consistent with reports [26] that local byproducts (tella and areke) were used as source feed in Ethiopia's central highlands. According to the results of focus group discussion, the low use of agroindustrial byproducts in the study area was due to their high cost and scarcity.

3.2. Palatability of Herbaceous Forage Species. A total of 75 herbaceous species from 13 families were found in the study area. Of all the groups of herbaceous plants identified, the *Poaceae* (grass) family contributed the largest percentage (48.0%), followed by *Fabaceae* (17.3%), *Asteraceae* (12.0%), and others (13.3%) (Table 2). This was consistent with earlier findings from rangelands in northeastern Ethiopia's Allaidege region, which showed that the *Poaceae* family dominated the herbaceous species [34].

According to the findings, approximately 42.7%, 30.7%, and 26.7% of the forage species, respectively, were highly palatable, less palatable, and nonpalatable (Table 2). This was different from the findings of [17], which indicated that in the Somali area of Eastern Ethiopia, around 34.2, 57.9, and 7.9% of identified forages were very palatable, less palatable, and nonpalatable, respectively. This demonstrated that the current study area's contribution from undesirable or invasive plant species was greater than in the Somali Region. This may be the result of highly edible species being overused and disturbed by livestock grazing. According to the conversation done with the respondents, overgrazing as a result of increased grazing pressure has replaced decreased and increased plants, and this is one of the main causes of the drop in the quantity of highly palatable species, which is supported by [17], overgrazing also encourages weed invasion and tends to limit perennial pasture land vegetation types. Other studies also claimed that overgrazing had an impact on the loss of plant species composition, biomass yield, and quality [14, 35]. Therefore, high-quality producing improved forages, particularly legumes, should replace the unpalatable forage species in order to increase the dry matter production and quality of the pasture [36].

3.3. Dry Matter Yield of Natural Pasture at Different Agroecologies and Grazing Systems. The current study's findings indicate that the overall dry matter yield of natural pasture (2.38 tons/ha) over a single growing season was less than 6 tons/ha for well-managed natural pasture [30] and 4.5 tons/

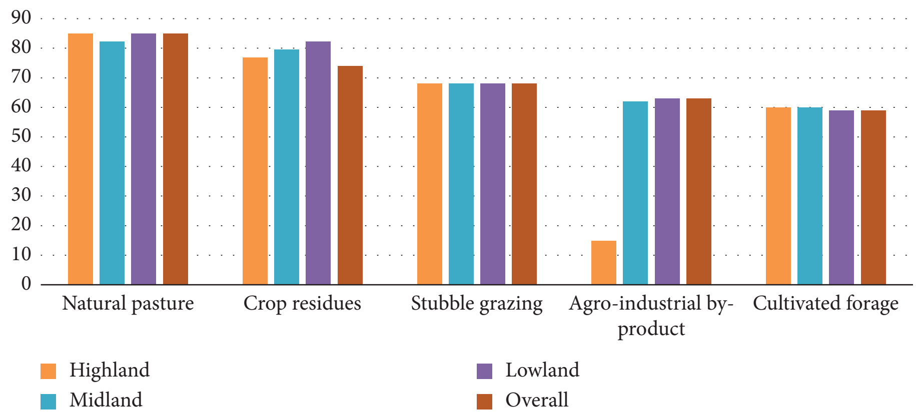

Figure 3: The main livestock feed sources in the various agroecologies in the study areas.

Table 2: Palatability of forage species in the study areas.

No.	Family	Scientific name	Palatability	Sources
1	*Fabaceae*	*Alysicarpus quartinianus A. Rich*	LP	
2	*Fabaceae*	*Alysicarpus rugosus (Willd) DC.*	LP	
3	*Rosaceae*	*Alchemilla pedata A. Rich.*	NP	[30]
4	*Acanthaceae*	*Acanthus pubescens (Oliv.) Engl*	NP	
5	*Asteraceae*	*Ageratum conyzoides* L.	NP	[31]
6	*Poaceae*	*Agrostis gracilifolia CE. Hubb.*	HP	[31]
7	*Poaceae*	*Agrostis quinqueseta (Hochst. ex Steud.) Hochst.*	HP	
8	*Poaceae*	*Andropogon abyssinicus*	LP	
9	*Poaceae*	*Andropogon chrysostachyus Steud.*	LP	
10	*Poaceae*	*Andropogon selloanus (Hack.) Hac*	LP	
11	*Poaceae*	*Andropogon distachyos*	HP	
12	*Poaceae*	*Andropogon* spp.	HP	[20]
13	*Asteraceae*	*Anthemis tigreensis J Gay ex A. Rich.*	NP	
14	*Poaceae*	*Arthraxon micans (Nees) Hochst.*	HP	[17]
15	*Poaceae*	*Aristida adoensis Hochst.*	LP	[17]
16	*Poaceae*	*Arthraxon prionodes*	HP	
17	*Poaceae*	*Agrostis quinqueseta (Hochst. ex Steud.) Hochst.*	HP	
18	*Asteraceae*	*Bidens setigera (Sch. Bip.) Sherff*	NP	
19	*Poaceae*	*Bothriochloa insculpta (Hochst. ex A. Rich.) A. Camus*	HP	[20]
20	*Resedaceae*	*Caylusea abyssinica (Fresen.) Fisch. & Mey*	NP	
21	*Cyperaceae*	*Carex steudneri Bock.*	LP	
22	*Apiaceae*	*Centella asiatica (L.) Urban*	NP	
23	*Commelinaceae*	*Commelina subula*	NP	
24	*Commelinaceae*	*Cyanotis barbata*	NP	
25	*Asteraceae*	*Crassocephalurn rubens (Juss. ex-Jacq.) S. Moore*	NP	
26	*Fabaceae*	*Crotalaria species*	LP	
27	*Poaceae*	*Cyperus rigidifolius*	HP	
28	*Cyperaceae*	*Cynodon dactylon (L.) Pers.*	HP	[32]
29	*Cyperaceae*	*Cyperus rotundus*	LP	[17]
30	*Cyperaceae*	*Cyperus dichroostachyus*	HP	
31	*Asteraceae*	*Dicrocephala integrifolia (L.f) Kuntze*	NP	
32	*Poaceae*	*Eleusine floccifolia*	LP	
33	*Poaceae*	*Eragrostis astrepta*	HP	[17]
34	*Poaceae*	*Eragrostis paniciformis (A. Br.) Steud.*	HP	
35	*Poaceae*	*Eragrostis botryodes*	LP	
36	*Poaceae*	*Eragrostis pascua*	HP	
37	*Poaceae*	*Eragrostis patentipilosa*	LP	
38	*Poaceae*	*Eragrostis porosa*	HP	
39	*Asteraceae*	*Euryops pinifolius A. Rich.*	NP	
40	*Asteraceae*	*Gnaphalium rubriflorum Hilliard*	NP	
41	*Asteraceae*	*Guizotia scabra (Vis.) Chiov.*	NP	
42	*Poaceae*	*Harpachne schimperi Hochst. ex A. Rich.*	LP	

Table 2: Continued.

No.	Family	Scientific name	Palatability	Sources
43	*Poaceae*	*Hyparrhenia anthistirioides*	HP	
44	*Poaceae*	*Hyparrhenia dregeana*	HP	
45	*Acanthaceae*	*Hygrophilla schulli*	NP	
46	*Poaceae*	*Hyparrhenia diplandra (Hack.) Stapf*	HP	
47	*Poaceae*	*Hyparrhenia rufa (Nees) Stapf*	HP	
48	*Acanthaceae*	*Hygrophilla* spp.	NP	
49	*Fabaceae*	*Teramnus labialis (Lf) Spreng.*	LP	
50	*Asteraceae*	*Guizotia scabra (Vis.) Chiov.*	NP	
51	*Fabaceae*	*Indigofera secundilora Poir.*	LP	
52	*Poaceae*	*Melinis repens (Willd.) Zizka*	LP	
53	*Fabaceae*	*Medicago polymorpha*	HP	
54	*Poaceae*	*Panicum coloratum* L.	HP	[20]
55	*Poaceae*	*Pennisetum ramosum (Hochst.) Schweinf*	LP	
56	*Poaceae*	*Pennisetum beckeroides*	LP	
57	*Poaceae*	*Pennisetum* spp.	LP	
58	*Poaceae*	*Pennisetum glaucifolium*	LP	
59	*Poaceae*	*Pennisetum glabrum*	LP	
60	*Plantaginaceae*	*Plantago lanceolata* L.	HP	
61	*Poaceae*	*Poa schimperiana Hochst. ex A. Rich.*	HP	
62	*Polygonaceae*	*Rumex nervosus*	NP	
63	*Poaceae*	*Setaria incrassata (Hochst.) Hack.*	HP	
64	*Dipsacaceae*	*Scabiosa columbaria* L.	HP	
65	*Malvaceae*	*Sida schimperiana Hochst. ex A. Rich*	NP	
66	*Malvacea*	*Sida alba* L.	NP	
67	*Poaceae*	*Snowdenia polystachya*	LP	
68	*Poaceae*	*Sporobolus panicoides*	LP	
69	*Fabaceae*	*Trifolium rueppellianum*	HP	[33]
70	*Fabaceae*	*Trifolium decorum*	HP	[33]
71	*Fabaceae*	*Trifolium praense*	HP	[32]
72	*Fabaceae*	*Trifolium acaule*	HP	[33]
73	*Fabaceae*	*Trifolium burchellianum*	HP	[33]
74	*Fabaceae*	*Trifolium campesre*	HP	[33]
75	*Fabaceae*	*Trifolium repens* L.	HP	[20]

HP: highly palatable, LP: less palatable, and NP: nonpalatable.

ha [31] and 5.4 tons/ha [32] in lowland northwest Ethiopia. This variance may be brought on by the poor condition of the pasture land [33] for the current study, as well as the soil's fertility, the quantity of rainfall [32], and the intensity of grazing on natural pasture [37, 38].

Grazing intensity has an impact on the dry matter yield of natural pasture [38]. In the current study, the dry matter yield of natural pasture was significantly higher ($p < 0.05$) in protected sites than communal grazing sites in all agroecologies. The low dry matter yield of the communal grazing area's natural pasture in comparison to protected areas was consistent with the findings of [13, 33, 39, 40]. Grazing restrictions during plant growth enabled species recovery and biomass accumulation, which contributed to higher dry matter yields in protected grazing areas compared to communal grazing areas [41, 42]. However, year-round grazing at the communal grazing site resulted in significantly lower biomass production [43]. This was due to continuous grazing, and trampling in the communal grazing site resulted in decreased plant leaf area, decreased photosynthetic potential, altered forage structures, and ultimately reduced the biomass of plant communities [40]. Because of the high grazing intensity at the communal grazing sites, the less palatable forage species would replace the more palatable forage species [17]. However, protecting or enclosing natural pastures for a specific period of time increases the proportion of palatable species and decreases the proportion of unpalatable species [16, 44], increases their potential, and boosts livestock productivity [33].

The dry matter production of natural pasture in protected grazing sites of highland, midland, and lowland agroecologies was around 2.14, 3.64, and 2.31 t/ha, respectively, while the dry matter production of natural pasture in communal grazing sites of highland, midland, and lowland agroecologies was 1.06, 2.40, and 1.61 t/ha, respectively (Table 3). According to the findings of this study, the dry matter yield of natural pasture was significantly higher ($p < 0.05$) in midland (ML) than in highland (HH) and lowland (HL) agroecologies at both protected and communal grazing sites. The greater dry matter production of natural pasture in midland agroecology was comparable to the findings of [45]. On the other hand, compared to both midland and lowland agroecologies, the dry matter production of natural pasture in highland agroecology was significantly lower ($p < 0.05$). This might be due to the possibility that the inability of plants to live at higher elevations due to low temperatures is the cause of the decreased

Table 3: Biomass yield of natural pasture (t/ha) at different agroecologies and grazing sites.

Agroecology	Grazing site	Biomass	p value
Highland	Protected	2.14 ± 0.36^a	<0.0001
	Communal	1.06 ± 0.47^b	
	Average	1.60 ± 0.36^a	
Midland	Protected	3.64 ± 0.53^a	<0.0001
	Communal	2.40 ± 0.71^c	
	Average	3.02 ± 0.53^a	
Lowland	Protected	2.31 ± 0.46^a	<0.0001
	Communal	1.61 ± 0.46^b	
	Average	1.96 ± 0.46^b	
	Overall mean	2.38 ± 0.41^a	
Grazing site	Agroecology	Biomass	p value
Protected	Highland	2.14 ± 0.36^c	<0.0001
	Midland	3.64 ± 0.47^a	
	Lowland	2.31 ± 0.46^b	
	Average	2.70 ± 0.46^b	
Communal	Highland	1.06 ± 0.47^c	0.0314
	Midland	2.40 ± 0.71^a	<0.0001
	Lowland	1.61 ± 0.46^b	<0.0001
	Average	1.69 ± 0.46^b	
	Overall mean	2.38 ± 0.56	

Means in the same column for each grazing type and agroecology are substantially different ($p < 0.05$) for each other. a, b, and c indicate the significance difference of biomass among highland, midland and lowland agroecologies, and between protected and communal grazing sites.

biomass yield in highland locations [46]. Low temperatures reduce the rate at which soil organic matter decomposes and the rate at which roots take up nutrients [47]. In contrast to the current study, the biomass yield of forage species increased with altitude, i.e., the biomass yield of forage increased from lowland to highland agroecologies [44, 48], whereas the biomass yield of forage species decreased as elevation increased [47]. The reduced biomass production in lowland agroecology when compared to midland agroecology might be attributable to the elevated temperatures that slow the growth of shoots, which in turn slows the formation of roots. High soil temperatures are particularly important because severe root injury significantly reduces shoot growth [49]. Therefore, in order to increase the biomass yield of natural pasture, high-temperature and moisture-resistant forage crops should be introduced into lowland and highland agroecologies, respectively [50].

3.4. Nutritional Composition of Natural Pasture at Different Agroecologies and Grazing Sites. The nutritional composition of natural pasture in the study areas varied across agroecologies and grazing sites (Table 4). The variation may be attributed to forage species composition, grazing intensity, soil fertility, temperature, and water shortage [51–54]. The average ash content (6.85%) of natural pasture in the study area was less than the findings of [55], 8.4% in the Kellem Wollega Zone and [56], 9.9% in the Bale Zone (Table 4). In the present study, the ash content of the natural pasture significantly ($p < 0.05$) decreased with increasing altitude, which was supported by the study [33]. The changes in ash contents of natural pastures among agroecologies may be related to rainfall, temperature, the nature of the soil, and the forage harvesting stage [57]. However, there was no significant ($p > 0.05$) difference in ash contents between protected and communal grazing lands.

The overall crude protein content (7.24%) of natural pastures in the study area was greater than 6.7% [58]. However, it was less than 8.1% [56] in the Bale Zone. In highland, midland, and lowland agroecologies, the mean crude protein (CP) content of natural pasture was 7.12, 7.63, and 6.90%, respectively (Table 4). This finding demonstrated that midland natural pasture has a greater CP content than highland and lowland agroecologies. The higher CP content in midland agroecology could be attributed to the increased proportion of legume species in midland agroecology compared to highland and lowland agroecologies. Also, better soil nutrients may be one of the causes of the observed variance in ML and other regions. This finding suggests that the nutritional value of herbaceous species is influenced by the potentiality of sites, which is compatible with the findings [33]. The lower CP contents in lowland agroecology might be related to increased lignification [59]. Compared to protected grazing pastures, the communal grazing pastures had a greater CP content (Table 4), which is similar to the findings of [33]. It is believed that the frequent clearance of old pastures by grazers and the application of manure to increase the fertility of the soil and plant nutrient content are the causes of the increased CP content in the communal grazing area [7].

The current study found that because natural pasture contains crude protein (CP) at levels over 7% feed dry matter, it can fulfill ruminants' maintenance needs in both high and midland agroecologies [22]. In contrast, lowland agroecology's CP content, which is less than 7%, cannot satisfy even the maintenance needs of ruminants in the study area [22]. Ruminant growth and lactation require

Table 4: Chemical composition of natural pasture at different agroecologies and grazing sites.

Agroecology	DM (%)	Ash (%)	OM (%)	CP (%)	NDF (%)	ADF (%)	ADL (%)
Highland	92.17 ± 0.34^{b}	5.06 ± 0.68^{c}	87.10 ± 0.76^{a}	7.12 ± 0.44^{a}	66.15 ± 0.96^{a}	50.70 ± 0.38^{a}	8.18 ± 0.91^{a}
Midland	91.71 ± 0.36^{b}	6.54 ± 0.71^{b}	85.17 ± 0.79^{b}	7.63 ± 0.50^{a}	65.63 ± 0.78^{a}	51.99 ± 0.55^{a}	8.20 ± 0.94^{a}
Lowland	93.00 ± 0.36^{a}	8.96 ± 0.68^{a}	84.04 ± 0.76^{b}	6.90 ± 0.44^{a}	65.14 ± 0.78^{a}	47.67 ± 0.38^{a}	7.45 ± 0.91^{a}
Overall	92.29 ± 0.34^{b}	6.85 ± 0.71^{b}	85.44 ± 0.76^{b}	7.24 ± 0.44^{a}	65.97 ± 0.78^{a}	49.80 ± 0.38^{a}	7.94 ± 0.91^{a}
p value	0.0041	0.0005	0.0119	0.8102	0.8281	0.7309	0.6859
Effect of grazing on chemical composition of natural pasture							
Protected	92.56 ± 0.25^{a}	7.20 ± 0.67^{a}	85.35 ± 0.34^{a}	6.69 ± 0.06^{a}	66.4 ± 0.29^{a}	51.96 ± 0.20^{a}	8.32 ± 0.12^{a}
Communal	92.00 ± 0.24^{a}	6.51 ± 0.34^{a}	85.49 ± 0.34^{a}	7.73 ± 0.59^{a}	63.75 ± 0.26^{a}	47.96 ± 0.19^{a}	7.63 ± 0.16^{a}
Overall	92.28 ± 0.24^{a}	6.86 ± 0.34^{a}	85.43 ± 0.34^{a}	7.24 ± 0.06^{a}	65.08 ± 0.29^{a}	49.96 ± 0.20^{a}	7.98 ± 0.16^{a}
p value	0.0909	0.2994	0.8198	0.4647	0.4909	0.2771	0.3518

Means within the same column with different superscript letters are significantly different ($p < 0.05$); DM (%): percentage of dry matter; OM: organic matter; CP: crude protein; NDF: neutral detergent fiber; ADF (%): acid detergent fiber; ADL (%): acid detergent lignin.

a minimum of 150 g of CP per kilogram of dry matter [22]. Less than 150 grams of CP are found in one kilogram of natural pasture in all agroecologies, which is insufficient to meet ruminant needs for lactation and growth. Thus, protein-rich feed should be provided to meet the needs of livestock for production.

Compared to communal grazing areas, protected grazing areas had higher values of neutral detergent fiber (NDF) and acid detergent fiber (ADF) (Table 4), which was consistent with the findings of [33]. The absence of adequate grazing animal use at the proper stage of forage plant growth may be one of the potential causes of the greatest concentration of NDF and ADF in protected grazing areas [7]. Indicators of poor forage quality include low CP content and a higher level of fiber [7]. It appears that, compared to other elements, the maturity stage has the greatest impact on the nutritional composition of herbaceous forage.

The average value of neutral detergent fiber (NDF) for natural pasture (65%) in the study area was close to the findings of [22, 59], where the average value of NDF was 64.5% and the average value of NDF for tropical grass was 66.2%, respectively. Roughage feeds with NDF contents of less than 45%, 45–65%, and more than 65%, respectively, were classified as high, medium, and low-quality feeds [60]. Thus, natural pastures are classified as low-quality feed in all agroecologies and may have an impact on feed intake, digestibility, and livestock productivity [60].

4. Conclusions

(i) The overall dry matter yield of natural pasture was low, with significant variation across agroecologies and grazing sites. In both protected and communal grazing sites, the dry matter yield of natural pasture was significantly higher in the midland agroecology than in the highland and lowland agroecologies, whereas the dry matter yield of natural pasture was significantly higher in the protected grazing areas than in the communal grazing sites in all three agroecologies.

(ii) The overall crude protein content of natural pastures in the study area was 7.24%, with differences between agroecologies and grazing sites. The crude protein content of natural pastures is less than 15% feed dry matter in all agroecologies and grazing sites, which cannot meet ruminant production requirements.

(iii) The average value of neutral detergent fiber for natural pasture was greater than 65%, indicating that the feed was low quality, which could affect feed intake, digestibility, and livestock productivity.

(iv) Therefore, it is critical to improve the dry matter yield and crude value of natural pasture through improved grazing practices (such as cut-and-carry grazing and rotational grazing), oversowing of improved forage crops, the application of organic and inorganic fertilizer, and irrigation.

(v) Future research will focus on the effect of the harvest season on forage yield, levels of crude protein, and in vitro dry matter digestibility.

Nomenclature

ADF: Acid detergent fiber
ADL: Acid detergent lignin
AOAC: Association of Official Agricultural Chemists
CP: Crude protein
DM: Dry matter
G: Gram
HL: Highland
km: Kilometer
LL: Lowland
m^2: Meter square
ML: Midland
NDF: Neutral detergent fiber
OM: Organic matter
SPSS: Statistical Package for Social Sciences
Ton/ha: Tons per hectare.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon reasonable request.

Disclosure

Alemu Gashe (Msc), Rangeland Ecology and Management Specialist, is the first author. Dr. Shashie Ayele (PhD) in Tropical Animal Production is the second author. Assistant Professor Workinesh Tiruneh (Msc), Animal Production Specialist, is the third author. Fourth author is the Associate Professor Berhanu Alemu, who holds a PhD in Animal Nutrition. Mesganaw Addis, assistant professor in animal production, is the fifth author.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

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References

[1] T. Alemneh and M. Getabalew, "Beef cattle production systems, challenges and opportunities in Ethiopia," *Health*, vol. 5, no. 1, p. 555651, 2019.

[2] M. Getabalew, T. Alemneh, and D. Akeberegn, "Dairy production in Ethiopia-existing scenario and constraints," *Biomedical Journal of Scientific & Technical Research*, vol. 16, no. 5, pp. 12304–12309, 2019.

[3] A. A. Afras, "Review on breeding objectives and practices of dairy cattle production in Ethiopia," *Journal of Cell and Animal Biology*, vol. 13, no. 1, pp. 1–7, 2019.

[4] T. Firew and A. Getnet, "Feed resources assessment in Amhara regional state," *Ethiopia. Ethiopian sanitary and phyto-sanitary standards and livestock and meat marketing program (SPS-lmm)*, p. 104, Texas A&M University System, Addis Ababa, Ethiopia, 2010.

[5] V. Ny, T. Needham, and F. Ceacero, "Potential benefits of amino acid supplementation for cervid performance and nutritional ecology, with special focus on lysine and methionine: a review," *Animal Nutrition*, vol. 11, pp. 391–401, 2022.

[6] C. Datt and N. Singh, "Fodder cultivation and pasture management in Tripura," *Sustainable Food Security*, 2010.

[7] H. K. Teka, I. C. Madakadze, A. A. Ayana, and H. Abubeker, "Effect of seasonal variation on the nutritional quality of key herbaceous species in semi-arid areas of Borana, Ethiopia," *Indian Journal of Animal Nutrition*, vol. 29, no. 4, pp. 324–332, 2012.

[8] M. Balehegn, A. Ayantunde, T. Amole et al., "Forage conservation in sub-Saharan Africa: review of experiences, challenges, and opportunities," *Agronomy Journal*, vol. 114, no. 1, pp. 75–99, 2022.

[9] A. J. Ash and D. S. Smith, "Evaluating stocking rate impacts in rangelands: animals don't practice what we preach," *The Rangeland Journal*, vol. 18, no. 2, pp. 216–243, 1996.

[10] I. Bogunovic, K. Kljak, I. Dugan et al., "Grassland management impact on soil degradation and herbage nutritional value in a temperate humid environment," *Agriculture*, vol. 12, no. 7, p. 921, 2022.

[11] S. A. A. Mohammed, *Impact of Tillage, weed Control, protection and Seeding with Two Leguminous Species on Rangeland Improvement at Western Darfur State Sudan*, University of Khartoum, Khartoum, Sudan, 2016.

[12] A. Gashe and A. Kassa, "Evaluation of grazing land condition in gozamen district, east Gojjam zone, Amhara regional state, Ethiopia," *International journal of scientific research in environmental science and toxicology*, vol. 3, no. 2, pp. 1–12, 2018.

[13] Y. Fenetahun, Y. Yuan, X. Xinwen, and W. Yongdong, "Effects of grazing enclosures on species diversity, phenology, biomass, and carrying capacity in Borana Rangeland, Southern Ethiopia," *Frontiers in Ecology and Evolution*, vol. 8, Article ID 623627, 2021.

[14] B. Teklu, T. Negesse, and A. Angassa, "Effects of farming systems on floristic composition, yield and nutrient content of forages at the natural pasture of Assosa zone (western Ethiopia)," *Tropical and Subtropical Agroecosystems*, vol. 12, no. 3, pp. 583–592, 2010.

[15] T. Abate, A. Ebro, and L. Nigatu, "Evaluation of woody vegetation in the rangeland of Southeast Ethiopia," *International Research Journal of Agricultural Science and Soil Science*, vol. 2, pp. 113–126, 2012.

[16] D. Gemedo, B. Maass, and J. Isselstein, "Rangeland condition and trend in the semi-arid Borana lowlands, southern Oromia, Ethiopia," *African Journal of Range and Forage Science*, vol. 23, no. 1, pp. 49–58, 2006.

[17] A. K. Gezahegn, *Characterization of Rangeland Resources and Dynamics of the Pastoral Production Systems in the Somali Region of Eastern Ethiopia*, University of the Free State, Bloemfontein, South Africa, 2006.

[18] Z. Tessema, A. Ashagre, and M. Solomon, "Botanical composition, yield and nutritional quality of grassland in relation to stages of harvesting and fertiliser application in the highlands of Ethiopia," *African Journal of Range and Forage Science*, vol. 27, no. 3, pp. 117–124, 2010.

[19] S. Yalew, B. Asmare, and Y. Mekuriaw, "Effects of fertilizer type and harvesting age on species composition, yield and chemical composition of natural pasture in the highlands of Ethiopia," *Biodiversitas Journal of Biological Diversity*, vol. 21, no. 11, 2020.

[20] J. Henning, L. Garry, D. David, and S. Ray Smith, "Forage identification and use guide," *Cooperative Extension Service*, University of Kentucky, Lexington, KY, USA, 2000.

[21] C. Aoac, "Xanthophylls in dried plant materials and mixed feeds," *Method 970.64. Official Methods of Analysis of the Association of Official Analytical Chemists*, pp. 1048-1049, Association of Official Analytical Chemists Inc, Arlington, VA, USA, 15 edition, 1990.

[22] P. J. Van Soest and J. Robertson, *Analysis of Forages and Fibrous Foods*, Cornell University, Ithaca, NY, USA, 1985.

[23] T. Feyisa and M. Dejen, "Assessment of major livestock feed resources and feeding systems in Bench-Maji zone; South Western part of Ethiopia," *Journal of Animal and Feed Research*, vol. 7, no. 6, pp. 145–153, 2017.

[24] A. M. O. Notenbaert, M. Herrero, R. Kruska et al., "Classifying livestock production systems for targeting agricultural research and development in a rapidly changing world," *ILRI Discussion Paper 19*, ILRI (International Livestock Research Institute), Nairobi, Kenyaper, 2009.

[25] S. Salo, G. Tadesse, and D. Haylemeskel, "Survey on constraints of improved forage adoption in anelemo woreda, Hadiya zone, Ethiopia," *Agricultural Research & Technology: Open Access Journal*, vol. 12, no. 2, 2017.

[26] T. Serekebrhan, A. Getachew, M. Yosef, and A. Getnet, "Assessment of farmers perception towards production and utilization of improved forages for dairy cattle feeding in the

central highlands of Ethiopia," *East African Journal of Veterinary and Animal Sciences*, vol. 2, no. 1, pp. 45–56, 2018.

[27] J. Ayele, T. Tolemariam, A. Beyene, D. A. Tadese, and M. Tamiru, "Assessment of livestock feed supply and demand concerning livestock productivity in Lalo Kile district of Kellem Wollega Zone, Western Ethiopia," *Heliyon*, vol. 7, no. 10, p. 8177, 2021.

[28] M. Birhan and T. Adugna, "Livestock feed resources assessment, constraints and improvement strategies in Ethiopia," *Middle-East Journal of Scientific Research*, vol. 21, no. 4, pp. 616–622, 2014.

[29] T. Zewdu and A. G. Desta, *Assessment of Feed Resources and Grazing Land Condition in Gozamen District, East Gojjam Zone, Amhara Region*, Haramaya University, Harar, Ethiopia, 2015.

[30] Y. Denekew, "Assessment of botanical composition and stage of harvesting of selected natural pasture for optimum utilization as hay at Andassa Livestock Research Center, northwestern Ethiopia," unpublished M.Sc. thesis, North Western Ethiopia(Alemaya University), Hawassa, Ethiopia, 2004.

[31] A. Mengistu, "Feed resources in Ethiopia," in *Proceedings of the 1 National Livestock Improvement Conference*, IAR, Addis Ababa, Ethiopia, February 1987.

[32] B. Agza, K. Binyam, A. Solomon Zewdu, and S. Eskinder Aklilu, "Forage yield and nutritive value of natural pastures at varying levels of maturity in North West Lowlands of Ethiopia," *World Journal of Agricultural Sciences*, vol. 1, no. 3, pp. 106–112, 2013.

[33] M. Asrat, A. Angassa, and A. Abebe, "The effects of area enclosures on rangeland condition, herbaceous biomass and nutritional quality in Southeast Ethiopia," *Science, Technology and Arts Research Journal*, vol. 4, no. 2, pp. 79–88, 2016.

[34] A. Tegegn, L. Nigatu, and A. Kassahun, "Changes in plant species composition and diversity along a grazing gradient from livestock watering point in Allaidege rangeland of North-eastern Ethiopia rangelands," *Livestock Research for Rural Development*, vol. 23, no. 9, pp. 45–53, 2011.

[35] Q. Chen, D. U. Hooper, and S. Lin, "Shifts in species composition constrain restoration of overgrazed grassland using nitrogen fertilization in Inner Mongolian steppe, China," *PLoS One*, vol. 6, no. 3, Article ID 16909, 2011.

[36] A. Mengistu, "Contry pasture/forage profile Ethiopia," 2006, https://www.cmi.no/file/1726-norway-and-security-sector-reform-in-developing.pdf.

[37] Y. Melak, A. Angassa, and A. Abebe, "Effects of grazing intensity to water source on grassland condition, yield and nutritional content of selected grass species in Northwest Ethiopia," *Ecological Processes*, vol. 8, no. 1, pp. 12-13, 2019.

[38] A. Ayana, "Vegetation responses to site, elevation and land use in semi-arid rangeland of southern Ethiopia," *African Journal of Agricultural Research*, vol. 11, no. 5, pp. 379–391, 2016.

[39] T. Atsbha, S. Wayu, N. Gebretsadkan, T. Giday, and T. Gebremariam, "Exclosure land management for restoration of herbaceous species in degraded communal grazing lands in Southern Tigray," *Ecosystem Health and Sustainability*, vol. 6, no. 1, Article ID 1829993, 2020.

[40] Y. Na, J. Li, B. Hoshino, S. Bao, F. Qin, and P. Myagmartseren, "Effects of different grazing systems on aboveground biomass and plant species dominance in typical Chinese and Mongolian steppes," *Sustainability*, vol. 10, no. 12, p. 4753, 2018.

[41] G. Belay and T. Negesse, "Livestock feed dry matter availability and utilization in burie zuria district, North Western Ethiopia," *Tropical and Subtropical Agroecosystems*, vol. 22, no. 1, 2019.

[42] L. Menin, "Adaptation of forage and browse legumes to the semi-arid mid-altitude regions of Kenya--an interim report," in *African Forage Plant Genetic Resources, Evaluation of Forage Germplasm and Extensive Livestock Production Systems*, , pp. 134–144, Pasture Network For Eastern And Southern Africa (Panesa), 1988.

[43] S. M. Mureithi, "Effects of enclosures and land zoning on the restoration of degraded semi-arid rangeland in Kenya," 2012, https://www.researchgate.net/publication/292609824_Effects_of_enclosures_and_land_zoning_on_the_restoration_of_degraded_semi-arid_rangeland_in_Kenya.

[44] F. Yeneayehu, Y. D. Wang, and Xu-Xinwen, "Assessment of impact of ecological elevation on grass species diversity in Yabello Rangeland, Southern Ethiopia," *International Journal of Biodiversity and Conservation*, vol. 12, no. 2, pp. 118–127, 2020.

[45] D. W. Dirsha, M. W. Ashenafi, and G. N. Gebeyehu, "Feed resources assessment, laboratory evaluation of chemical composition of feeds and livestock feed balance in enset (Ensete ventricosum)-based mixed production systems of Gurage zone, southern Ethiopia," *International Journal of Livestock Production*, vol. 9, no. 6, pp. 112–130, 2018.

[46] S. Saeed, K. B. Muhammad Younus, A. Alia, and H. S. Syed, "Impact of altitude on soil physical and chemical properties in Sra Ghurgai (Takatu mountain range) Quetta, Balochistan," *International Journal of Scientific Engineering and Research*, vol. 5, no. 3, pp. 730–735, 2014.

[47] J. Bhandari and Y. Zhang, "Effect of altitude and soil properties on biomass and plant richness in the grasslands of Tibet, China, and Manang District, Nepal," *Ecosphere*, vol. 10, no. 11, p. 2915, 2019.

[48] T. Hiwot, Z. Tessema, and B. Emiru, "Effect of human settlement and altitude on rangeland herbaceous species biodiversity and productivity in Kafta-Humera Woreda, Tigray, Ethiopia," *Journal of Environment and Earth Science*, vol. 4, no. 15, pp. 108–116, 2014.

[49] J. L. Hatfield and J. H. Prueger, "Temperature extremes: effect on plant growth and development," *Weather and Climate Extremes*, vol. 10, pp. 4–10, 2015.

[50] F. Feyisssa, A. Getnet, K. Gezahegn, M. Alemayehu, and G. Driba, "Cultivated forage crops research and development in Ethiopia," *Pasture and Rangeland Kesearch and Development*, p. 89, Ethiope Society of Animal Production(ESAP), Addis Ababa, Ethiopia, 2015.

[51] T. Gebremariam and S. Belay, "Chemical composition and digestibility of major feed resources in Tanqua-Abergelle district of Central Tigray, Northern Ethiopia," *The Scientific World Journal*, vol. 2021, Article ID 5234831, 8 pages, 2021.

[52] A. Baranova, J. Oldeland, S. Wang, and U. Schickhoff, "Grazing impact on forage quality and macronutrient content of rangelands in Qilian Mountains, NW China," *Journal of Mountain Science*, vol. 16, no. 1, pp. 43–53, 2019.

[53] L. M. Delevatti, A. S. Cardoso, R. P. Barbero et al., "Effect of nitrogen application rate on yield, forage quality, and animal performance in a tropical pasture," *Scientific Reports*, vol. 9, no. 1, pp. 7596–7599, 2019.

[54] E. Habermann, E. A. Dias de Oliveira, D. R. Contin et al., "Warming and water deficit impact leaf photosynthesis and decrease forage quality and digestibility of a C4 tropical grass," *Physiologia Plantarum*, vol. 165, no. 2, pp. 383–402, 2019.

[55] J. Ayele, T. Tolemariam, A. Beyene, D. A. Tadese, and M. Tamiru, "Biomass composition and dry matter yields of

feed resource available at Lalo kile district of Kellem Wollega Zone, Western Ethiopia," *Heliyon*, vol. 8, no. 2, p. 8972, 2022.

[56] G. Mekuanint and D. Girma, "Livestock feed resources, nutritional value and their implication on animal productivity in mixed farming system in Gasera and Ginnir Districts, Bale Zone, Ethiopia," *International Journal of Livestock Production*, vol. 8, no. 2, pp. 12–23, 2017.

[57] M. Türk, S. Albayrak, and O. Yüksel, "Effects of phosphorus fertilisation and harvesting stages on forage yield and quality of narbon vetch," *New Zealand Journal of Agricultural Research*, vol. 50, no. 4, pp. 457–462, 2007.

[58] B. Lemma and L. Hidoto, "Growth, yield and grain nutrients response of wheat (*Triticum aestivum* L.) to biochar, lime and farmyard manure amendment of the croplands in southern Ethiopia," 2020, https://www.researchgate.net/publication/340193263_Growth_yield_and_grain_nutrients_response_of_wheat_Triticum_aestivum_L_to_biocharlime_and_farmyard_manure_amendment_of_the_croplands_in_southern_Ethiopia.

[59] L. R. McDowell, *Nutrition of Grazing Ruminants in Warm Climates*, Elsevier, Amsterdam, Netherlands, 1985.

[60] T. Wahyono, M. M. Sholikin, Y. Konca, T. Obitsu, S. Sadarman, and A. Jayanegara, "Effects of urea supplementation on ruminal fermentation characteristics, nutrient intake, digestibility, and performance in sheep: a meta-analysis," *Veterinary World*, vol. 15, no. 2, pp. 331–340, 2022.