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Herbaceous species composition, biomass yield, and forage value of natural pastures in South Ari District, Southern Ethiopia

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Abstract

Natural pastures constitute the principal feed resource for livestock in Ethiopia, yet information on their species composition, biomass productivity, and nutritive value remains limited for many agro-ecological zones. This study aimed to (i) identify herbaceous plant species, (ii) quantify dry matter (DM) biomass yield, and (iii) evaluate the nutritive value of dominant forage species in natural pastures of South Ari District, Southern Ethiopia. The study area was stratified into highland, midland, and lowland agro-ecologies and two land-use types (communal and private grazing lands). Herbaceous species composition was assessed using 1 m² quadrats, biomass yield was estimated through destructive sampling, and nutritive value was determined for selected dominant species using standard laboratory procedures. A total of 23 herbaceous species belonging to Poaceae, Fabaceae, and Asteraceae were identified, with grasses accounting for 45.5% of the species. Dry matter yield ranged from 1.11 to 1.27 t DM ha⁻¹ yr⁻¹ in communal grazing lands and 1.73 to 2.12 t DM ha⁻¹ yr⁻¹ in private grazing lands, with significantly higher yields recorded in lowland areas ($P < 0.05$). Crude protein content of selected species ranged from 5.95% (*Cymbopogon citratus*) to 14.35% (*Calopogonium mucunoides*), while neutral detergent fiber values ranged from 37.67% to 74.42%, indicating variable forage quality. In conclusion, natural pastures in South Ari District are dominated by grass species with moderate biomass yield and variable nutritive value, with private grazing lands outperforming communal areas. Improved grazing management, protection of communal pastures, and strategic introduction of forage legumes are recommended to enhance pasture productivity and nutritional quality.

Highlight

Herbaceous plant species in communal and privately owned natural pasture were Assessed.

Twenty-three herbaceous plants were identified, most of which were grasses.

Key preferred forage species included *Cynodon dactylon*, *Sporobolus indicus*, and *Hyparrhenia rufa*.

Private grazing lands had higher dry matter yield than communal lands.

Results emphasize the need for improved grazing management to enhance pasture productivity.



Keywords Herbaceous, Composition, Nutrients, Biomass, Livestock

1 Introduction

Livestock production plays a vital role in the Ethiopian economy and rural livelihoods, contributing substantially to household income, food security, and agricultural sustainability. The sector relies predominantly on natural pastures and crop residues, which together account for more than 85% of the national livestock feed supply [1].

Natural pastures are composed mainly of herbaceous species, including grasses, legumes, and forbs, whose productivity and nutritive value vary with species composition, grazing intensity, soil fertility, rainfall, and agro-ecology [2, 3]. In most Ethiopian grazing lands, grasses from the Poaceae family dominate, while legumes are often scarce due to continuous grazing pressure and poor pasture management, resulting in reduced crude protein availability for livestock [4]. Seasonal fluctuations in rainfall and temperature further influence pasture growth and quality, with marked declines during the dry season leading to feed shortages and reduced livestock productivity [5].

Previous studies conducted in different regions of Ethiopia have documented considerable variability in herbaceous species composition, biomass yield, and forage quality. For example, studies in Bale Zone [6], West Shewa [7] and East Gojjam [3] reported that natural pastures are predominantly grass-based, although the relative abundance of legumes and forbs varies depending on agro-ecological conditions and grazing intensity. In the southern highlands, Mosisa et al. [8] identified 20 herbaceous species with grasses accounting for about 45% of the composition, while Gebregergs [9] reported higher species richness in Northwestern Tigray, identifying 57 species across 21 families. Similarly, Mersha and Seyoum [10] documented 16 indigenous herbaceous forage species in North Shewa Zone. These variations highlight the influence of environmental factors such as altitude, rainfall distribution, and soil fertility, as well as management practices, on pasture composition and diversity.

In terms of productivity, dry matter (DM) yield of natural pastures in Ethiopia is generally low to moderate and is often constrained by overgrazing, land degradation, and seasonal variability. Studies have shown that protected or privately managed grazing lands tend to produce higher biomass and maintain better species composition compared to communal grazing areas due to reduced grazing pressure and improved management practices [11, 12]. Similarly, the nutritive value of herbaceous species varies widely depending on plant species, stage of maturity, and environmental conditions. For instance, crude protein (CP) content and fiber fractions such as neutral detergent fiber (NDF) and acid detergent fiber (ADF) are key indicators of forage quality and digestibility [13]. However, the low proportion of legumes in many natural pastures limits protein availability, which can negatively affect livestock performance [14].

Previous studies have provided valuable insights into herbaceous species composition, biomass productivity, and forage quality; however, their findings vary across agro-ecological zones and management systems, highlighting the need for location-specific and integrated assessments. Comprehensive studies that integrate herbaceous species composition, biomass productivity, forage preference, and chemical composition across multiple agro-ecologies and land-use systems remain limited. Moreover, despite its high livestock population and ecological diversity, South Ari District lacks well-documented

baseline information on herbaceous species composition, dry matter productivity, and nutritive value of natural pastures. In particular, comparative information across agro-ecological zones and land-use systems (communal versus private grazing lands) is scarce.

The novelty of this study lies in its integrated assessment of herbaceous species composition, biomass yield, livestock forage preference, and chemical composition across multiple agro-ecologies and land-use types in South Ari District. By combining ecological field data, laboratory analysis, and indigenous knowledge from livestock keepers, this study provides a more comprehensive understanding of pasture dynamics than previous studies conducted in other regions of Ethiopia.

Therefore, the objectives of this study were to (i) identify and characterize herbaceous species of natural pastures, (ii) estimate dry matter biomass yield across agro-ecologies and grazing systems, and (iii) evaluate the nutritive value of selected dominant forage species in South Ari District, Southern Ethiopia.

2 Materials and methods

2.1 Description of the study area

The study was conducted in South Ari District of Ari Zone, Southern Ethiopia. The district is located at geographic coordinates of 6°04'30" N and 36°30'–37°00' E. There are 33 kebeles (28 rural and 5 municipal) in the district, with altitudes ranging from 500 to 3,418 m above sea level. The district comprises three agro-ecological zones: highland (20%), midland (70%), and lowland (10%) of the total area. The district has a bimodal rainfall pattern, with a short rainy season from March to May (Belg), followed by the main rainy season from July to September (Meher). The mean annual rainfall ranges from 601 to 1,600 mm. The mean annual temperature varies between 10.1 °C and 27.5 °C [15].

Agriculture is the predominant livelihood activity, characterized by mixed crop and livestock production. The woreda is endowed with a diverse livestock population, including 269,613 cattle, 124,249 sheep, 33,331 goats, 23,596 equines, 180,084 chickens, and 16,964 bee colonies [15].

2.2 Study design and sampling strategy

The study employed a stratified sampling design based on three agro-ecological zones (highland, midland, and lowland) and two land-use systems (communal and private grazing lands). Stratification was used to capture agro-ecological and management-related variability in herbaceous species composition, biomass yield, and nutritive value. Within each agro-ecological zone and land-use system, representative grazing sites were purposively selected to ensure the practical feasibility and ecological relevance of sampling. Grazing sites were selected in consultation with local development agents and livestock keepers, taking into account accessibility and land-use history.

2.3 Data collection methods

Data collection involved household questionnaire surveys, field observations, and laboratory analysis. The district was stratified into three agro-ecological zones (highland, midland, and lowland) to capture ecological variability. Within each agro-ecological zone, two land-use types were considered: communal grazing lands and private grazing lands.

2.4 Household survey for forage preference assessment

A multistage sampling procedure combining purposive and random techniques was employed. South Ari District was purposively selected due to its high cattle population, availability of natural pasture resources, and prevalence of free-grazing practices. The district was stratified into three agro-ecological zones: highland (2,300–3,418 m a.s.l.), midland (1,500–2,300 m a.s.l.), and lowland (500–1,500 m a.s.l.). A total of six kebeles (two per agro-ecology) were randomly selected proportionally across the zones: Weset and Dordora (highland), Zomba and Goydamer (midland), and Tembel and Mendri (lowland).

Households with extensive livestock herding experience and detailed knowledge of the local plant flora were purposively selected from each agro-ecological zone. The total number of respondents was determined using the Cochran [16] formula:

$$n_0 = \frac{Z^2(p)(q)}{d^2} = 196.$$

Where, n_0 = desired sample size determined, when population greater than 10,000; Z = standard normal deviation (1.96 for 95% confidence level); $p = 0.15$ (proportion of population to be included in sample i.e. 15%); $q = (1-p)$ i.e. (0.85); d = is degree of accuracy desired (0.05), with 5% error term. Accordingly, 196 households were selected with 80, 61, and 55 respondents from the highland, midland, and lowland agro-ecological zones, respectively.

During the interviews, respondents were asked to assess the preference of different herbaceous plant species by their livestock. Species were categorized into four preference levels: highly desirable/preferred, desirable/preferred, less desirable/preferred, and undesirable/not preferred. In addition, households were asked to specify which livestock species consume each identified plant species, including cattle, sheep, goats, equines, or all livestock types. Furthermore, respondents were requested to identify and rank the top five most valuable forage species based on their practical herding experience and knowledge of local vegetation. This participatory approach helped integrate indigenous knowledge with ecological data.

2.5 Field sampling of herbaceous vegetation

Herbaceous species composition and biomass yield were assessed using 1 m × 1 m (1 m²) quadrats, a standard plot size for pasture and rangeland studies [17, 18]. The study included three agro-ecological zones (highland, midland, and lowland) and two land-use types (communal and private grazing lands). Within each zone and land-use type, a total of 36 quadrats were established (18 in communal and 18 in private grazing lands) to collect representative data on species composition and biomass.

We acknowledge that 36 quadrats may not fully capture the species diversity across ecologically heterogeneous zones. In addition, sampling was conducted only during the main growing season. These limitations were due to time and budget constraints and should be considered when interpreting species richness and seasonal variation in forage availability.

2.6 Species identification

Within each quadrat, all herbaceous plant species were identified and recorded during the active growing period. Initial identification was conducted in the field using local vernacular names, with guidance from knowledgeable herders and local elders. Scientific verification was subsequently performed using standard botanical references, including Flora of Ethiopia and Eritrea [19].

The frequency of each species in the transects was calculated using the formula: Frequency (%) = $(n_i/N) \times 100$. Where: n_i = number of transects in which species i occurs, N = total number of transects sampled. Species were classified by their occurrence frequency as follows: Abundant/Very frequent (> 50%), Frequent/Common (25–50%), Occasional/Less abundant (5–25%), and Rare (< 5%) [20].

2.7 Biomass yield estimation

To estimate potential biomass yield, representative samples of grasses, legumes, and other herbaceous species were collected from each agro-ecological zone and both land-use types (communal and private grazing lands) using 1 m × 1 m quadrats, a standard plot size for rangeland studies. All above-ground biomass within each quadrat was manually harvested at approximately 2 cm above the ground using a sickle [21]. The harvested material was sorted into functional groups (grasses, legumes, and other herbaceous species/weeds), and fresh weight was recorded.

Representative sub-samples were oven-dried at 105 °C for 24 h to constant weight to determine dry matter (DM) content. The total dry weight (TDW) of each species per hectare was calculated using the formula: TDW of individual species = TFW of a species * SDW of species/SDW of species, was used. Where TFW: total fresh weight of species, SDW: sub-sample dry weight.

2.8 Chemical analysis

The dominant herbaceous species, including *Cynodon dactylon*, *Hyparrhenia rufa*, *Sporobolus indicus*, *Galinsoga parviflora*, *Calopogonium mucunoides*, and *Cymbopogon citratus*, were selected for nutritive value analysis. Samples were initially air-dried and subsequently oven-dried at 65 °C for 72 h to standardize moisture content. The dried samples were milled to pass through a 1 mm sieve and analyzed in triplicate for dry matter (DM), ash, and crude protein (CP) following AOAC [22] procedures. Neutral detergent fiber (NDF) was determined according to Van Soest et al. (1991), while acid detergent fiber (ADF) and acid detergent lignin (ADL) were analyzed following Van Soest and Robertson [13]. Crude protein was calculated as nitrogen content × 6.25.

We acknowledge that analyses were conducted on samples collected during a single season; therefore, seasonal variation in nutrient content was not captured. This limitation is discussed in the manuscript, and we recommend that future studies assess nutritive value across multiple seasons to better capture annual variability.

2.9 Source of plant materials

All plant materials used in this study were obtained from naturally occurring herbaceous species growing in communal and private grazing lands of South Ari District, Ari Zone, Southern Ethiopia. The dominant species selected for nutritive value analysis, *Cynodon dactylon*, *Hyparrhenia rufa*, *Sporobolus indicus*, *Galinsoga parviflora*, *Calopogonium*

mucunoides, and *Cymbopogon citratus*, were collected in situ from natural pastures across the three agro-ecological zones (highland, midland, and lowland).

Sampling sites were located between approximately 6°04'30" N latitude and 36°30'–37°00' E longitude, at altitudes ranging from 500 to 3,418 m above sea level. Only naturally occurring pastures were included in this study; cultivated or improved forage plots were not considered.

2.10 Statistical analysis

Data were checked, coded, and analyzed using the Statistical Package for Social Sciences (SPSS, version 21), while Microsoft Excel (version 10) was used for data organization and management. Descriptive statistics, including mean, standard error, frequency, percentage, and confidence intervals (CI), were calculated to summarize species composition, biomass yield, and nutritive values. Post-hoc comparisons were conducted using Tukey's test to separate means when significant differences were observed. A two-factor fixed-effects model was used to evaluate the effects of agro-ecology and land-use type on the measured variables.

The following model was used: $Y_{ij} = \mu + \alpha_i + L_j + \Sigma_{ij}$, Where: Y_{ij} = total observation due to i , and j , μ = is overall mean, α_i = location (agro-ecology), L_j = land use system (grazing types) and Σ_{ij} = random error.

We acknowledge that the hierarchical nature of the data (quadrats nested within land-use types and agro-ecologies) was not modeled using mixed-effects approaches due to resource and time constraints. Future studies could apply mixed-effects models or repeated-measures analyses to better account for nested and temporal variability.

3 Results

3.1 Herbaceous plant species composition and frequency

A total of 23 herbaceous species, representing multiple botanical families, were recorded in the natural pastures of South Ari District (Table 1). Grasses (Poaceae) were the most dominant, accounting for 45.5% of the species, followed by legumes (Fabaceae, 25%) and forbs (Asteraceae, 29.5%). This composition reflects a typical natural pasture system in southern Ethiopia, where grasses constitute the bulk of forage. The relatively low proportion of legumes in communal grazing areas may indicate higher grazing pressure or poor management, as legumes are generally more sensitive to overgrazing than grasses.

Forage species were classified based on their relative importance for livestock feeding into highly desirable (HD), desirable (D), less desirable (LD), and undesirable (UD) categories. Highly desirable species, including *Cynodon dactylon*, *Sporobolus indicus*, *Hyparrhenia rufa*, and *Snowdenia polystachya*, were prevalent, indicating that the pastures continue to provide valuable forage for cattle, sheep, goats, and equines. Less desirable and undesirable species, such as *Ageratum conyzoides* and *Bidens tripartita*, were present, highlighting areas that may require pasture improvement or management intervention.

3.2 Frequency of grass species (poaceae)

Frequency analysis (Table 2) showed that *Cynodon dactylon*, *Sporobolus indicus*, and *Hyparrhenia rufa* were consistently abundant across both communal (CG) and private grazing (PG) lands, although some variation occurred between agro-ecological zones.

Table 1 Herbaceous plant species identified in the study area with their local names, forage value, life form, and livestock type supported

s/n	Botanical name (Scientific)	Local name	Family name	For- age value	Life form	Livestock type
1	<i>Cynodon dactylon</i>	Gillima	Poaceae	HD	P	Cattle, sheep, goats, equine
2	<i>Sporobolus indicus</i>	Bucha	Poaceae	HD	P	Cattle, sheep, goats, equine
3	<i>Hyparrhenia rufa</i>	Bogina	Poaceae	HD	P	Cattle, sheep, goats, equine
4	<i>Cymbopogon citratus</i>	Waarikaa	Poaceae	HD	P	Cattle, sheep, goats, equine
5	<i>Digitaria abyssinica</i>	Gichila	Poaceae	HD	A	Cattle, sheep, goats, equine
6	<i>Cynodon dactylon</i>	Garda	Poaceae	D	P	Cattle, sheep, goats, equine
7	<i>Deschampsia cespitosa</i>	Felkka	Poaceae	HD	A	Cattle, equine
8	<i>Digitaria sanguinalis</i>	Saribuki	Poaceae	HD	A	Cattle
9	<i>Alopecurus aequalis</i>	Gircha	poaceae	HD	A	Cattle, sheep, goats, equine
10	<i>Miscanthus sinensis</i>	Misha	Poaceae	D	P	Cattle, equine
11	<i>Pennisetum clandestinum</i>	Tsokirssa	poaceae	D	P	Cattle, equine
12	<i>Snowdenia polystachya</i>	Bachi	poaceae	HD	A	Cattle, sheep, goats, equine
13	<i>Galinsoga parviflora</i>	Abaye	Asteraceae	D	A	Cattle, equine
14	<i>Calopogonium mucunoides</i>	Turena	Fabaceae	HD	P	All
15	<i>Cyperus difformis</i>	Chaffe	Cyperaceae	HD	A	Equine
16	<i>Allium cernuum</i>	Fereflash	Amaryllidaceae	LD	P	Shoats
17	<i>Trifolium rueppellianum</i>	Torkka	Fabaceae	D	P	Shoats
18	<i>Guizotia abyssinica</i>	Hawisha	Asteraceae	D	A	Cattle, shoats
19	<i>Amaranthus retroflexus</i>	Hukuma	<u>Amaranthaceae</u>	LD	P	Shoats
20	<i>Sida acuta</i>	Chopisha	Malvaceae	HD	P	Cattle
21	<i>Triumfetta rhomboidea</i>	Langa	Fabaceae	D	A	Cattle
22	<i>Ageratum conyzoides</i>	Aykenton	Asteraceae	UD	A	Cattle
23	<i>Bidens tripartita</i>	Sungulakatsi	Asteraceae	UD	A	Cattle

For example, *Cynodon dactylon* had a higher frequency in midland PG sites (20.56%) compared to highland PG sites (16.67%), indicating site-specific differences likely influenced by microclimate, soil fertility, and grazing pressure. Several species, such as *Digitaria abyssinica* and *Snowdenia polystachya*, were less abundant in communal areas, suggesting that heavy grazing and trampling may reduce the presence of palatable grasses.

3.3 Frequency of legumes, forbs, and other herbaceous species

The frequency of legumes, forbs, and other minor herbaceous species is presented in Table 3. *Calopogonium mucunoides* was the most frequent legume, particularly in midland private grazing sites (16.88%), while other species such as *Trifolium rueppellianum* and *Guizotia abyssinica* showed moderate occurrence. Forbs, including *Galinsoga parviflora*, were more abundant in midland communal lands, suggesting that site-specific management practices and grazing intensity influence species distribution. Less desirable species, including *Ageratum conyzoides* and *Bidens tripartita*, were rare across both land-use types, reflecting their limited contribution to forage biomass but potential importance for ecosystem diversity.

3.4 Integration of species composition and land-use patterns

Private grazing lands consistently supported higher frequencies of highly desirable forage species compared to communal lands, which often exhibited lower frequencies due

Table 2 Frequency of grasses species (*poaceae* families)

s/n	Botanical name	Local name	Family name	Land use units	Agro-ecology				P-value
					Highland	Midland	Lowland	Overall	
1	<i>Cynodon dactylon</i>	Gilima	<i>Poaceae</i>	CG	18.33	19.67	18.78	18.93	0.102
				PG	16.67 ^c	20.56 ^a	18.21 ^b	18.48	0.020
2	<i>Sporobolus indicus</i>	Bucha	<i>Poaceae</i>	CG	15.10 ^b	17.00 ^a	15.67 ^b	15.92	0.040
				PG	14.56 ^b	16.34 ^a	16.32 ^a	15.74	0.020
3	<i>Hyparrhenia rufa</i>	Bogina	<i>Poaceae</i>	CG	11.67 ^c	13.74 ^a	12.56 ^b	12.66	0.040
				PG	14.40 ^a	13.33 ^b	13.67 ^b	13.80	0.020
4	<i>Cymbopogon citratus</i>	Waarikaa	<i>Poaceae</i>	CG	9.67 ^b	11.66 ^a	11.67 ^a	11.00	0.011
				PG	12.11 ^a	9.67 ^b	12.33 ^a	11.37	0.010
5	<i>Digitaria abyssinica</i>	Gichila	<i>Poaceae</i>	CG	8.46 ^b	8.53 ^b	9.33 ^a	8.77	0.041
				PG	10.47 ^a	8.96 ^b	10.14 ^a	9.86	0.000
6	<i>Cynodon dactylon</i>	Garda	<i>Poaceae</i>	CG	7.33 ^a	6.11 ^b	7.11 ^a	6.85	0.001
				PG	8.59 ^a	6.66 ^b	8.10 ^a	7.78	0.523
7	<i>Deschampsia cespitosa</i>	Felkka	<i>Poaceae</i>	CG	6.67 ^a	5.20 ^b	5.82 ^{ab}	5.90	0.000
				PG	6.33	6.00	6.00	6.11	0.100
8	<i>Digitaria sanguinalis</i>	Saribuki	<i>Poaceae</i>	CG	5.58 ^a	4.50 ^b	4.50 ^b	4.86	0.030
				PG	3.50 ^c	5.33 ^a	4.50 ^b	4.44	0.000
9	<i>Alopecurus aequalis</i>	Gircha	<i>Poaceae</i>	CG	4.27	4.13	4.56	4.32	0.220
				PG	3.37 ^b	4.33 ^a	3.40 ^b	3.70	0.001
10	<i>Miscanthus sinensis</i>	Misha	<i>Poaceae</i>	CG	4.00 ^a	2.98 ^c	3.42	3.47	0.043
				PG	3.22	3.67	2.33	3.07	0.120
11	<i>Pennisetum landustinum</i>	Tsokirssa	<i>Poaceae</i>	CG	3.67	1.99	3.33	2.99	0.113
				PG	3.00	2.89	2.13	2.70	0.200
12	<i>Snowdenia polystachya</i>	Bachi	<i>Poaceae</i>	CG	2.88 ^a	1.52 ^c	2.00 ^b	2.13	0.044
				PG	2.11	2.26	2.11	2.16	0.060
13	Others			CG	2.33 ^a	1.30 ^b	1.25 ^b	1.63	0.14
				PG	1.67 ^a	1.00 ^b	0.76 ^b	1.14	0.022

Where; superscripts (a, b, c) show significant difference at $P < 0.05$; N: Number of Respondent; %: Percentage; NS: Non-significant at $P > 0.05$; CG: communal grazing, PG: private grazing; Frequency: $> 50\%$ = Abundant, $25-50\%$ = Frequent, $5-25\%$ = Less abundant, and $< 5\%$ = Rare

to higher grazing pressure. The mixture of abundant, frequent, and less abundant species across agro-ecological zones highlights the spatial heterogeneity of pasture composition. These results suggest that pasture management strategies, such as temporary protection of grazing lands or controlled grazing, could help maintain or enhance the abundance of palatable species while conserving minor but ecologically important plants.

3.5 Dry matter yield of natural pasture in South Ari District

In the current study, grass (1.90 ± 0.062 t DM ha⁻¹) and legume (1.22 ± 0.074 t DM ha⁻¹) species from communal grazing lands in lowland agro-ecologies produced significantly higher ($P < 0.05$) dry matter yields than those in other agro-ecological zones. Similarly, on private grazing lands, legume (2.42 ± 0.030 t DM ha⁻¹) and herb (1.22 ± 0.077 t DM ha⁻¹) species in lowland areas recorded the highest dry matter production compared to the other altitude categories (Table 4.).

3.6 Chemical composition of selected pasture species in South Ari District

The dry matter (DM) content of the analyzed leaf samples from fodder tree species ranged from 88.43% to 90.20%. Among these, *Vernonia amygdalina* exhibited the highest DM content (91.04%), which was significantly greater than that of the other

Table 3 Frequency (%) of legumes, forbs and other herbaceous species

s/n	Botanical name	Local name	Family name	Land use	Agro-ecology				P-value
					Highland	Midland	Lowland	Overall	
1	<i>Galinsoga parviflora</i>	Abayele	Asteraceae	CG	16.30	27.27	20.33	21.30	0.201
				PG	17.72	18.37	18.00	18.03	0.061
2	<i>Calopogonium mucunoides</i>	Turena	Fabaceae	CG	15.94 ^b	17.67 ^a	15.56 ^b	16.39	0.021
				PG	14.51 ^b	14.80 ^b	16.88 ^a	15.00	0.013
3	<i>Cyperus difformis</i>	Chaffe	Cyperaceae	CG	13.33	11.67	13.67	12.89	0.122
				PG	12.72	13.10	13.00	12.94	0.109
4	<i>Allium cernuum</i>	Fereflash	Amaryllidaceae	CG	12.11	10.77	10.00	10.96	0.092
				PG	11.15 ^a	10.54 ^b	9.56 ^c	10.42	0.001
5	<i>Trifolium rueppellianum</i>	Torkka	Fabaceae	CG	10.67 ^a	9.00 ^b	9.67 ^{ab}	9.78	0.001
				PG	10.09 ^a	9.31 ^b	8.12 ^c	9.17	0.01
6	<i>Guizotia abyssinica</i>	Hawisha	Asteraceae	CG	9.00 ^a	8.00 ^b	8.00 ^b	8.33	0.03
				PG	8.80 ^a	8.12 ^a	7.33 ^b	8.08	0.04
7	<i>Amaranthus retroflexus</i>	Hukuma	Amaranthaceae	CG	6.60 ^b	7.85 ^a	7.21 ^a	7.22	0.041
				PG	8.56 ^a	7.00 ^b	6.21 ^c	7.26	0.01
8	<i>Sida acuta</i>	Chopisha	Malvaceae	CG	5.00 ^b	6.67 ^b	5.25 ^b	5.64	0.02
				PG	6.25	6.00	5.99	6.08	0.051
9	<i>Triumfetta rhomboidea</i>	Langa	Fabaceae	CG	4.84 ^b	5.33 ^a	4.20 ^c	4.79	0.040
				PG	4.14 ^b	5.33 ^a	4.10 ^b	4.52	0.011
10	<i>Ageratum conyzoides</i>	Aykenton	Asteraceae	CG	3.60 ^b	4.92 ^a	3.11 ^b	3.88	0.001
				PG	3.10	4.30	4.03	3.81	0.081
11	<i>Bidens tripartite</i>	Sungu-lakatsi	Asteraceae	CG	1.41 ^b	4.21 ^a	1.83 ^b	2.48	0.006
				PG	1.70	4.00	3.78	3.16	0.235

Where; superscripts (a, b, c) show significant difference at $P < 0.05$; N: Number of Respondent; %: Percentage; NS: Non-significant at $P > 0.05$; CG: communal grazing, PG: private grazing; Frequency: $> 50\%$ = Abundant, $25-50\%$ = Frequent, $5-25\%$ = Less abundant, and $< 5\%$ = Rare

Table 4. Herbage (Mean $\pm$ SEM) yield (tDMha⁻¹year⁻¹) of herbaceous species in the study area

Plant species (tDM/ha)	Land use pattern	Agro-ecologies				P-value
		Highland	Midland	Lowland	Overall	
Grasses	CG	1.72 $\pm$ 0.055 ^c	1.88 $\pm$ 0.185 ^b	1.90 $\pm$ 0.062 ^a	1.83 $\pm$ 0.101	0.030
	PG	2.40 $\pm$ 0.085	2.54 $\pm$ 0.066	2.71 $\pm$ 0.142	2.55 $\pm$ 0.098	0.105
Legumes	CG	1.04 $\pm$ 0.050 ^c	1.10 $\pm$ 0.099 ^b	1.22 $\pm$ 0.074 ^a	1.12 $\pm$ 0.074	0.033
	PG	1.80 $\pm$ 0.071 ^c	2.08 $\pm$ 0.060 ^b	2.42 $\pm$ 0.030 ^a	2.10 $\pm$ 0.054	0.001
Weeds	CG	0.58 $\pm$ 0.011	0.50 $\pm$ 0.044	0.70 $\pm$ 0.051	0.59 $\pm$ 0.035	0.112
	PG	0.99 $\pm$ 0.053 ^c	1.07 $\pm$ 0.026 ^b	1.22 $\pm$ 0.077 ^a	1.09 $\pm$ 0.052	0.010
Mean ($\pm$SE)	CG	1.11 $\pm$ 0.039	1.16 $\pm$ 0.109	1.27 $\pm$ 0.062	1.18 $\pm$ 0.070	
	PG	1.73 $\pm$ 0.070	1.90 $\pm$ 0.051	2.12 $\pm$ 0.083	1.91 $\pm$ 0.053	

Where; Means with different superscripts (a, b, c) along row are significantly differed at $P < 0.05$; SE: Standard Error; NS: Non-significant at $P > 0.05$; tDMha⁻¹: Tons of dry matter per hectare

pasture species evaluated (Table 5). *Galinsoga parviflora* showed the highest ash content (12.16%), significantly exceeding that of the other species. The crude protein (CP) content varied considerably among the species, with the highest value recorded for *Calopogonium mucunoides* (14.35%) and the lowest for *Cymbopogon citratus* (5.95%) The neutral detergent fiber (NDF) content of *Sporobolus indicus* was significantly higher than that of the other pasture species.

Table 5 Chemical composition of selected pasture species in the study area

Plant species	Nutrient contents					
	DM%	Ash%	CP%	NDF%	ADF%	ADL%
<i>Cynodon dactylon</i>	88.60	11.10	7.58	65.65	42.11	8.50
<i>Hyparrhenia rufa</i>	89.00	8.46	8.49	61.55	33.98	4.95
<i>Sporobolus indicus</i>	90.21	10.73	6.54	74.42	30.93	4.20
<i>Galinsoga parviflora</i>	90.01	12.16	12.09	37.67	28.70	8.03
<i>Calopogonium mucunoides</i>	88.43	9.72	14.35	40.65	27.21	5.62
<i>Cymbopogon citratus</i>	90.20	8.87	5.95	52.01	32.02	3.70

DM%: Dry Matter Percentage; CP: Crude Protein; NDF: Neutral Detergent Fiber; ADF: Acid Detergent Fiber; ADL: Acid Detergent Lignin; %: Percentage; SEM: standard error of mean

4 Discussion

A total of 23 herbaceous species were identified in the natural pastures of South Ari District, with grasses (Poaceae) dominating (45.5%), followed by legumes (Fabaceae, 25%) and forbs (Asteraceae, 29.5%). This composition broadly aligns with findings from other regions of Ethiopia. For example, Alemu et al. [3] reported similar grass dominance in East Gojjam, while Alemayehu and Woldegebriel [23] documented comparable species distribution in Benishangul-Gumuz. In the southern highlands, Mosisa et al. [8] recorded 20 herbaceous species, of which 45% were grasses, 15% legumes, 10% sedges, and 30% forbs. In Northwestern Tigray, Gebregergs [9] identified 57 species across 21 families, including 16 grasses and 41 non-grasses, while Mersha A, Seyoum [10] reported 16 indigenous herbaceous forage species in North Shewa Zone. Differences in species richness and composition among these regions likely reflect variations in agro-ecology, soil fertility, grazing management, and sampling methods. Methodological differences such as quadrat size, number of sampling plots, and single-season sampling may also contribute to observed discrepancies.

Highly desirable species, including *Cynodon dactylon*, *Sporobolus indicus*, *Hyparrhenia rufa*, and *Calopogonium mucunoides*, were prevalent, suggesting that the pastures continue to provide valuable forage. However, the presence of less desirable and undesirable species (*Ageratum conyzoides*, *Bidens tripartita*) highlights areas where pasture quality may be declining. The low abundance of legumes in communal grazing areas may reflect higher grazing pressure, although direct measurements of stocking rates were not taken. Therefore, conclusions regarding overgrazing effects are indicative rather than definitive, and future studies incorporating quantitative grazing pressure data would improve causal inference.

The observed dry matter (DM) yield varied across land-use types and agro-ecologies. Private grazing lands consistently produced higher biomass than communal areas, and lowland sites outperformed midland and highland zones. These findings align with previous studies [10, 11] showing that reduced grazing pressure and temporary pasture protection enhance species recovery and biomass accumulation. In contrast, communal grazing areas with continuous heavy grazing and trampling often show lower yields and a shift from palatable to less palatable species, as observed in this study. Similar patterns have been reported in West Shewa [7] and the Central Rift Valley [12].

While this study provides valuable insights, it was conducted during a single growing season, and the number of quadrats per site was limited. This may underestimate temporal and spatial variability in species composition, biomass yield, and forage quality.

Seasonal changes in growth and nutrient content are particularly relevant for perennial and annual species; therefore, multi-season sampling in future studies is recommended.

The chemical composition of selected forage species revealed considerable variability. Crude protein (CP) ranged from 5.95% (*Cymbopogon citratus*) to 14.35% (*Calopogonium mucunoides*), while neutral detergent fiber (NDF) ranged from 37.67% to 74.42%, reflecting differences in species, plant maturity, soil nutrient status, and environmental conditions. Overall, the CP content (20.42%) was higher than reported for Bale Zone (8.1%; [6] and the average ash content (11.6%) exceeded values reported in Kellem Wollega Zone (8.4%; [14]). The mean NDF content (52.17%) was lower than the tropical grass averages of 64.5–66.2% reported by Van Soest and Robertson (1985). According to Van Soest's classification, feeds with NDF < 45%, 45–65%, and > 65% correspond to high-, medium-, and low-quality roughages, respectively, indicating that natural pastures in South Ari District provide moderate-quality forage, although the scarcity of legumes may limit livestock performance.

The findings indicate that pasture productivity and nutritive value in South Ari District are influenced by a combination of land-use type, agro-ecology, and management practices. Protecting pastures through temporary enclosures or rotational grazing could enhance forage quality, biomass yield, and livestock productivity.

5 Conclusion

This study demonstrated that natural pastures in South Ari District are dominated by grass species, with 23 herbaceous species identified across agro-ecologies and land-use systems. Biomass production and nutritive value varied significantly, with private grazing lands and lowland areas producing higher dry matter yields than communal and highland sites. Crude protein content of dominant forage species ranged from 5.95% to 14.35%, indicating variable forage quality and potential protein deficiencies in grass-dominated pastures.

For future work, we recommend multi-season sampling and increased quadrat coverage to better capture temporal and spatial variability. Controlled grazing trials and the introduction of legumes could be implemented to improve pasture productivity and quality. These measures would support sustainable livestock production, enhance forage availability, and inform local grazing management strategies.

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Author contributions

Y.T.: Conceptualization, methodology, supervision, data analysis, resources, writing—review and editing; K.K.: Investigation, methodology, data collection, writing—original draft preparation; T.O.: Supervision, resources, writing—review and editing.

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Data availability

All data generated or analyzed during this study are included in this published article.

Declarations

Ethics approval and consent to participate

The study protocol involving human participants was reviewed and approved by the Research and Postgraduate Programs Directorate Ethical Review Committee of Jinka University. All procedures involving human participants were conducted in accordance with the ethical standards of the institutional research committee and the principles of the Declaration of Helsinki for research involving human subjects. All survey participants were informed about the study

objectives and provided written informed consent. Participation was voluntary, and confidentiality of respondents' information was maintained throughout the study.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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