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Research article

Biomass composition and dry matter yields of feed resource available at Lalo kile district of Kellem Wollega Zone, Western Ethiopia

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ABSTRACT

This study aimed to assess the available livestock feed resources in the Lalo kile district of Kellem Wollega Zone, Western Ethiopia, in terms of species biomass composition and dry matter yield of dominant forage species. The district was stratified into two agro-ecologies: mid-altitude areas and low-altitude areas. The effects of grazing intensity on dry matter yields and biomass composition were analyzed using a randomized complete block design replicated three times having two blocks differed by two agro-ecologies (three mid-altitude kebeles and three low-altitude kebeles). The present study used seventy-two pasture samples and 20 × 20 m forage trees collected randomly from the two agro-ecologies of the study area. The General Linear Model of the SAS 19.0 version was used to compare the effects of the agro-ecology and species on dry matter yield and biomass composition. The result of the study indicated that the average dry matter yield for grasses, legumes, and other herbaceous forages was 1.156 t/ha, 0.242 t/ha, and 0.182 t/ha, with an overall 1.58 t/ha in the study district, respectively. About 73.13% of grasses, 15.32% of legumes, and 11.55% of other herbaceous were the species biomass composition in the study area. The midland agroecology had the average biomass fodder yields 7.98–19.78 kg/tree and 1.06–2.41 kg/shrub while lowland agroecology had 9.87–178.06 kg/tree and 1.34–3.87 kg/shrub. There was an estimate of 74.36–100 kg/ha fodder shrubs and 500–800 kg/ha fodder trees on cultivated and uncultivated land in the study area. The herbage yield of natural pasture is 1.733 t $DMha^{-1}$ in the mid and 1.427 t $DMha^{-1}$ in the low altitudes of the study area, with a mean herbage yield of 1.58 t $DMha^{-1}$ during vegetation cover. The grazing capacity of the study area was 0.23 TLU/ha/year in the mid and 0.19 TLU/ha/year in the low altitudes of the study area, with a mean value of 0.21 TLU ha/year. The presence of limited grazing land in the study area led to overgrazing, which in turn resulted occurrence of land degradation associated with poor biomass yield, low quality and variable supply of feeds between the season. Therefore, this study suggests setting up land-use regulation policy to allocate separate land for feed production and commonly use for livestock feeding to improve livestock productivity and contribute to food security and poverty alleviation of small holder farmers in the study area.

1. Introduction

Livestock plays a crucial role in Ethiopian agriculture. However, the level of contribution from the livestock sub-sector is generally low (ILRI, 2006). Currently, productivity per animal is very low, and the contribution of the sector to the overall economy is much lower than expected due, among others, to poor nutrition. Feed is a very important factor in animal production. Crop residues and natural pastures are the major source of feeds for livestock. However, they are poor in major nutrients such as energy and protein (Tessema and Barras, 2006).

Plantation of improved forage crops is not yet widely practiced and hence livestock rearing entirely depends on available natural pasture (Malede and Takele, 2014). The total area of grazing and browsing is estimated to be 61–65 million ha, of which 12% is in mixed farming and

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the rest in pastoral areas (MoA, 2000). The highland part of Ethiopia is known to have practiced stall-feeding and continuous grazing using crop residues as an integral feed resource (Ahmed, 2006). Overgrazing is a serious problem in Ethiopia which leads to negatively affect forage yield and quality associated with reduced ground cover and consequently leading replace the growth of herbaceous plants by annual grasses and forbs such as tall perennial bunch grasses (Herlocker, 1999). Feed yield and quality are obviously affected species composition and productivity which would eventually impact livestock productivity. Botanical composition of forage species is of paramount importance to identify the best species for rehabilitating degraded ranges, determining compatible animal to available forage species, employing optimal allocation to different class of animals, estimating the extent of overgrazing, and determining the key forage species and livestock for a particular environment. The fundamental goal in creating and executing suitable management interventions such as livestock feeding techniques is to identify the current forage species of natural pasture and their nutritional value. There has been no previous research in the Lalo kile area on the direct measurement of species composition changes from frequency distribution. In the country, estimates of carrying capacity based on pasture quality and nutritional qualities are also scarce. Therefore, the goal of the current study was to determine forage species composition, dry matter production, and carrying capacity.

2. Material and methods

2.1. Description of the study area

This study was conducted at Lalo kile kebele of Kellem Wollega zone, western Ethiopia, located 510 km away to the west of Addis Ababa, Ethiopia's capital city (Figure 1). The geographical coordinate of the district includes latitudes of 8° 43′ 36″ and 9° 3′ 31″ north, and longitudes of 35° 12′ 52″ and 35° 26′ 54″ east while an altitudinal range of 1430–1780 m.a.s.l., consisting agro-ecological setting of mid-altitude (60 percent) and low altitude (40 percent). The district has a sub-humid climate with a long-term rain failure that gets 1,000–1,500 mm per year with a bimodal distribution and typically lasts from April to November during the rainy season. The district has the highest temperature of 150 °C and lowest temperature of 310 °C. The district's geography is distinguished by a high, undulating slope and soil textures of black, white, and red. The total number of households in the district is predicted to be 7,797, with 7,157 male-headed families and 640 female-headed households. The district has a total population of 49,783, with 23,760 men and 26,023 females. Thus, the population density is 123.28 people/km^2 (ARDO, 2015). The district's farming system is characterized by a mixed farming approach that includes both crops and animal production. The district is distinguished by a rain-fed agricultural system that includes a diverse array of cereals, pulses, oilseed crops, and livestock husbandry activities. Maize, sorghum, finger millet, teff, haricot beans, beans, peas, and vegetables are the most important crops farmed in the area. Coffee, pepper, noug, and sesame are cash crops, while wheat, barley, sweet potatoes, fruit, and Irish potatoes are minor crops. The majority of agricultural residue given to animals in the district includes maize stover, finger millet, sorghum, and teff straw. The total land area of the district was 40,382 ha, including 24,065 ha of cultivable land, 1,342 ha of community grazing pasture, 1292.93 ha of natural forest, 2019.1 ha of degraded land, 1580 ha of water body, and 10082.97 ha of other land (ARDO, 2015). This district's entire livestock population was assessed to be 103,674 cattle, 43,126 sheep, 26,234 goats, 9,854 donkeys, 4,340 horses, 3,211 mules, and 44,583 chickens, of which 41,819 were indigenous and 2,764 were exotic chicken (LDHAD, 2015).

2.2. Sampling and design of experiment

The current study employed 72 grassland samples and 20 × 20 m forage trees picked at random from the study area's two agro-ecologies. To investigate the effects of grazing intensity on biomass composition, dry matter yields, and forage nutritional values, a randomized complete block design with three replicates on two blocks varied by altitude position (one mid-altitude block and one low-altitude block) was used.

To estimate the potential natural pasture biomass yield and dry matter production in the study area, representative samples of grasses, legumes, and other herbaceous vegetation were collected from sites with high, medium, and low vegetation cover based on grazing pressure according to Thairu and Tessema (1985) and visual observation according to Mannetje (2000). The proportions of grasses, legumes, and other herbaceous plants were examined at a time when grasses achieve almost 50% blooming and vegetative development often ceases. The measurements were taken on natural pasture (communal grazing, private grazing, fallow fields, and roadside areas) with 1 m by 1-meter quadrants, as reported by Mannetje (1978) and Tarawali et al. (1995). By tossing a piece of stone towards the back, the quadrant was randomly put on grazing

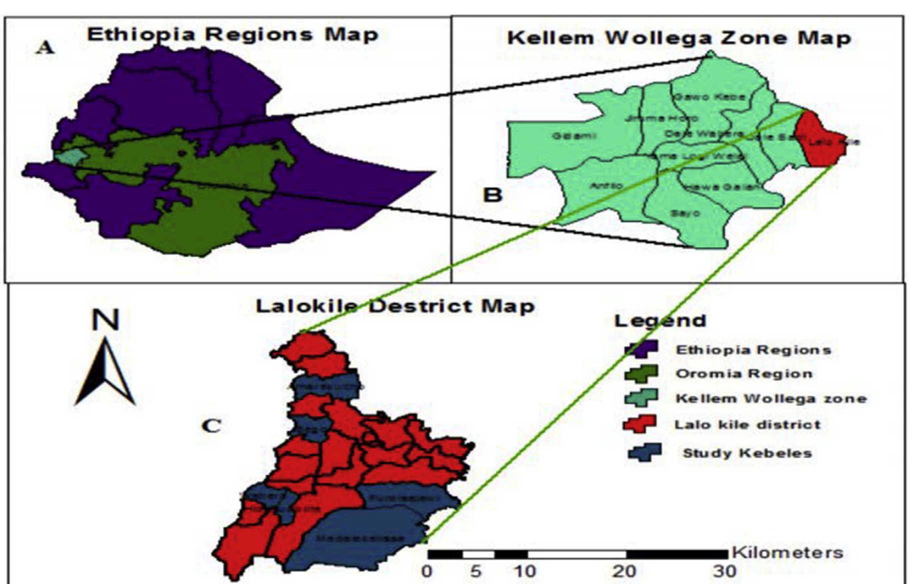

Figure 1. Map of the study area.

ground with high, medium, and low vegetative cover. All of the samples collected inside the quadrant were taken at a height of 5 cm above ground level. The composites were combined, and the total fresh weight was determined by direct measurement and translated to the total area of grazing land. The two agro-ecologies were sampled with 72 sub-samples (18 quadrates each from private, community, fallow land, and roadside feeds). In all, 24 composite sampling units from both agro-ecologies were used. The dry matter yield of each species was determined in an oven (65 °C for 72 h)(AOAC, 1995). Based on the DM weights obtained from sample sites, the percent composition of each species of grasses, legumes and herbaceous species for each quadrant was calculated and the total biomass production capacities of the area were obtained as follows according to Tothil et al. (1978):

i. $\text{TDW of individual species} = \frac{\text{TFW of a species}}{\text{SFW of a species.}} \times \text{SDW of species}$
ii. $\text{\% Composition of each species at a site} = \frac{\text{TDW of a species}}{\text{GTDW of all the species}} \times 100$

Where TFW is the total fresh weight of individual species, SFW is sub-sample fresh weight, SDW is sub-sample dry weight, TDW is total dry weight and GTDW is the total dry weight of all species (Tothil et al., 1978).

The potential yield of indigenous fodder trees and shrubs were estimated by measuring steam diameter using a measuring tape and applying the equation of Petmark (1983). Measuring the circumference of each selected shrubs and trees was done and then each number of species was counted on randomized quadrant of 20 × 20 m in the grazing land was counted from the two altitudes. The yield per plant was estimated by cutting the branches and collecting the edible part followed by weighing (leaves and shoots) of the tree. The diameter of the plants was calculated using the formula; D = 0.636 C where D is the diameter and C is the circumference of the plant. The potential yield of each browsing plant was calculated by using the formula developed by Petmark (1983).

iii. LogW = 2.24 logDT-1.5 (for trees)
iv. LogW = 2.62 logDS-2.46 (for shrubs).

Where W was leaf DM yield in kg, DT was the diameter of the trunk (cm) at 80 cm height (for tree leaf biomass) and DS was the diameter of the stem (cm) at 30 cm height (for shrub leaf biomass) (Petmark, 1983).

2.3. Grazing capacity estimations

Grazing capacity can be explained as the maximum capacity of a given rangeland that can accommodate stocking of herbivores' sustainability for defined period of time (FAO, 1988), which is often computed using the formula described by Thalen (1979) as follows:

i. $G = (F/R) \times g$

Where G is the grazing capacity of tropical livestock units (TLU) per unit area for a given grazing season in TLU ha^{-1}. Calculation was made in dry season of key months where fodder availability was sparse. The dry season was calculated to be 125 days (December to March), and one tropical livestock unit was calculated to be 250 kg (FAO, 1988). F is the weight of herbage output per unit area during the grazing season in kg ha^{-1}. R refers to herbage dry matter requirement per TLU per year in kg TLU^{-1}. In accordance with de Leeuw and Tothill's (1990) findings, a daily herbage dry matter intake of 2.5 percent of live weight, corresponding to 6.25 kg/day, was employed, g is the grazing efficiency, which is the proportion of fodder material consumed by the grazing animal. The ratio typically ranges between 0.1 and 0.9, although 0.3 is commonly used since grazing land has a limit for optimal pasture regeneration.

2.4. Statistical analysis

The data respective to each dry matter yield and biomass composition was analyzed using SAS Version 19.0 (SAS, 2008). The General Linear Model was used to compare the effects of the agro-ecologies and species on the dry matter yield of available feeds. When significant was spotted at $P \leq 0.05$, least significant difference (LSD) was used to separate the means.

3. Result and discussion

3.1. Species biomass composition from natural pastures

Table 1 lists the primary grasses, legumes, and herbaceous plants found in the research area. Natural pasture, which comprises grasses, legumes, various plants, weeds, and fodder shrubs and trees in the research region, is one of the key cattle feed supplies during the rainy season. With a diverse range of grasses, legumes, and other herbaceous species, natural occurring pastures offer 51.6 percent of the animal feed supplies in the study area. The current finding was comparable to that of (Yadessa, 2015), who stated that natural pasture grazing accounts for 58.9 % in the Meta Robi district of the west Shewa zone. The pasture's availability, sward structure, and nutritional values reflect the features of the species percentages and environment that affect their growth and senescence.A total of 32 species edible to cattle were found in the study district. There were 15 different grass species and 17 different non-grass species among them 12 were legumes and 5 were other herbaceous plants. The study area was dominated by annual grasses, legumes, and other herbaceous plants. This situation was encountered as a result of inadequate natural pasture management and continuous grazing pressure on limited land. Similar to previous report by Herlocker (1999), overgrazing had led to minimize forage yield, ground cover and quality and consequently leading to replace perennial grass species by annual grass and herb species. In the present study, grass species such as *Digitaria abyssinica*, *Pennisetum clandustinum*, Snowdine polystarch, and *Pennisetum purpureum* were identified as the predominant grass species followed by legume species of Medicago burweed, *Vigna vexillata*, and *Cucumis ficifolius* in both agro-ecologies of the study area. Several writers described indigenous grass species in various places (Tesfaye, 2008; Solomon et al., 2007; Habtamu et al., 2012). Due to significant grazing pressure in the study region, the abundance of grasses such as Snowdine polystarch and *Plantago lanceolata* L. species was typical of degraded sites.

Table 2 shows the average biomass yield from private, community, roadside, and fallow land in the study district. The decline of the areas and the diminishing biomass production of grazing grounds in the research areas are two major concerns. The average dry matter production of grasses, legumes, and other plants in the mid-altitude area was 1.206 t/ha, 0.974 t/ha, and 0.212 t/ha from private grazing land, and 1.14 t/ha, 0.12 t/ha, and 0.09 t/ha from communal grazing land, respectively. Private grazing land yielded 1.242 t/ha, 0.282 t/ha, and 0.234 t/ha at the study area's low altitude, whereas community grazing land yielded 0.975 t/ha, 0.04 t/ha, and 0.11 t/ha. The biomass and dry matter output of private grazing legume were significantly different ($p < 0.05$) between the two research areas agro-ecologies. The results reveal how heavy and persistent grazing pressure reduced biomass production in low-altitude areas compared to the study district's mid-altitude. The current study identified 1.156 t/ha, 0.242 t/ha, and 0.182 t/ha of average dry matter yields of grasses, legumes, and other herbaceous, respectively, with an overall average of 1.58 t/ha in the study area. In agreement to these findings, Zewdie and Yoseph (2014) reported that 1.172 t/ha, 0.0127 t/ha, and 0.048 t/ha average dry matter yield of grasses, legumes, and forbs, respectively, around Ziway, Ethiopia's central rift valley. However, a higher average dry matter yields of 1.891 t/ha grasses, 0.399 t/ha legumes, and 0.205 t/ha other herbs were achieved

Table 1. Widely important grasses, legumes and herbaceous species for livestock feeding in the study area.

Scientific name	Vernacular Name (Afan Oromo)	% of respondents(n)	Edible parts	Livestock species	Type of fodders
Pennisetum clandustinum	Coqorsa	95.4% (63)	leaf, twigs	Cattle, sheep,goat, donkey	Grasses
Digitaria abyssinica	Warati	97.6% (124)	leaf	Cattle, sheep,goat, donkey	Grasses
Pennisetum sphocelatum	Migra	74.8% (95)	leaf	Cattle, sheep,goat, donkey	Grasses
Berchemia discolor	Jajjaba	42.6 (26)	leaf	Cattle, donkey, horse, mule	Grasses
Snowdine polystarch	gargaara	67.7% (86)	leaf	Cattle, sheep,goat, donkey	Grasses
Plantago lanceolata L.	qorxobbi	46.4% (59)	leaf	Cattle, sheep,goat, donkey	Grasses
Dignathia hirtella Stapf	Qamboo	31.1 (19)	leaf	Cattle, donkey, horse, mule	grasses
Panicum hochstetteri Steud.	Marga gogorri	23% (14)	Leaf	Cattle, donkey, horse, mule	Grasses
Pennisetum purpureum	Elephant grass	72.4% (92)	Leaf	Cattle, sheep,goat, donkey	grasses
Medicago burweed	Siddisa	57.4% (73)	Leaf	Cattle, sheep,goat, donkey	legumes
Trifoliu burchellionum	Hasangira	31.8% (21)	Leaf	Cattle, sheep,goat	Other herbs
Grewia bicolor Juss	Haroressa	24.6% (15)	Leaf	Cattle, sheep,goat, donkey	legumes
Vigna vexillata L. A. Rich.	Gurra hantuta	69.3% (88)	Leaf, twigs	Cattle, sheep,goat, donkey	legumes
Aristida kenyensis Henr	Biilaa	22% (28)	Leaf	Cattle, sheep, goat, equine	grass
Cucumis ficifolius A. Rich	Facaa'a	52.0% (66)	Root	Cattle, goats	legumes

Table 2. Species biomass composition and dry matter yield from private, communal, fallow land and roadside feed resources.

Feed resources		Mid altitude				Low altitude				Average				
		Grass	Legume	Other herb	Total	Grass	Legume	Other herb	Total	Grass	Legume	Other herb	Total	P-value
Private grazing	Fresh wt (t/ha)	4.63 ± 1.02	4.11 ± 0.35*	2.22 ± 1.10	10.96 ± 0.5	5.63 ± 1.20	1.15 ± 0.43*	1.93 ± 0.23	8.71 ± 0.62	5.13 ± 1.11	2.63 ± 0.39	2.07 ± 0.66	9.83 ± 0.72	0.002
	Dry w/t (t/ha)	1.21 ± 0.21	0.97 ± 0.02*	0.21 ± 0.05	2.39 ± 0.09	1.24 ± 0.62	0.28 ± 0.03*	0.23 ± 0.08	1.76 ± 0.24	1.22 ± 0.41	0.63 ± 0.02	0.22 ± 0.06	2.07 ± 0.16	0.004
	Biomass (%)	50.42	40.72	8.86	100.00	70.65	16.04	13.31	100.00	58.99	30.26	10.75	100.0	
Communal grazing	Fresh wt (t/h)	3.91 ± 0.70	0.73 ± 0.31	0.72 ± 0.07	5.36 ± 0.36	3.97 ± 1.21	0.25 ± 0.04	0.73 ± 0.07	4.95 ± 0.44	3.94 ± 0.95	0.49 ± 0.17	0.72 ± 0.07	5.15 ± 0.40	0.032
	Dry w/t (t/ha)	1.14 ± 0.21*	0.12 ± 0.01*	0.09 ± 0.01	1.35 ± 0.07	0.97 ± 0.20	0.04 ± 0.02*	0.11 ± 0.01	1.13 ± 0.07	1.06 ± 0.20	0.08 ± 0.01	0.10 ± 0.01	1.24 ± 0.07	0.001
	Biomass (%)	84.44	8.89	6.67	100.00	86.66	3.56	9.78	100.00	85.45	6.47	8.08	100.00	
Fallow land	Fresh wt (t/h)	4.33 ± 0.34	1.46 ± 0.33	0.40 ± 0.09	6.19 ± 0.25	5.07 ± 1.41	0.51 ± 0.03	0.33 ± 0.01	5.91 ± 0.48	4.70 ± 0.87	0.98 ± 0.18	0.36 ± 0.05	6.05 ± 0.36	0.301
	Dry w/t (t/ha)	1.26 ± 0.20*	0.24 ± 0.10*	0.05 ± 0.01	1.55 ± 0.10	1.24 ± 0.63	0.08 ± 0.02*	0.05 ± 0.02	1.37 ± 0.22	1.25 ± 0.41	0.16 ± 0.06	0.05 ± 0.01	1.46 ± 0.16	0.005
	Biomass (%)	81.29	15.48	3.23	100.00	90.54	5.82	3.64	100.00	85.64	10.94	3.42	100.00	
Roadside	Fresh wt (t/h)	3.80 ± 1.03	0.67 ± 0.32	3.39 ± 1.32*	7.86 ± 0.89	4.36 ± 2.04	0.57 ± 0.04	1.92 ± 0.06	6.85 ± 0.71	4.08 ± 1.53	0.62 ± 0.18	2.65 ± 0.69	7.35 ± 0.80	0.004
	Dry w/t (t/ha)	1.11 ± 0.11	0.11 ± 0.02	0.42 ± 0.07	1.64 ± 0.06	1.07 ± 0.09	0.09 ± 0.03	0.29 ± 0.04	1.45 ± 0.05	1.09 ± 0.10	0.10 ± 0.03	0.35 ± 0.05	1.54 ± 0.06	0.003
	Biomass (%)	67.68	6.71	25.61	100.00	73.80	6.20	20.00	100.00	70.56	6.47	22.97	100.00	
Mean	Fresh wt (t/h)	4.16 ± 0.77	1.74 ± .33	1.68 ± 0.64	7.59 ± 0.49	4.75 ± 1.46	0.62 ± 0.14	1.22 ± 0.09	6.60 ± 0.56	4.46 ± 1.11	1.18 ± 0.23	1.45 ± 0.36	7.09 ± 0.57	0.007
	Dry w/t (t/ha)	1.18 ± 0.18	0.36 ± 0.04	0.19 ± 0.04	1.73 ± 0.08	1.13 ± 0.38	0.12 ± 0.03*	0.17 ± 0.04	1.43 ± 0.15	1.16 ± 0.28	0.24 ± 0.16	0.18 ± 0.03	1.58 ± 0.11	0.001
	Biomass (%)	68.03	20.83	11.14	100.00	79.40	8.62	11.98	100.00	73.13	15.32	11.55	100.00	

*Significantly different ($P < 0.05$).
W/t = weight; t/ha = tons/hectare.

under shifting cultivation while a relatively lower of 1.251 t/ha grasses, 0.218 t/ha legumes, and 0.216 t/ha other herbs were obtained in the permanent farming system, respectively. The variation could be explained due to the existence of minimum livestock pressure. The way humans utilize and maintain grazing pasture impacts its quality and quantity, seasonal distribution (Thomson, 2007), and in sever scenarios results in disturbance of species composition, leading to eliminate the nutritional and palatable species and replace by unpalatable ones. The current study also identified fallow land as one of the available feed resources for livestock in the study area as it is dominated by Grasses (Snowdine polystarch, *Digitaria abyssinica*), legumes (*Vigna vexillata* L. A. Rich, Medicago burweed) and weeds (Trifoliu burchellionum, *Ageratum conyzoides*, *Aspilia mossambicensis* and *Bidens rueppellii*). The biomass and dry matter output of fallow grasses, legumes and herbs were significantly different ($p < 0.05$) between the two research areas agro-ecologies. Fallow land contained the average biomass dry matter yield of 1.26 t/ha, 0.24 t/ha, and 0.05 t/ha, grasses, legumes, and other herbs, respectively, in midland and lowland agroecology of the district. In general, the average dry matter yield of 1.253 t/ha grasses, 0.16 t/ha legumes, and 0.05 t/ha weeds were calculated in the study district. The biomass and dry matter output of roadsides herbs were significantly different ($p < 0.05$) between the two research areas' agro-ecologies. The average biomass dry matter production of grasses, legumes, and other herb from the roadside was also 1.11 t/ha, 0.11 t/ha, and 0.42 t/ha in the research area's mid altitudes, and 1.07 t/ha, 0.09 t/ha, and 0.29 t/ha in the study area's low altitudes. Overall, grass species accounted for 73.13 % of DM biomass production in the study district, whereas legumes and other herbaceous plants accounted for only 15.32 % and 11.55 %, respectively. The current result was different from Zewdie and Yoseph (2014) stated in comparable research conducted near Ziway, Ethiopia's central rift valley, that the average DM biomass composition of grasses was 86.1 %, legumes (2.2 %), and herbs (11.7 %).

Cattle and sheep diets based on grasses and legumes were substantially greater than goat diets, whereas other herbs were higher for sheep and goats. In comparison to cattle and sheep, the goat diet was considerably reliant on browsing. This difference in animal behavior while eating demonstrates the critical nature of maintaining a mixed herd under an open grazing system in order to properly exploit the diverse flora composition found in natural pastures.

3.2. Biomass yield from indigenous fodder trees and shrubs

The biomass yield of selected indigenous fodder trees of two agro-ecology is presented in Table 3. The most widely utilized fodder trees and shrubs identified by the interviewed households were *Sapium ellipticum (93.3%)*, *Ficus ovata (90.0%)*, *Vernonai amygadalina (82.5%)*, *Ficus sur* Fossk (82.3%), *Mcraceae (78.3%)*, *Rubus apetalus* Poir (78.0%), *Ficus thonningii* Blume (69.1%), *Combretum Collinum (66.0%)*, *Ficus Vasta* Forssk (65.3%), *Cordia Africana (45.0%)*, *Syzygium Guineanse (40.5%)* and *Grewia Ferruginea (38.3%)* during dry season when no other forage is available. Previous studies reported the available feed resources of shrubs and fodder trees in different agroecological settings of Ethiopia (Abebe et al., 2008; Diriba et al., 2013; Mulugeta and Kindu, 2013; Takele et al., 2014).

The biomass dry matter output of shrubs and fodder trees were significantly different ($p < 0.01$) between the two research areas' agro-ecologies. This study indicated that low land altitude of the study area had higher dry matter yield of fodder trees and shrubs compared to the mid-altitude counterpart. The variation of dry matter yields among different species could be reflected due to variation in potential biomass yield which was associated to differences in growth of the species and availabilities of the species. Moreover, the biomass yield in each species is affected by variation in kebeles, which was potentially ascribed to spatial differences, climatic factors and soil fertility.

In general, the mid land agroecology had 7.98–19.78 kg/tree and 1.06–2.41 kg/shrub while the lowland had 9.87–178.06 kg/tree and 1.34–4.34 kg/shrub average dry matter yields of fodder trees and shrubs in the study area. In contrast to the current findings, Takele et al. (2014) reported higher biomass yields of 24.55 kg/tree/shrubs to 958.76 kg/tree of selected indigenous fodder tree/shrubs in Wolayta zone, southern Ethiopia.

The total biomass dry matter production of fodder shrubs and trees was estimated at 74.36–100 kg/ha and 500–800 kg/ha on cultivated land and uncultivated land edible by livestock in the study area, respectively. The result was less than browses in favorable humid and sub-humid climate situations were reported to produce from 2.3 to 4.69 tons of DM forage per hectare per year (Baumer, 1992) and leaf biomass yield of 1–4.3 tons per hectare was reported (Lemma et al., 1996). Biomass yield of forage is affected by cutting interval and tree density, indicating that higher DM yield per hectare is achieved with long cutting interval and higher tree density.

Table 3. The biomass yields (kg) of selected indigenous fodder trees at the 80 cm height and shrubs at 10 cm height of the two agro-ecologies.

Tree species	Species	Biomass yield/ tree/shrub (kg)	CV	LSD	*p-value*	Sem
Mid altitude						
Sapium ellipticum	Tree	19.78	26.21	40.95	0.133	
Ficus ovata	Tree	16.95	26.21	22.45	0.401	
Rubus apetalus Poir	Tree	7.98	26.21	13.88	0.060	*
Vernonai amygadalina	Tree	9.87^{c}	26.21	93.46	0.001	**
Ficus sur Fossk	Tree	19.78^{b}	26.21	34.42	0.002	**
Cordial africana	Tree	16.95	26.21	13.41	0.010	*
Rhoicissus tridentata	Shrubs	1.06	26.21	1.27	0.946	
Combertum paniculatum	Shrubs	2.41^{e}	26.21	3.00	0.009	**
Ricinus comiunis	Shrubs	1.34^{f}	26.21	2.60	0.008	**
Ficus palmata Forsk	Shrubs	1.15	26.21	1.24	0.962	
Coronopus didymus	Shrubs	1.82	26.21	3.08	0.878	
Low altitude						
Ficus thonningii Blume	Tree	62.14	26.21	38.55	0.128	
Madalle	Tree	27.95	26.21	41.46	0.401	
Combretum collinum	Tree	19.78	26.21	22.45	0.628	
Ficus vasta Forssk	Tree	178.06^{a}	26.21	12.88	0.002	**
Syzygium guineanse	Tree	49.07	26.21	89.96	0.185	
Grewia ferruginea	Tree	9.88	26.21	35.92	0.563	
Myrsine africana L.	Shrubs	1.49	26.21	15.41	0.946	
Acanthus polystachius	Shrubs	3.60	26.21	1.77	0.090	*
Teclea nobilis	Shrubs	3.87	26.21	3.00	0.041	*
Coronopus didymus	Shrubs	1.34^{f}	26.21	3.60	0.001	**
Musa paradisiaca	Shrubs	4.34^{d}	26.21	1.74	0.009	**
Impatiens tinctoria	Shrubs	2.23	26.21	4.08	0.080	*

Mean values in a column having different superscripts differ significantly each other; kg = kilogram; CV = Coefficient of variance; LSD = Least significance difference; Sem = Standard error of mean; ** = ($P < 0.01$).

3.3. Grazing capacity estimations

Carrying or grazing capacity (CC) is defined as the maximum possible stocking of herbivores that rangeland can support on a sustainable basis (FAO, 1988). Estimates of CC are commonly based on the assumption that livestock requires a daily dry matter (DM) intake equivalent to 2.5%–3.0% of their body weight (de Leeuw and Tothill, 1990). Thus, for a tropical livestock unit (TLU) of 250 kg of weight, 2.3 to 2.7 t of dry feed per annum is needed. To calculate an appropriate balance between forage supply and demand three multipliers are additionally required to adjust for: grazing efficiency (the proportion of total herbage livestock can harvest, forage loss (due to trampling, fouling, decomposition, etc) and proper use, which is the maximum proportion of forage that can be grazed without causing rangeland deterioration (FAO, 1988).

Although each of these three factors needs consideration, most estimates have used a single multiplier that combines adjustments for all. For instance, Le Houérou and Hoste (1977) assumed that, in the Sahel, total dry matter (TDM) had 40% edible forage, while in Ethiopia, Cossins and Upton (1987) indicated that one TLU demanded 8 t DM which reflects utilization rate of 30%. The herbage yield of natural pasture is 1.733 t $DMha^{-1}$ in the mid and 1.427 t $DMha^{-1}$ in the low altitudes of the study area, with a mean herbage yield of 1.58 t $DMha^{-1}$ during vegetation cover. The grazing capacity of the study area was 0.23 TLU/ha/year in mid and 0.19 TLU/ha/year in low altitude of the study area, with a mean value of 0.21 TLU ha/year. The assumption indicated that herbage yield obtained at peak vegetation cover is the amount of biomass yield available in the dry season. The results of this the study, therefore, will be useful to researchers and policymakers in taking appropriate interventions to improve livestock production in the study area.

4. Conclusion

The current investigation found 32 indigenous fodder species, 15 of which were grass species and 17 of which were not. Twelve of the non-grass plants were legumes, while five were other herbaceous. Additionally, this study indicated that a lack of grazing pasture is a significant issue, as it leads in overgrazing, which results in soil degradation, low biomass output, poor quality, and seasonal fluctuation in feed availability. The study concludes that improvements in livestock output and productivity should be supported through the use of cut and carry systems and tethering. Additionally, land-use policy regulation should be implemented in the district to provide a separate area for animal feed production and productivity development under the smallholder farming system.

Declarations

Author contribution statement

Jabesa Ayele: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Wrote the paper.

Taye Tolemariam; Metekia Tamiru: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Abegaze Beyene: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data.

Dawit Adisu Tadese: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data.

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Data availability statement

Data will be made available on request.

Declaration of interests statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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