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EVALUATION OF THE STINGING NETTLE (*Urtica simensis*) AS NON-CONVENTIONAL ANIMAL FEEDSTUFF IN SELECTED HIGHLAND AREAS OF SOUTH WOLLO OF ETHIOPIA

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ABSTRACT: This study assessed the use of stinging nettle as animal feed and evaluated its biomass yield and nutritional quality in Dessie Zuria and Legambo districts, Ethiopia. Data were collected from 384 randomly selected respondents and growing niches across 8 *kebeles*. Findings indicated a demand for 1935 tons of dry matter (DM), while available feed resources contributed only 915.41 tons of DM, highlighting a significant feed shortage. Stinging nettle, which remains vegetative in both wet and dry seasons, was identified as a potential supplementary feed. Over 77.86% of respondents reported that ruminants consume the leaves and stems, while 13.02% noted that chickens rarely use the leaves, and equines never consume any part of the plant. Cattle preferred stinging nettle in both seasons, but small ruminants showed preference only during the dry season, and chickens showed the least preference in the wet season. Most households (83.6-89.3%) treated the plant by wilting it for 2-6 hours, while others (4.40-10.16%) dry it, and the rest (4.69-9.89%) mix it with other feeds to minimize its stinging nature. Common growing niches for stinging nettle include backyards, pastureland, and roadsides, with the first producing a higher biomass yield of 22.29 tons/ha (P<0.02) than the roadsides (14.89 tons/ha), and the pastureland yielded intermediate biomass (19.21 tons/ha). Stinging nettle from pastureland niche had higher crude protein (CP, 25.26%) and *in vitro* dry matter digestibility (60.90%, P<0.001). The ash (7.90%), neutral detergent fiber (NDF, 39.74%), and acid detergent fiber (24.16%) contents were lower for samples taken from the pastureland niche. In conclusion, stinging nettle is suitable for supplementation due to its favorable nutritional qualities. Further studies, such as animal feeding trials and investigations into anti-nutritional factors, are needed for more detailed information on the use of the stinging nettle plant as an animal feedstuff.

Keywords: Agro-ecology, Biomass yield, Growing niche, Nutritional quality, Stinging nettle, Wilting.

INTRODUCTION

The livestock sector in Ethiopia is vital for providing food, income, services, and foreign exchange (Osei et al., 2018). The productivity of livestock depends on animals' nutrition, health status, and genetic potential (Getahun, 2012). Among these key factors, nutrition is the most critical factor, representing a significant cost in livestock production. Unfortunately, Ethiopia's livestock productivity remains low, lagging behind the growth of the human population, which leads to a decline in per capita consumption of animal products (Tegegne and Feye, 2020). This productivity challenge primarily stems from several factors, with feed scarcity both in quality and quantity being the principal problem (Alemayehu et al., 2016).

Livestock feed resources in Ethiopia mainly originate from natural pastures and crop residues. However, the natural pastures are shrinking due to the expansion of crop production to support the rapidly growing human population and urbanization (Kassahun et al., 2016). Besides, crop residues, which are obtained post-harvest, tend to be more fibrous and less digestible. Consequently, both crop residues and natural pastures typically fail to meet the nutritional needs of livestock, resulting in low productivity (Dereje et al., 2015; Getnet et al., 2016). Furthermore, smallholder farmers rarely utilize grains, essential ingredients in concentrated livestock feeds, due to their high cost and limited availability, as there is direct competition for grains with food for human consumption. Therefore, enhancing feed availability and quality is critical for boosting livestock productivity in the country (Tegene et al., 2009; Ayele et al., 2021).

Although efforts have been made to introduce improved species of grasses, legumes, and fodder trees across various regions in Ethiopia, the adoption of these forages within the mixed crop livestock farming systems faces numerous challenges (Diribi, 2022). To improve the productivity and reproductive capacity of animals under smallholder conditions, ensuring the availability and quality of feedstuffs is imperative. One potential option to these challenges, particularly in the dry season, could be the use of indigenous drought-resistant and non-conventional feed resources (Chharang, 2022). Assessing alternative feeds from locally available sources could help meet nutritional

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needs, reduce competition for human food, lower feed costs, and contribute to self-sufficiency (Belay and Janssens, 2021).

Among the locally available feed resources, stinging nettle (*Urtica simensis*), which is endemic to Ethiopia, can be one of the potential feed resources for livestock (Dagem et al., 2016). Stinging nettle, known locally as '*samma*' in Amharic, is a perennial plant recognized for its unpleasant stinging hairs on the stems and leaf surfaces. It is an erect and non-branched plant that grows wild in the highland regions of Ethiopia, such as north and south Gondar, north and south Wollo, north Shewa, and Wag Hamra (Dagem et al., 2016). Stinging nettle is nutritionally robust and has a higher nutritional value (Bhusal et al., 2022). The leaves are rich in protein and vitamins (Joshi et al., 2014), with an average crude protein (CP) content of about 22% (Teixeira et al., 2023). The leaves contain crude protein, ash, crude fiber, and carbohydrate contents of 33.77%, 16.21%, 9.08%, and 37.39%, respectively (Kregiel et al., 2018). Despite its high nutritional potential, stinging nettle is underutilized as animal feed (Dereje et al., 2015). Earlier studies indicate that the nutritional value of stinging nettle as animal feed is influenced by anti-nutritional factors, harvesting stage, and nitrogen fertilization (Radman et al., 2016). Additionally, Jimoh et al. (2010) reported that the leaves contain alkaloids, phytates, and saponins, which may affect livestock health.

Currently, there is limited information on the use of stinging nettle as animal feed, and its biomass yield and the nutritional quality, especially in the highland areas of South Wollo, where it is used as animal feed in districts like Dessie Zuria and Legambo. Therefore, this study was carried out in the highland areas of Dessie Zuria and Legambo districts to assess the extent of use of stinging nettle as animal feed and evaluate its biomass yield and nutritional quality.

MATERIALS AND METHODS

Description of the study area

The study was carried out in the highland areas of Dessie Zuria and Legambo districts, located in South Wollo, Ethiopia. Dessie Zuria is located between 10°50′00″ and 11°30′00″ N latitude and 39°20′00″ and 40°00′00″ E longitude, covering a total area of 937.32 km². On the other hand, Legambo district lies between 10°40′00″ and 11°20′00″ N latitude, and 38°40′00″ and 40°00′00″ E longitude with an area of 1017 km² (Figure 1).

Dessie Zuria district has a diverse landscape, including valleys, gorges, and mountainous areas, and it is classified into three agro-ecological zones: sub afro-alpine (*wurch*), highland (*dega*), and midland (*woina dega*), comprising 25, 30, and 45% of the district's total area, respectively. The altitude ranges from 1800 to 3700 meters above sea level (masl). Likewise, Legambo district has a comparable landscape and is similarly categorized into three agro-ecological zones: 2.2% *wurch*, 48.4% *dega*, and 49.4% *woina dega*. The altitude of Legambo district ranges from 2100 to 4050 masl. According to 17 years of climatic data (2002 to 2018) collected from the Kombolcha Meteorological Agency, Dessie Zuria district had mean annual minimum and maximum temperatures of 4.25 and 14.75°C, respectively. Over a span of 20 years (1999-2018), the mean annual rainfall was recorded at 1354.3 mm. Based on 10 years of data (2009 to 2018) obtained from the same meteorological agency, Legambo district's mean annual minimum and maximum temperatures were 4.8 and 18.3°C, respectively. Additionally, the mean annual rainfall obtained over 20 years (1998-2017) was 1180.3 mm. Both districts have a mixed crop-livestock production system. The common livestock species include cattle, sheep, goats, equines, poultry, and honeybee colonies. The primary feed resources for livestock consist of natural pastures and crop residues, with the latter primarily derived from barley (*Hordeum vulgare*) and wheat (*Triticum aestivum*) straws, and maize (*Zea mays*) stover.

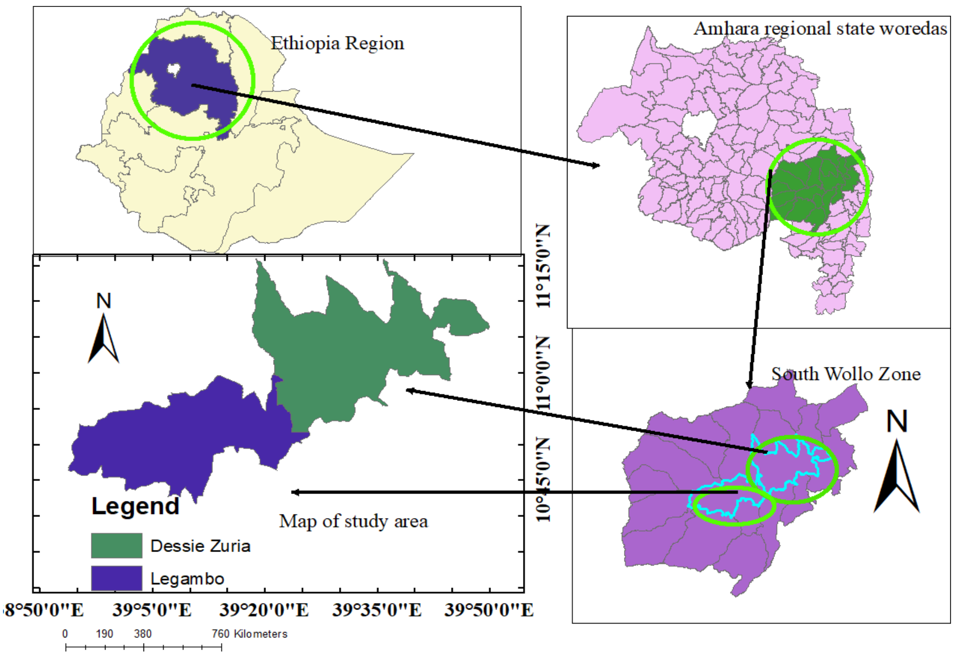

Figure 1 - Map of Dessie Zuria and Legambo districts, South Wollo, Ethiopia

Sample size determination, sampling design, and method of data collection for the survey study

A rapid rural appraisal (RRA) was conducted to identify *kebeles* (smallest administrative units within a district) which were highly dominated by stinging nettle plants. Since it was difficult to find previous exploratory studies regarding stinging nettle use as animal feed and its nutritional quality in South Wollo, a 50% expected use of this plant as animal feed was considered. Using 5% desired absolute precision and a 95% confidence interval (CI), the sample size was determined using the formula for sample size determination in random sampling for a large population (Thrusfield, 2007): $n = [(Z\alpha/2)^2 P(1-P)]/d^2 = [(1.96)^2(0.5)(1-0.5)]/(0.05)^2 = 384$ where, n = required sample size; $Z\alpha/2$ = reliability coefficient or confidence interval (CI) = 1.96 for the 95%; P = expected use of stinging nettle as animal feed; and d = desired absolute precision. Accordingly, 384 respondents were selected for the study.

In the two districts, eight rural *kebeles* were purposefully selected based on their potential for stinging nettle and accessibility. In each district, two *kebeles* were selected from the highland (*dega*) agro-ecology and another two from the sub afro-alpine (*wurch*) agro-ecology. A total of 48 respondents were randomly selected from each *kebele*. Data were collected from respondent household heads using a pre-tested semi-structured questionnaire. Eight enumerators, one for each *kebele*, were chosen from development agents and received training before and during the questionnaire pre-testing. The survey was conducted using a single-visit multiple-subject survey method of ILCA (1990).

The questionnaire generated information on the mode of utilization of stinging nettle, including the parts of the plant consumed by livestock, preference levels, seasonal availability, and preparation practices for fresh herbage prior feeding to livestock. Additionally, one focus group discussion (FGD) was conducted in each district with 8-12 participants, including elders, livestock keepers, and agricultural experts. Key informants, who were knowledgeable about stinging nettle and for data related to land and livestock holdings of the study districts and major livestock feed resources, were also consulted to provide supplementary information.

The feed supply was estimated using key data from respondents, particularly the total dry matter yield. The nutrient contributions from each feed type were assessed based on the total dry matter (DM) output and nutrient content of each feed type (Kumara et al., 2022). Practical carrying capacity (PCC) was used to calculate the total demand for forage, indicating the actual number of livestock carried by a certain area within a certain period and reflecting the current carrying capacity. Demand for feed was calculated by standardizing the number of each animal species into Tropical Livestock Units (TLU; Rothman-Ostrow et al. 2020) using the conversion factors of 0.7 for cattle, 0.1 for small ruminants, 0.01 for chicken, 0.8 for horses, 0.7 for mules, and 0.5 for donkeys (ILCA, 1990; Jahnke, 1982). Furthermore, the theoretical carrying capacity (TCC) was used to estimate feed supply by including all available feed resources. The TCC represents the maximum number of livestock an area can support in a certain period to meet the requirements for livestock production (growth, reproduction, etc.) under the premise of moderate grazing and sustainable grassland production (Xu, 2014). Hay, crop residues, and natural grasses, comprising over 90% of livestock feed resources in Ethiopia, were used for the estimation of the quantity of feed supplied in the study area.

Sampling stinging nettle and preparation of samples

Stinging nettle herbage sampling was conducted after completing the household survey. Stinging nettle plants that grew naturally were collected in the highland (*dega*) and sub afro-alpine (*wurch*) agro-ecological zones of both districts. Based on the information generated during the survey part of the study, the stinging nettle plants were sampled at a maturity stage preferred by livestock species, as reported by respondents. Three niches (backyard, pastureland, and roadside), on which stinging nettle grows with high production potential, were considered for sampling in each of the 8 *kebeles*. A niche refers to the specific environmental conditions under which stinging nettle species thrive (Neto and Albuquerque, 2018). It includes sets of biotic and abiotic factors of the environment that define the limits within which a species can survive (Fodor, 2011). In each selected niche, 3 quadrats, each measuring 1 m^2 (1 m × 1 m) were demarcated at random (Tarawali et al., 1995). The entire stinging nettle within each quadrat was harvested at a stubble height of 20 cm from the ground using a sickle.

The harvested stinging nettle herbage biomass from a specific niche was thoroughly mixed to make a composite sample, from which a 1 kg sub-sample was taken. A total of 72 samples (8 *kebeles* × 3 niches/*kebele* × 3 samples/niche) were collected. The samples were partially dried under shade to prevent spoilage and nutrient loss until transported to the feed analysis laboratory of Holeta Agricultural Research Center.

Analysis of the chemical composition of stinging nettle

The proximate chemical compositions of stinging nettle were analyzed following standard methods (AOAC, 1999). Moisture content was determined by drying samples in an oven at 102°C for 16 h (AOAC method 950.46). The dried samples were incinerated in a muffle furnace at 550°C for 5-6 h to determine the ash content. The N content was determined by the Kjeldahl method (AOAC method 981.10; AOAC, 1999) using a mixture of copper sulfate and potassium sulfate in a 2:1 ratio as a catalyst. The crude protein (CP) content was calculated by multiplying the N concentration by 6.25. Neutral detergent fiber (NDF), acid detergent fiber (ADF), and acid detergent lignin

(ADL) were determined by the method of Van Soest et al. (1991); whereas, *in vitro* dry matter digestibility (IVDMD) was determined following the methods of Tilley and Terry (1963).

Statistical analysis

Data were analyzed using SAS software, version 9.1 (SAS Institute Inc., Cary, NC, USA) (SAS, 2004). Descriptive statistics, including frequency, means, percentages, range, and standard deviation, were employed for the survey data. Nominal frequency data for specific variables were compared using the one-way Chi-Square test. Laboratory analysis data were subjected to analysis using the General Linear Model (GLM) procedure of SAS. The least squares means were generated using the LSMEANS option and separated by PROC GLM with the PDIFF option for treatments with significant effects at $P<0.05$ using Tukey's multiple comparison procedure. The following model was used to analyze the effect of all possible factors on the quantitative data:

$Y_{ijkl} = \mu + D_i + A_j + N_k + (DA)_{ij} + (DN)_{ik} + (AN)_{jk} + (DAN)_{ijk} + e_{ijkl}$,

where, Y_{ijk} = response or dependent variable (biomass yield and chemical composition of stinging nettle) across districts, agro-ecologies, and niches,

μ = overall mean; D_i = the effect of district (i = Dessie Zuria and Legambo); A_j = the effect of agro-ecology or altitude (j = sub afro-alpine and highland); N_k = the effect of niche type (k = backyard, pastureland, and roadside); $(DA)_{ij}$ = the interaction between the i^{th} district and the j^{th} agro-ecology; $(DN)_{ik}$ = the interaction between the i^{th} district and the k^{th} growing niche; $(AN)_{jk}$ = the interaction between the j^{th} agro-ecology and the k^{th} growing niche; $(DAN)_{ijk}$ = the second-order interaction; and e_{ijkl} = the random error.

RESULTS

Feed supply and demand in the study area

Table 1 illustrates the estimated feed produced for the maintenance requirement of the livestock population in the study districts. The total annual utilizable dry matter (DM) produced from major livestock feed resources was 915.41 tons, markedly insufficient compared to the 1935 tons of DM required for the 712 tropical livestock units (TLUs) present (Table 2). This negative feed balance signifies a substantial feed gap in the study area.

Table 1 - Estimated amount of feed produced for maintenance requirement of the livestock population in the study districts.

District	Feed resource	Area covered (ha)	Estimated feed productivity (tons/ha)	Total DM feed produced (ton)
Dessie Zuria	Barley straw	144	1.8	259.20
	Natural pasture	41.37	2.0	82.74
	Fallow land	38.25	1.8	68.85
	Improved forage	1.31	8.0	10.48
Legambo	Barley straw	147.00	1.8	264.60
	Natural pasture	52.50	2.0	105.00
	Fallow land	27.25	1.8	49.05
	Improved forage	9.49	8.0	75.49
Total				915.41

DM = dry matter; ha = hectare

Table 2 - Estimated amount of feed demanded for maintenance requirement of the livestock population in the study districts

Species	Dessie Zuria			Legambo		
	Number	TLU	Annual DM demand (ton)	Number	TLU	Annual DM demand (ton)
Cattle	511	358	817	540	378	862
Sheep	1179	118	269	1622	162	370
Goat	163	16	37	263	26	59
Horses	109	87	199	147	118	269
Donkeys	190	95	217	223	112	256
Mules	48	33	75	67	46	105
Chicken	532	5	11	593	6	14
Total	-	712	1625	-	848	1935

Conversion factors used to change animal numbers to tropical livestock unit (TLU): cattle = 0.7, sheep and goat = 0.1, horses = 0.8, donkeys = 0.5, mules = 0.7, and chicken = 0.01 (ILCA, 1990; Jahnke, 1982).

Table 3 - Respondents' observation on the consumption of the different parts of stinging nettle by livestock species in Dessie Zuria and Legambo districts, South Wollo, Ethiopia

Species	Part of stinging nettle consumed	Dessie Zuria		Legambo		Overall	
		N=192	%	N=192	%	N=384	%
Cattle	Leaf	0	0.00	1	0.52	1	0.26
	Leaf and stem	176	91.67	189	98.44	365	95.05
	None	16	8.33	2	1.04	18	4.69
Sheep	Leaf	3	1.56	0	0.00	3	0.78
	Leaf and stem	173	90.11	190	98.96	363	94.53
	None	16	8.33	2	1.04	18	4.69
Goat	Leaf	35	18.23	21	10.94	56	14.59
	Leaf and stem	136	70.83	163	84.89	299	77.86
	None	21	10.94	8	4.17	29	7.55
Chicken	Leaf	14	7.29	36	18.75	50	13.02
	Leaf and stem	0	0.00	0	0.00	0	0.00
	None	178	92.71	156	81.25	334	86.98
Horse	Leaf	0	0.00	0	0.00	0	0.00
	Leaf and stem	0	0.00	0	0.00	0	0.00
	None	192	100.00	192	100.00	384	100.00
Donkey	Leaf	0	0.00	0	0.00	0	0.00
	Leaf and stem	0	0.00	0	0.00	0	0.00
	None	192	100.00	192	100.00	384	100.00
Mule	Leaf	0	0.00	0	0.00	0	0.00
	Leaf and stem	0	0.00	0	0.00	0	0.00
	None	192	100.00	192	100.00	384	100.00

None refers to respondents who noted that any part of the stinging nettle was not consumed by animals

Table 4 - Extent of preference for stinging nettle plant by livestock species as perceived by respondents in Dessie Zuria and Legambo districts, South Wollo, Ethiopia

Species	Preference	Dessie Zuria		Legambo		Overall	
		N=192	%	N=192	%	N=384	%
Cattle	Low	18	9.38	14	7.29	32	8.33
	Moderate	23	11.98	29	15.10	52	13.54
	High	151	78.64	149	77.60	300	78.13
Sheep	Low	21	10.94	36	18.75	57	14.84
	Moderate	148	77.08	118	61.46	266	69.27
	High	23	11.98	38	19.79	61	15.89
Goat	Low	35	18.23	59	30.73	94	24.48
	Moderate	142	73.96	103	53.65	245	63.80
	High	15	7.81	30	15.62	45	11.72
Chicken	Low	192	100.00	186	96.88	378	98.44
	Moderate	0	0.00	1	0.52	1	0.26
	High	0	0.00	5	2.60	5	1.30

Mode of utilization of stinging nettle

Parts of stinging nettle consumed by different livestock species and their level of preference

Tables 3 and 4 summarize the parts of stinging nettle consumed by different livestock species and their preference levels. The survey revealed that around 77.86-95.05% of respondents observed ruminants (cattle, sheep, and goats) consuming all parts of the stinging nettle plant (leaves and stems). In contrast, only 13.02% of respondents noted that chickens rarely consume the leaves, while equines (horses, donkeys, and mules) do not consume any part of the plant. The majority of respondents (78.13%) stated that cattle highly prefer stinging nettle, with moderate preference noted for sheep (69.27%) and goats (63.80%). Chickens particularly exhibited the least preference (98.44%).

Season of feeding

Table 5 presents the seasonal feeding patterns of livestock species concerning stinging nettle plant. Slightly more than half of the respondents (52.3%) indicated that cattle consume the plant during both dry and wet seasons.

Small ruminants are reported to favor the plant predominantly in the dry season, as indicated by nearly 75-76% of the respondents. Chickens under free-range conditions rarely eat the plant during the wet season. Although preferences vary over seasons, the stinging nettle remains vegetative throughout both periods, as confirmed by 169 (88.02%) and 159 (82.81%) respondents in Dessie Zuria and Legambo districts, respectively (Figure 2).

Form of feeding of stinging nettle plant to animals

Due to its stingy nature, stinging nettle is often unsuitable for animal consumption unless treated. Over 83% of respondents stated wilting as a common treatment method to reduce the stinginess of the plant before feeding to ruminants. Additionally, less frequently used methods included drying and mixing the stinging nettle with other palatable feeds (Table 6).

Growing niches and wilting time of stinging nettle

A significant proportion (58.3%, P<0.003) of respondents indicated a need for 2 to 6 hours of wilting before feeding stinging nettle to animals. The most common growing niche for the plant was the backyard, followed by roadside, pastureland, farmland, and areas around water bodies (Table 7).

Biomass yield and chemical composition of stinging nettle

There was no significant difference in dry matter yield (DMY) of stinging nettle based on variations in district and agro-ecology. However, a significant difference (P<0.02) was noted in DMY among the growing niches. The backyard growing niche produced higher DMY than the roadside niche, and that of the pastureland was in-between (Table 8). The effects of district, agro-ecology, and growing niche on the chemical composition and *in vitro* dry matter digestibility (IVDMD) of stinging nettle are presented in Table 9. Values of all parameters did not vary significantly (P>0.05) between the two districts. Agro-ecology had a significant effect on dry matter (DM; P<0.01), neutral detergent fiber (NDF; P<0.003), and acid detergent fiber (ADF; P<0.03) contents, with higher values recorded in the sub afro-alpine than in the highland agro-ecology. Stinging nettle collected from different niches showed significant variations in all the chemical composition and IVDMD parameters except for the acid detergent lignin (ADL) content. The crude protein (CP) (P<0.001), organic matter (OM), and IVDMD (P<0.0001) contents of stinging nettle collected from the pastureland niche were higher than those obtained from the other niches. Conversely, lower contents of ash, NDF (P<0.0001), and ADF (P<0.004) were recorded for samples collected from the pastureland niche compared to the other niches. There was some inconsistency due to the significant interaction effect between the factors. Although the NDF value was higher in the roadside niche than in the backyard niche, the backyard niche from Dessie Zuria and the roadside niche from Legambo had comparable but higher NDF values compared to the NDF value at Legambo in the backyard niche. On the other hand, the pastureland niche in Dessie Zuria and the backyard niche in Legambo had higher IVDMD values than the values recorded in a similar niche of the other district. The overall average contents of the chemical composition and IVDMD of stinging nettle were 23.60% for CP, 43.43% for NDF, 25.45% for ADF, 3.82% for ADL, 10.25% for ash, and 56.07% for IVDMD.

Table 5 - The season when stinging nettle is mainly consumed by domestic animals in Dessie Zuria and Legambo districts, South Wollo, Ethiopia

Species	Season	Dessie Zuria		Legambo		Overall	
		N=192	%	N=192	%	N=384	%
Cattle	Wet	3	1.6	0	0.0	3	0.8
	Dry	66	34.4	96	50.0	162	42.2
	Both	107	55.7	94	49.0	201	52.3
	None	16	8.3	2	1.0	18	4.7
Sheep	Wet	4	2.1	0	0.0	4	1.0
	Dry	153	79.7	139	72.4	292	76.0
	Both	19	9.9	51	26.6	70	18.2
	None	16	8.3	2	1.0	18	4.7
Goat	Wet	4	2.1	0	0.0	4	1.0
	Dry	153	79.7	135	70.3	288	75.0
	Both	14	7.3	49	25.5	63	16.4
	None	21	10.9	8	4.2	29	7.6
Chicken	Wet	12	6.3	19	9.9	31	8.1
	Dry	1	0.5	3	1.6	4	1.0
	Both	1	0.5	14	7.3	15	4.0
	None	178	92.7	156	82.3	334	87.0

None refers to respondents who noted that the animals did not consume the stinging nettle at both seasons

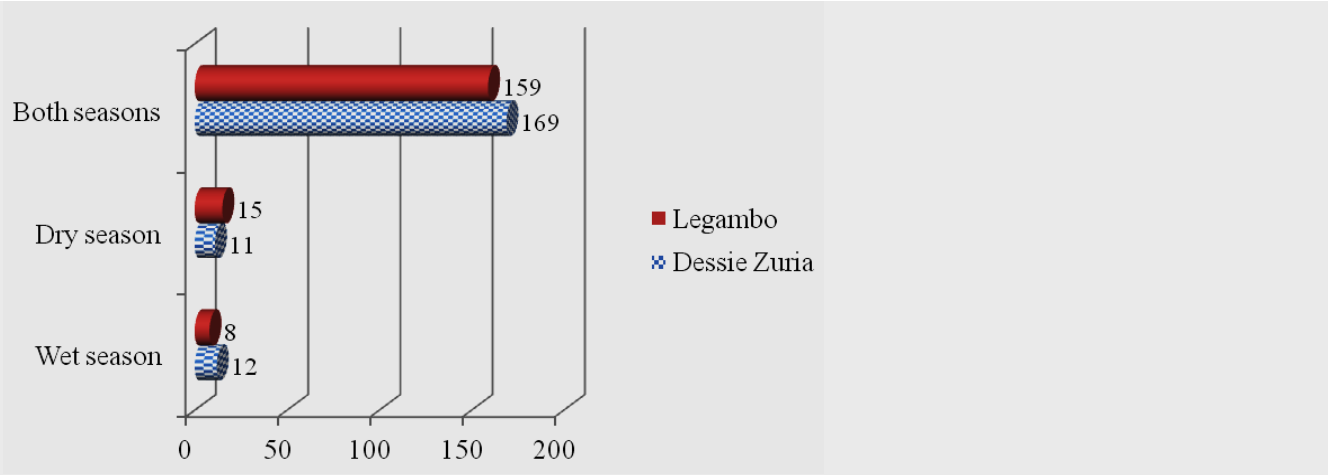

Figure 2 - Vegetativeness of stinging nettle over seasons

Table 6 - Practices or forms of feeding of stinging nettle to livestock species in Dessie Zuria and Legambo districts, South Wollo, Ethiopia

Species	Form of feeding	Dessie Zuria		Legambo		Overall	
		N=192	%	N=192	%	N=384	%
Cattle	Wilting	163	84.90	180	93.75	343	89.3
	Drying	7	3.60	10	5.21	17	4.4
	Mix with other feeds	22	11.5	2	1.04	24	6.3
Sheep	Wilting	166	86.46	161	83.86	327	85.15
	Drying	10	5.21	29	15.10	39	10.16
	Mix with other feeds	16	8.33	2	1.04	18	4.69
Goat	Wilting	165	85.94	156	81.25	321	83.60
	Drying	5	2.60	20	10.42	25	6.51
	Mix with other feeds	22	11.46	16	8.33	38	9.89

Table 7 - Growing niches and wilting time of stinging nettle in Dessie Zuria and Legambo districts, South Wollo, Ethiopia

Variables	Dessie Zuria		Legambo		Overall		P-value
	N=192	%	N=192	%	N=384	%	
Time of wilting							
2-6 h	117	60.9	107	55.7	224	58.3	0.003
7-11 h	51	26.6	48	25.0	99	25.8	
12 h	24	12.5	37	19.2	61	15.9	
Growing niche							
Backyard	76	39.6	76	39.6	152	39.6	0.038
Roadside	48	25.0	49	25.5	97	25.3	
Farmland	20	10.4	30	15.6	50	13.0	
Pastureland	42	21.9	31	16.1	73	19.0	
Side of a water body	6	3.1	6	3.1	12	3.1	

Table 8 - Values (Mean±SEM) of the dry matter yield of stinging nettle plant (ton/ha) at varying niches and agro-ecologies in Dessie Zuria and Legambo districts, South Wollo, Ethiopia

Niche	Dessie Zuria		Legambo		Overall mean	P-value
	SA	HL	SA	HL		
Backyard	21.83±3.28	19.51±3.28	26.75±3.28	21.11±3.28	22.29±1.64[a]	0.02
Pastureland	17.02±3.28	17.54±3.28	20.34±3.28	21.92±3.28	19.21±1.64[ab]	
Roadside	13.50±3.28	16.50±3.28	12.40±3.28	17.16±3.28	14.89±1.64[b]	
Overall mean	17.45±1.89	17.85±1.89	19.83±1.89	20.06±1.89	18.80	
P-value		0.87				

SA = sub afro-alpine, HL= highland, SEM = standard error of the mean

Table 9 - Chemical composition and *in vitro* organic matter digestibility (%) of stinging nettle at varying agro-ecologies and niches in Dessie Zuria and Legambo districts, South Wollo, Ethiopia

Source of variation \ Chemical composition	DM	Ash	OM	CP	NDF	ADF	ADL	IVDMD
District (A)								
Dessie Zuria	86.27	10.67	89.33	23.47	44.45	25.69	3.94	55.71
Legambo	87.06	9.82	90.18	23.73	42.42	25.22	3.70	56.44
P-value	NS	NS	NS	NS	0.002	NS	NS	NS
Agro-ecology (B)								
Highland	85.97[b]	9.78	89.56	23.48	42.47[b]	24.89[b]	3.41	56.02
Sub afro-alpine	87.36[a]	10.71	89.96	23.72	44.39[a]	26.01[a]	4.24	56.13
P-value	0.01	NS	NS	NS	0.003	0.03	NS	NS
Niche (C)								
Backyard	87.73[a]	11.25[a]	88.75[b]	22.83[b]	44.44[b]	25.89[a]	3.97	53.88[b]
Pastureland	85.88[b]	7.90[b]	92.10[a]	25.26[a]	39.74[c]	24.16[b]	3.29	60.90[a]
Roadside	86.49[ab]	11.59[a]	88.41[b]	22.71[b]	46.13[a]	26.30[a]	4.20	53.44[b]
P-value	0.02	0.0001	0.0001	0.001	0.0001	0.004	NS	0.0001
Interactions								
A × B	NS	NS	NS	NS	NS	NS	NS	NS
A × C	NS	NS	NS	NS	0.013	NS	NS	0.005
B × C	NS	NS	NS	NS	NS	NS	NS	0.006
A × B × C	0.01	0.01	NS	NS	NS	NS	NS	0.012
Overall mean	86.67	10.25	89.75	23.60	43.43	25.45	3.82	56.07

[a,b,c] Values in a column, within each source of variation, followed by a common superscript letter are not significantly different at $p<0.05$; DM = dry matter, OM = organic matter, CP = crude protein, NDF = neutral detergent fiber, ADF = acid detergent fiber, ADL = acid detergent lignin, IVDMD = *in vitro* dry matter digestibility, NS = not significant.

DISCUSSION

Feed supply and demand in the study area

The forage gap analysis has indicated a wide disparity between the amounts of forage supplied and demanded in the study area. The rapid increase in human population has led to a reduction in grazing lands. Specifically, lands allocated for fallowing and improved forage production have been converted to cropland to sustain families' food security. Consequently, the amount of feed produced for livestock has diminished, resulting in a negative feed balance. Similar negative feed balances were reported by Adinew et al. (2020) in the Misha district of the Hadiya zone, Ethiopia. The current investigation has revealed feed shortages as a critical issue affecting both study districts. Despite the feed scarcity, there is a great opportunity to raise output levels by addressing the issue of nutritional imbalance and enhancing livestock performance (Jabesa et al., 2021).

The local feed resources are under increasing pressure to meet the growing demands of the livestock population, aiming to improve productivity (Habib et al., 2016). Through focus group discussions and key informant interviews, it was revealed that local inhabitants utilize stinging nettle as an alternative feed resource for livestock due to the scarcity of conventional feed resources. However, it’s important to note that biodiversity of plant species, including herbaceous and browse forages, tends to decline with altitude increase, while the prevalence of stinging nettle rises (Swierszcz et al., 2024). These conditions may have further contributed to the use of stinging nettle as a non-conventional animal feed in the highland areas of the study districts to address the imbalance between the demand and supply of feed.

The lack of adequate feed, both in quantity and quality, improper utilization of crop residues, inconsistent supply of agro-industrial by-products, poor quality of commercial concentrates, and high cost of all the feed resources significantly contribute to feed shortages across Ethiopia (Melkamu and Wazir, 2022). This feed gap, defined by the discrepancy between available feed resources (expressed as dry matter (DM), metabolizable energy (ME), and CP) and the requirements of all animal species, indicates a 9% deficiency in DM and 45% and 42% deficiencies in ME and CP, respectively, reflecting the lack of quality feed in Ethiopia. Although the yearly feed availability equals the amount produced in that year, and imported and stocked feeds from previous years, the current study only accounted for the feed produced in the year under study to estimate the amount of feed supplied, as feed importation and stocking for future years were not common in the study area.

Mode of utilization of stinging nettle

Parts of stinging nettle consumed by livestock species and level of preference

This study highlighted the vital role of stinging nettle as a wild, non-conventional herbaceous feed source for ruminant domestic animals (cattle, sheep, and goats) and, to a lesser extent, for chickens (non-ruminants), with no contribution to equines (horses, donkeys, and mules). The feeding of stinging nettle by various livestock species may depend on their adaptive feeding behavior and the availability of alternative feed options (Ginane et al., 2015). Ruminants exhibit specific feeding behaviors that differ from non-ruminants, characterized by various morphological adaptations for consuming and digesting the chemical compounds of the plant cell wall (Nielsen et al., 2016).

Season of feeding

Due to seasonality in forage production, where feed is more abundant during the main rainy season and scarce during the dry season, there is no consistent supply of feed in Ethiopia. This inconsistency requires urgent attention to alternative methods of feed production, conservation, and utilization to sustain feed availability throughout the year. Consistent with the current study, reports indicate that farmers use various locally available non-conventional feed sources during times of feed scarcity as a coping mechanism to sustain livestock production (Juana et al., 2013). Unlike naturally growing grasses, stinging nettle remains vegetative in both the dry and wet seasons, similar to the forage trees and shrubs, and can be supplemented at any time of the year when feed scarcity occurs.

Form of feeding of stinging nettle plant to animals

Focus group participants indicated that stinging nettle, growing in pure stands in specific niches like backyards or roadsides, is harvested and allowed to wilt before being fed to livestock. In contrast, the plants growing in a mixture with other herbaceous forages on pasturelands are either grazed directly in the field or harvested and supplied to animals after drying for hay along with the other herbaceous forages. This illustrates the experiences of local farmers in managing feed resources effectively amidst challenges of availability. The plant loses its stinging nature following drying and becomes a valuable animal feed (Dereje et al., 2016).

Growing niches, biomass yield, and chemical composition of stinging nettle

Stinging nettle plants grow in various niches, each with distinct fresh or dry matter biomass yield potentials. The variation may primarily be associated with differences in soil fertility and harvesting frequency. The yield was higher in the backyard niche than on roadsides, likely due to the more fertile soil enriched by animals' organic manure and waste from homesteads. Stinging nettle plants thrive better in nitrogen-rich soils (Dereje et al., 2016; Kregiel et al., 2018).

The survey revealed that stinging nettle plants in pasturelands grow together with herbaceous grasses or legumes, which results in more frequent grazing. This frequent grazing or defoliation of the plants enables more tiny tillers of lower fibrous content to develop, leading to lower values of NDF and ADF, but higher contents of OM, CP, and IVDMD (McDonald et al., 2010). Grasses, legumes, and grass-legume mixtures with over 19% CP are rated as prime quality, while those below 8% are considered inferior (Kazemi et al., 2012). In the current study, the average CP content of stinging nettle was 23.60%, with all samples exceeding 22.71%, indicating a high quality consistent with the findings of Kassahun et al. (2016). The ADL values were comparable to those reported by Dereje et al. (2016), although some studies noted slightly higher CP values of 25.7% and 25.5% (Dereje et al., 2015; Dereje et al., 2016). Differences in CP values among studies may arise from variations in plant maturity and morphology, soil fertility, agro-ecology, and rainfall patterns (Dereje et al., 2016).

Overall, the average chemical composition and IVDMD values of stinging nettle in this study were 23.60% CP, 43.43% NDF, 25.45% ADF, 3.82% ADL, 10.25% ash, and 56.07% IVDMD. In contrast, Belete et al. (2012) reported a lower CP content of 14.40%, and higher values for some of the other parameters: 35.3% ADF, 13.5% ADL, and 13.2% ash in indigenous browse trees. According to NRC (2007), a CP content of above 20% is suitable for use as a protein supplement in low-quality roughages. The variability in IVDMD values across different growing niches can be linked to differing soil fertility levels. The lower IVDMD values for stinging nettle from backyard and roadside niches likely correlate with higher NDF and ADF values and lower CP contents. Conversely, the higher IVDMD for the stinging nettle collected from the pastureland niche can be attributed to elevated CP levels and reduced NDF and ADF values.

CONCLUSION

Based on the findings from the present study, there is severe feed scarcity in the highland areas of Dessie Zuria and Legambo districts. This situation has led livestock owners to utilize the non-conventional stinging nettle as an alternative animal feed. The leaves and stems of this herbaceous plant are used by ruminant animals, while only the leaves are rarely used by chickens. However, equines do not feed this plant. Livestock owners usually prepare the plant by wilting it for 2-6 hours before feeding it to animals, while a few of them adopt drying or mixing the stinging nettle with other herbaceous forages. Common growing niches for stinging nettle include the backyard, pastureland, and roadside areas, producing promising biomass yields ranging between 12.40 and 26.75 tons/ha. The plant is also a good source of crude protein (CP). The pastureland niche provides the plant with better CP and *in vitro* dry matter digestibility (IVDMD), and lower levels of fiber. With its superior biomass yield, high CP content, and IVDMD, stinging nettle is suitable for supplementation in animal feeding, mainly for ruminants during the dry season when feed supply is scarce. Further studies, such as animal feeding trials and investigations into anti-nutritional factors, are needed for more detailed information on the use of stinging nettle plant.

DECLARATIONS

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Data availability

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

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Authors' contribution

Fatuma Abera involved in the inception of the study, data collection, data analysis and drafting of the manuscript. Dr. Ali Seid participated in the design, data analysis, and write-up of the manuscript. Dr. Aemiro Kehaliew conducted chemical composition analysis of forage samples and design of the study.

Competing interests

All authors declare that they have no conflicts of interest regarding this research work.

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