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Botanical composition and carrying capacity of forage along the roadsides in the highlands of Bandung Regency

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ABSTRACT

Forage is the primary feed source for ruminant livestock, especially dairy cattle, as it provides essential nutrients for productivity. However, limited forage availability due to land conversion and seasonal changes has encouraged farmers to utilize field grasses, including roadside vegetation, as an alternative feed source. This study aimed to determine the botanical composition and carrying capacity of forage along the roadsides in the highlands of Bandung Regency. The sampling method used was purposive sampling, which involved deliberately selecting research locations through direct field surveys for data and sample collection. Sampling was conducted in five districts in the highlands of Bandung Regency—Ciwidey, Rancabali, Pangalengan, Cimaung, and Arjasari—with ten sampling plots in each district, resulting in a total of 50 plots. Sampling used a quadrat measuring 1 m × 1 m, which was placed randomly. Data were analyzed both qualitatively and quantitatively. The results showed that there were 72 botanical species, with *Galinsoga parviflora* being the most dominant species based on frequency of occurrence. At the same time, *Pennisetum clandestinum* was the most dominant species based on forage production. Based on biomass proportion, grasses dominated at 77.32%, legumes at 1.02%, and weeds at 21.66%. The carrying capacity of the roadsides in the highlands of Bandung Regency was 0.92 LU/ha/year, with forage production of 4.93 tons DM/ha/year, indicating that the roadside areas can support approximately one mature dairy cow, or two heifers, or four calves. The roadside in Rancabali District had the highest forage production, reaching 7.70 tons DM/ha/year with a carrying capacity of 1.40 LU/ha/year.

Keywords: Bandung Regency, Forage source, Highlands, Roadside ecosystem

INTRODUCTION

Forage (HPT) is the primary feed source for ruminant livestock, especially dairy cattle, as it provides essential nutrients such as carbohydrates, protein, fat, minerals, vitamins, and water. Its availability is crucial for improving ruminant livestock productivity and must be supported by adequate forage provision, both in quality and quantity. Forage refers to plant materials derived from grasses, legumes, weeds, or other plants that can be provided to livestock either fresh or after processing. Adequate forage supply helps maintain optimal rumen function, thereby supporting high livestock productivity.

The year-round availability of forage in Indonesia remains constrained by several factors, including the conversion of land into residential and industrial areas In addition, seasonal changes cause fluctuations in forage availability. During the rainy season, forage production is abundant, while during the dry season, forage production decreases or becomes difficult to obtain. Consequently, smallholder farmers often rely on field grasses, including those from roadsides, to meet their forage needs.

Dairy farms are generally located in cool highland areas to minimize heat stress. Highland areas, particularly in Bandung Regency, offer optimal temperatures and humidity for dairy cattle productivity. The soil in these areas tends to be more fertile due to volcanic ash deposits from previous eruptions. Therefore, the roadsides in the highlands of Bandung Regency offer potential for smallholder dairy farmers to utilize as a source of forage, especially for those without their own forage land, and as an alternative source of sufficient feed throughout the year.

The composition of forage found along roadsides can determine feed quality. Botanical composition analysis is a method used to describe the presence of specific plant species and the ecosystem of a pasture (Dominanto & Tirojah, 2016). These ecosystems may develop either intentionally or naturally. Some forages are intentionally cultivated by local communities as animal feed, while others consist of wild plant species. According to Putra et al. (2018), botanical composition can be determined by detecting the composition of grass, legume, and weed components.

The structure and composition of plant species can be assessed through quantitative and qualitative descriptive measurements. Quantitative measurements include species richness and diversity, while qualitative descriptions involve listing the plant species present in an area. Information on vegetation structure and composition is crucial for determining land carrying capacity, as the quantity and type of available forage determine the land's ability to meet livestock feed requirements. Carrying capacity is a method used to analyze the ability of grazing land to support a number of livestock to ensure that their feed requirements can be met adequately throughout the year. The term also refers to the capacity of grazing land to produce sufficient forage for a given number of livestock grazing within a specific area, usually expressed as the number of livestock units per hectare (Harminto et al., 2023). The botanical composition and carrying capacity of the roadsides can be influenced by various factors such as plant type, species, climate, and soil conditions. Therefore, analyzing botanical composition and calculating carrying capacity are essential for the sustainable management of forage resources. Information on botanical composition provides an overview of the diversity and dominance of existing plant species, while carrying capacity data indicate the land's ability to supply feed for livestock. These two parameters form an important basis for planning land use and management to maintain livestock productivity without disturbing the balance of the existing vegetation ecosystem.

The roadsides in the highlands of Bandung Regency are areas with great potential for the utilization of forage as a source of livestock feed. However, the types of natural grasses found along these roadsides and their forage production capacity remain unknown. Therefore, this study aims to determine the botanical composition and carrying capacity of forage along the roadsides of Bandung Regency highlands to meet the forage needs of ruminant livestock, particularly dairy cattle.

MATERIALS AND METHODS

Research time and location

The research was conducted from March to April 2024 in Bandung Regency, West Java Province, specifically along roadsides in five districts representative of the highland areas of the regency. These districts include Ciwidey at an altitude of 1,262 m above sea level (m asl),

Rancabali at 1,681 m asl, Cimaung at 829 m asl, Pangalengan at 1,410 m asl, and Arjasari at 909 m asl (BPS Bandung Regency, 2024).

Research method

The sampling method used in this study was purposive sampling by determining the research location through direct field surveys to collect data and samples along the roadsides of Bandung Regency highlands. The botanical composition was analyzed to determine the composition of forages growing along these roadsides. Observations of botanical composition were conducted on each sample plot, with 10 sample plots taken from each district using a 1 m × 1 m quadrat, which was placed randomly.

Observations of grass, legume, and weed species were conducted using the PlantNet application as a guide for identification and subsequent determination of species types based on standard botanical references, including PROSEA (https://prosea.prota4u.org/), POWO (https://powo.science.kew.org/), USDA Plants Database (https://plants.usda.gov/), and other relevant flora guides. Each species found in each quadrat was counted, and the forage was then cut and weighed to determine the fresh weight.

The distribution of species is determined based on the number of each species present in each sample taken and their frequency. According to Aprijani (2008), to determine the dominant species in a pasture, the absolute frequency of the species (AFS) and the relative frequency of the species (RFS) are calculated using the following formulas:

$$\text{AFS} = \frac{\text{Number of Species Plots}}{\text{Total Plots}} \text{ x } 100\%$$

$$\text{RFS} = \frac{\text{AFS}}{\text{Total AFS}} \text{ x } 100\%$$

The moisture content and dry matter of forages were calculated using the formula by Mannetje & Haydock (1963):

$$\text{Moisture Content (\%)} = \frac{\text{Fresh Weight - Dry Weight}}{\text{Fresh Weight}} \text{ x } 100\%$$

$$\text{Dry Matter (\%)} = 100\% - \text{\% Moisture Content}$$

The botanical composition based on dry weight (biomass) and the calculation of carrying capacity were determined using formulas modified from Yesti et al. (2025):

$$\text{Botanical Composition (\%)} = \frac{\text{Dry Weight of Plant Group}}{\text{Total Dry Weight of All Plant Groups}} \text{ x } 100\%$$

The carrying capacity was calculated by dividing the dry matter (DM) forage production per hectare per year by the DM requirement per livestock unit (LU) per year (Proper Use Factor 60%). The roadside area was estimated by multiplying the quadrat area by the number of quadrats and converting the total to hectares. The DM requirement for one LU is 2.5% of the livestock's body weight (Manu, 2013).

$$\text{Carrying Capacity} = \frac{\text{Forage Production}}{\text{DM/LU/Year}}$$

RESULTS AND DISCUSSION

Botanical composition

The results showed that the roadsides in the highlands of Bandung Regency have diverse vegetation types. A total of 72 vegetation species were identified. The data in Table 1 showed that based on frequency of occurrence, the botanical composition is dominated by *Galinsoga*

parviflora (8.9%), *Cynodon dactylon* (8.5%), *Digitaria sanguinalis* (8.5%), *Alternanthera philoxeroides* (6.0%), and *Pennisetum clandestinum* (4.8%).

Table 1. Ranking of Species Occurrence along the Roadsides of Bandung Regency Highlands

Rank	Species	Total Plots	RFS (%)
1	*Galinsoga parviflora*	22	8.9
2	*Cynodon dactylon*	21	8.5
3	*Digitaria sanguinalis*	21	8.5
4	*Alternanthera philoxeroides*	15	6.0
5	*Pennisetum clandestinum*	12	4.8
6	*Dittrichia viscosa*	12	4.8
7	*Cyperus compressus*	7	2.8
8	*Paspalum scrobiculatum*	7	2.8
9	*Commelina difusa*	7	2.8
10	*Sphagneticola trilobata*	7	2.8
11	*Eleusine indica*	5	2.0
12	*Axonopus compressus*	5	2.0
13	*Calyptocarpus vialis*	5	2.0
14	*Drymaria cordata*	5	2.0
15	*Centella asiatica*	5	2.0
16	*Bellis perennis*	4	1.6
17	*Poa annua*	3	1.2
18	*Ageratum conyzoides*	3	1.2
19	*Marsypianthes chamaedrys*	3	1.2
20	*Synedrella nodiflora*	3	1.2
21	*Macroptilium lathyroides*	3	1.2
22	*Sida acuta*	3	1.2
23	*Plantago major*	3	1.2
24	*Asystasia gangetica*	3	1.2
25	*Clinopodium gracile*	3	1.2
26	*Murdannia nudiflora*	3	1.2
27	*Commelina communis*	3	1.2
28	*Mimosa pudica*	2	0.8
29	*Panicum repens*	1	0.4
30	Other species	52	21.3
	Total		100

Note: RFS = Relative Frequency of Species (Species Percentage)

Galinsoga parviflora generally grows around agricultural areas, fertile lands exposed to sunlight or partial shade, riverbanks, wetlands, abandoned lands, and even along roadsides. This species is non-toxic and can be used as cattle feed (Ali et al., 2017; Santosa et al., 2020). *Cynodon dactylon* is a natural grass that can grow in almost all soil types, including plantations, roadsides, riverbanks, grazing areas, abandoned lands, and fertile soils with high nitrogen content. In addition to its role as animal feed, this species also has potential as a traditional medicinal ingredient because it contains bioactive compounds effective in treating various

diseases (Waghela et al., 2022). *Digitaria sanguinalis* can be used as animal feed and grows in various environments, including cultivated lands, plantations, grasslands, fields, and along roadsides (Oreja et al., 2025). *Alternanthera philoxeroides* is also a species that can be utilized as animal feed and as a supplement in poultry feed. It generally thrives in swampy or waterlogged environments but is also commonly found in terrestrial habitats such as roadsides, parks, and agricultural lands, particularly during the rainy season (Puro et al., 2025; Sharma & Das, 2025). Furthermore, *Pennisetum clandestinum*, also known as Kikuyu grass, is commonly found in the highlands of Bandung Raya, especially along roadsides. This species is suitable for animal feed due to its high nutrient content and is also highly palatable for horses (Royani et al., 2021; Mansyur et al., 2024).

Table 2. Species and Total Dry Matter of Forage along the Roadsides of Bandung Regency Highlands

No.	Species	Total Species	DM (g)
1	*Pennisetum clandestinum*	284	882
2	*Paspalum scrobiculatum*	198	822
3	*Cynodon dactylon*	297	512
4	*Digitaria sanguinalis*	294	504
5	*Galinsoga parviflora*	111	119
6	*Drymaria cordata*	57	113
7	*Dittrichia viscosa*	44	107
8	*Eleusine indica*	49	105
9	*Alternanthera philoxeroides*	103	88
10	*Poa annua*	55	76
11	*Axonopus compressus*	63	76
12	*Elytrigia repens*	15	64
13	*Panicum repens*	25	60
14	*Ageratina riparia*	31	60
15	*Sphagneticola trilobata*	35	52
16	*Plantago major*	22	35
17	*Asystasia gangetica*	18	31
18	*Commelina communis*	11	29
19	*Eragrostis pilosa*	10	27
20	Other species	424	347
	Total	**2,146**	**4,109**

Note: DM = Dry Matter

The forage commonly used as staple feed for ruminant livestock comes from the gramineae family or grasses, while forage from the leguminosae group or certain shrubs can serve as a source of protein, minerals, and vitamins (Rembo et al., 2021). The diversity of botanical composition along the roadsides is influenced by various environmental factors such as climate, rainfall, temperature, altitude, and the physical and chemical properties of the soil. This is consistent with the opinion of Pourbabaei et al. (2020), that the composition and structure of plant communities are affected by environmental factors including soil, topography, and climatic conditions. Altitude is among the most influential factors in determining the composition of forest ecosystems and the physicochemical properties of the soil.

The cool and humid climate of the highlands supports the growth of various tropical and subtropical grass species, such as *Pennisetum clandestinum* and *Cynodon dactylon*. Furthermore, human activities such as grazing, mowing, and vehicle traffic also play a role in determining the types of vegetation that can grow and survive in the area. Thus, the composition of forage vegetation in roadside areas reflects not only natural ecological conditions but also the interaction between environmental factors, anthropogenic factors, and species adaptations to ecosystem pressures.

Based on the data in Table 2, the species with the highest dry weight *were Pennisetum clandestinum* (882 g), *Paspalum scrobiculatum* (822 g), *Cynodon dactylon* (512 g), *Digitaria sanguinalis* (504 g), and *Galinsoga parviflora* (119 g). The high dry weight indicates that these species have large biomass and strong growth capacity at the study site. Based on biomass production, the results showed that grass dominated by 77.32%, legumes 1.02%, and weeds 21.66%.

Grass species such as *Pennisetum clandestinum* and *Cynodon dactylon* are known for their rapid vegetative growth, strong root systems, and ability to form dense shoots, stolons, and rhizomes (Skerman & Riveros, 1990; Muscolo et al., 2013; Noor et al., 2023), allowing them to dominate growing areas and form extensive cover. This allows these species to produce high dry matter yields, even if their relative frequency is not always the highest. In addition, high dry weight reflects photosynthetic efficiency and the plant's ability to optimally utilize resources such as water, light, and nutrients. C4 grass species such as *Pennisetum clandestinum*, *Paspalum scrobiculatum*, *Cynodon dactylon*, and *Digitaria sanguinalis* have highly efficient photosynthetic pathways, allowing substantial dry matter accumulation even in open roadside areas with relatively nutrient-poor soils. Anggara et al., (2025) stated that C4 plants have higher photosynthetic efficiency than C3 plants, producing higher net photosynthesis under similar conditions.

Carrying capacity

The results showed that forage production was 10.28 tons/ha/year in fresh weight and 4.93 tons/ha/year in dry weight. The carrying capacity along the roadsides of Bandung Regency highlands was 0.92 livestock units (LU)/ha/year, or equivalent to supporting one mature dairy cow, or two heifers, or four calves.

The carrying capacity of this study is lower than the carrying capacity of the study by Hambakudo (2022) in the natural grasslands of Maubokul Village, Pandawai District, East Sumba Regency, which are dominated by natural grasses during the rainy season, with a value of 1.12 LU/ha/year. This is due to differences in ecological conditions and the dominant vegetation types. The availability of forage in the natural grassland of East Sumba is relatively higher because the vegetation is dominated by natural grasses that have adapted to local environmental conditions. Meanwhile, forage productivity on the roadsides of the Bandung Regency highlands tends to be lower due to factors such as the intensity of anthropogenic disturbances (traffic activities and land clearing), competition between plant species, limited soil conditions, and seasonal variations that affect the availability of water and soil nutrients. However, the carrying capacity in this study was higher than that reported by Hambakudo (2021) in the natural grazing fields of Haharu Sub-district, East Sumba Regency, which were dominated by natural grasses during the dry season, with a value of 0.03 LU/ha/year. The low carrying capacity at these sites was mainly due to low forage production during the dry season, limited water availability, dominance of grasses without legumes, alkaline soil conditions, and hilly topography. Based on these findings, environmental conditions, dominant vegetation types, and seasonal factors significantly influence the differences in carrying capacity among locations. According to Reksohadiprodjo (1994), a pasture is considered productive if it has a minimum carrying capacity of 2.5 LU/ha/year. In this study, roadside areas in the highlands of

Bandung Regency have a carrying capacity below this standard; thus, these areas cannot be categorized as productive to support optimal livestock numbers. Furthermore, the composition of forage also affects productivity. The dominance of grasses with suboptimal nutritional value and the low proportion of legumes indicate that even though the amount of forage is sufficient, the quality inadequately supports maximum livestock growth and production.

Carrying capacity based on the districts

Forage production along the roadsides in the highlands of Bandung Regency based on the districts can be seen in Table 3. Forage production and carrying capacity vary across the districts. The roadside in Rancabali District has the highest forage production, at 7.70 tons DM/ha/year with a carrying capacity of 1.40 LU/ha/year, while the roadside in Pangalengan District has the lowest forage production, at 2.71 tons DM/ha/year with a carrying capacity of 0.50 LU/ha/year. The districts of Cimaung, Arjasari, and Ciwidey have moderate production and carrying capacity, ranging from 5.43 to 5.92 tons DM/ha/year, with a carrying capacity of 1.02–1.11 LU/ha/year. In general, carrying capacity increases with dry matter production, indicating more productive land.

Table 3. Forage Production along the Roadsides by Districts in the Bandung Regency Highlands

No.	District	Forage Production in FW (tons/ha/year)	Forage Production in DW (tons/ha/year)	Carrying Capacity (LU/ha/year)
1	Ciwidey	10.00	5.43	1.02
2	Rancabali	13.20	7.70	1.40
3	Cimaung	11.08	5.59	1.04
4	Pangalengan	7.76	2.71	0.50
5	Arjasari	9.34	5.92	1.11

Notes: FM = Fresh Weigth; DW = Dry Weight

Factors influencing differences in forage production and carrying capacity across districts include vegetation type, species dominance, altitude, temperature, humidity, soil conditions, and the intensity of sunlight received. In addition to environmental factors, human activities such as land maintenance, weeding, mowing, and the intensity of traffic and waste disturbances around the roads also affect forage growth and production. The combination of these environmental and anthropogenic factors creates unique ecological conditions in each district, resulting in variations in forage production and carrying capacity. According to Hae et al. (2020) and Hambakudo (2022), the carrying capacity of pastures is influenced by season, water availability, land slope, and shade. Muhakka et al., (2024) stated that the carrying capacity of a pasture area is generally determined by the amount of forage production. The higher the available forage production, the greater the potential number of livestock that can be supported in that area. A study by Yesti et al. (2025) reported that the carrying capacity of pastures is influenced by the composition of vegetation types, specifically the ratio among grasses, legumes, weeds, and the total dry matter produced. Hae et al. (2020) stated that carrying capacity can be increased by improving the botanical composition and the amount of fresh or dry matter through the introduction of more palatable forage types, such as legumes, in ideal proportions.

CONCLUSIONS

The composition of forage along the roadsides in the highlands of Bandung Regency showed that *Galinsoga parviflora* was the most dominant species based on frequency of occurrence, while *Pennisetum clandestinum* was the most dominant species based on forage production. Based on the proportion of biomass, grasses dominated at 77.32%, legumes at

1.02%, and weeds at 21.66%. The carrying capacity obtained was 0.92 LU/ha/year, with forage production of 4.93 tons DM/ha/year. The Rancabali roadside had the highest forage production at 7.70 tons DM/ha/year with a carrying capacity of 1.40 LU/ha/year, while the Pangalengan roadside had the lowest, at 2.71 tons DM/ha/year with a carrying capacity of 0.50 LU/ha/year.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest in the research, authorship, and/or publication of this article.

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