Characterization of forage weeds associated with grasslands under Voisin grazing system

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ABSTRACT

Objective: To characterize forb and browse species associated with cattle pastures under the Voisin grazing system.

Design/Methodology/Approach: Floristic inventories were conducted at four distinct sites: a weed-dominated pasture (WeedDom), a secondary vegetation pasture (SecVeg), a pasture invaded by weeds (WeedInv), and a fallow field with woody vegetation (W oodVeg). The phenological transition phase was recorded and the growth stage identified for the most abundant species in each paddock. Cattle foraging behavior was assessed using scan sampling of 10 cows during active grazing. Chemical analyses were performed on 18 forage species from all sites to determine crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), lignin, total phenolics, and tannins.

Results: A total of 65 species were identified in WeedDom, dominated by *Sida spinosa* L.; 51 species in WoodVeg, dominated by *Solanum adscendens* Sendtn.; 51 species in SecVeg, dominated by *Cleome viscosa* L.; and 57 species in WeedInv, with *Andropogon gayanus* (Kunth) as the dominant species. Most plants were in vegetative or early blooming stages during the transition phase. Cattle diets were diverse; *S. spinosa*, *Trianthema portulacastrum* L., *Gomphrena globosa* L., *Lagascea mollis* Cav., and *A. gayanus* were among the most preferred species. Crude protein content ranged from 5.8% to 20.3%, NDF from 31.5% to 72.9%, and ADF from 21.0% to 40.0%, with lignin levels reaching up to 29.4%. Forage species also contained phenolic compounds (1.28-14.48%) and tannins (1.15-13.78%).

Limitations/Implications: This was an exploratory study.

Findings/Conclusions: Most forbs and browse species associated with grazing areas across varying growth stages and exhibiting diverse nutrient and phenolic profiles were effectively utilized as forage by cattle under the Voisin grazing system.

Keywords: forbs, grasses, chemical composition, phenology.

Citation: Gamboa-Ahumada, D.I., Márquez-Mota, C.C., Ramírez-Martínez, A., Ortega-Jiménez, E., & López-Ortiz, S. (2025). Characterization of forage weeds associated with grasslands under Voisin grazing system. *Agro Productividad*. https://doi.org/10.32854/59krq716

Academic Editor: Jorge Cadena Iñiguez
Associate Editor: Dra. Lucero del Mar Ruiz Posadas
Guest Editor: Daniel Alejandro Cadena Zamudio

Received: July 18, 2025.
Accepted: August 15, 2025.
Published on-line: September XX, 2025.

Agro Productividad, 18(9) supplement. September. 2025. pp: 257-264.

INTRODUCTION

Inadequate grazing management represents one of the main causes of pasture and grassland degradation. Nevertheless, overgrazing and the associated plant successional process often maintain levels of plant diversity that are generally not considered functional for a productive pastoral system and are indiscriminately eliminated through the use of herbicides, intensive mowing, or burning (Espinosa-Palomeque *et al.*, 2020; Bautista-García *et al.*, 2022). However, this vegetation, often classified as undesirable, constitutes

a potential source of biomass with relevant nutritional value that, under proper management, can be utilized as part of cattle diets (Rodríguez *et al.*, 2018). Rational management involves establishing appropriate grazing and rest periods for pastures, as well as adjusting the stocking rate based on forage availability. This strategy promotes better forage utilization by cattle, including associated weedy species that might otherwise invade and displace dominant grasses. This research supports the use of the Voisin grazing system as a management tool to allow cattle to incorporate a greater diversity of associated weedy species present in grazing sites into their diets, particularly in areas with high plant heterogeneity and reduced grass dominance. Our study objective was to characterize the weedy species associated with pastures that form part of the cattle diet in sites with different plant composition and diversity, identifying their phenological stages and quantifying the chemical-nutritional composition of those species effectively consumed under a Voisin grazing system.

MATERIALS AND METHODS

Location and study area description

The research was conducted in a tropical dry deciduous forest ecosystem. The predominant climate corresponds to type AW1(w)(i)g (warm, dry, with regular rainfall), according to the Köppen classification modified by García (2004). The average annual precipitation is 1,500 mm.

Study site floristic diversity

Four grazing environments with varying degrees of vegetation intervention were evaluated, all managed under the Voisin grazing system with cattle, during the period from July to October 2022. The environments included: (1) a pasture dominated by forb species (WeedDom, 9 paddocks), (2) a fallow field with woody vegetation (WoodVeg, 5 paddocks), (3) a site with established secondary vegetation (SecVeg, 5 paddocks), and (4) a pasture invaded by forbs and browses but still dominated by grasses (WeedInv, 8 paddocks). In each paddock, five sample points were randomly selected. At each point, a 1 m^2 frame was placed to record the plant species present, followed by an extrapolation to characterize the general floristic composition of each site.

Optimal rest period and plant phenological stage

The optimal rest period (ORP) is defined as the moment when the pasture completes its vegetative stage and transitions toward floral bud formation (Klapp, 1977). In each paddock, the ORP was determined based on the most abundant species present. At that time, the phenological stage of each species was recorded using the methodology proposed by Van Soest (1994), with necessary adaptations for our study objectives.

Forb species in cattle diets

Scan sampling was conducted on 10 randomly selected cattle during active grazing, the frequency of consumption of each plant species was recorded to identify the preferred forbs in each evaluated environment.

Chemical analysis of selected forbs

Foliage of the forb species consumed by cattle was collected at each study site for chemical analysis. Neutral detergent fiber (NDF), acid detergent fiber (ADF), and lignin content were determined using the filter bag technique (Van Soest *et al.*, 1991). Crude protein was quantified using the Kjeldahl method (AOAC, 1990). Additionally, total phenolics were measured using the Folin–Ciocalteu method, with absorbance reading at 725 nm, and total tannins were quantified using the PVPP (polyvinylpyrrolidone) method following FAO (2000).

RESULTS AND DISCUSSION

Floristic diversity of evaluated sites

In the WeedDom site, 20 botanical families, 40 genera, and 65 species were identified. In WoodVeg, 19 families, 37 genera, and 51 species were recorded, while WeedInv contained 20 families, 34 genera, and 57 species. Finally, the SecVeg site recorded 15 families, 35 genera, and 51 species.

Overall, the species richness observed in this study follows that reported by other authors in similar grazing environments within the same region (Soto-Calderón *et al.*, 2018; Espinosa-Palomeque *et al.*, 2020). This difference may be attributed to the fact that, in the present study, species richness is reported specifically per site, rather than as an aggregate from all sites. Although floristic richness was dominated by forb species, the values recorded suggest that cattle may be selecting diets with diverse composition, taking advantage of the plant heterogeneity available across the evaluated environments.

Phenological stages of plants in the paddocks

At the time of identifying the optimal rest period (ORP), plant species were distributed across various stages of development. In general, most plants fell within phenological categories 0 to 5, according to the classification proposed by Van Soest (1994). Only a few species were observed at more advanced stages of physiological maturity. In the WeedDom site, both forb and grass species exhibited a higher proportion of individuals in the vegetative (categories 0 to 2) and early budding stage (stage 3). Only a small fraction of species was in more advanced reproductive phases (stages 4 and 5) (Figure 1).

At the WoodVeg site, more species were observed in early developmental stages, with progressive reduction as they advanced to later phenological phases. In particular, native grasses were predominantly found in initial vegetative stages 0, 1, and 2 (Figure 2).

At the SecVeg site, most forb species were in the early vegetative stage (stage 0), with only a small number distributed across subsequent phenological stages (1 to 5). In contrast, grasses present at this site were mainly in stages 3 and 4, corresponding to the onset of floral budding (Figure 3).

Finally, at the WeedInv site, fewer forb species were observed, as the grass Andropogon gayanus consistently dominated these paddocks. The forbs present were mostly in the early vegetative stage (stage 0), with a progressive decline in frequency toward more advanced phenological stages. Most grasses were found in stage 2, corresponding to the intermediate vegetative state (Figure 4).

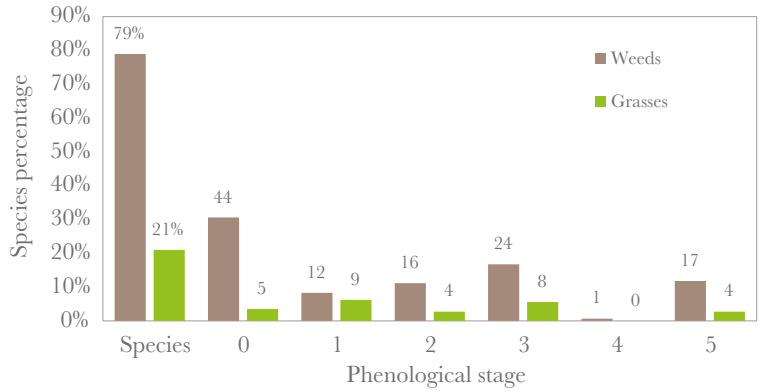

Figure 1. Frequency of phenological stages of grasses and associated species in a weed-dominated pasture (WeedDom) at the optimal pasture rest period. Numbers above the bars indicate the number of species corresponding to each percentage.

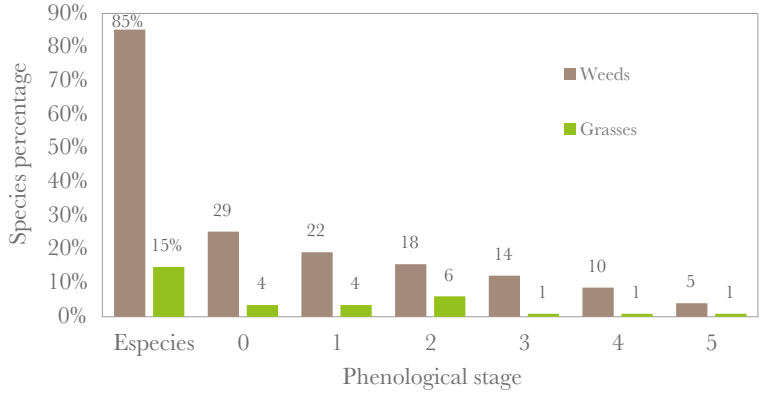

Figure 2. Frequency of phenological stages of grasses and associated species in a fallow field with secondary vegetation (WoodVeg) at the optimal pasture rest period. Numbers above the bars indicate the number of species corresponding to each percentage.

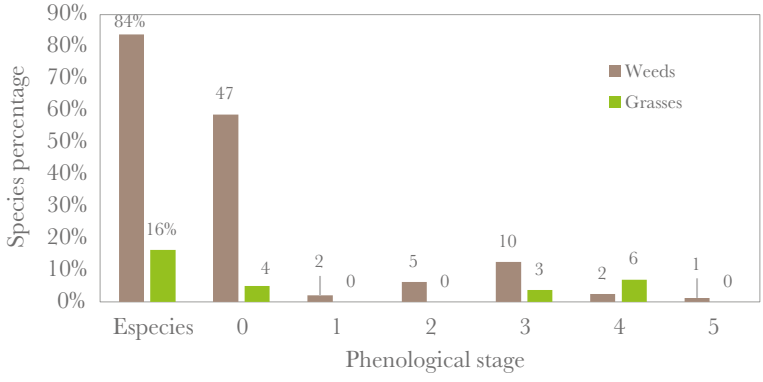

Figure 3. Frequency of phenological stages of grasses and associated species in a site with secondary vegetation (SecVeg) at the optimal rest period. Numbers above the bars indicate the number of species corresponding to each percentage.

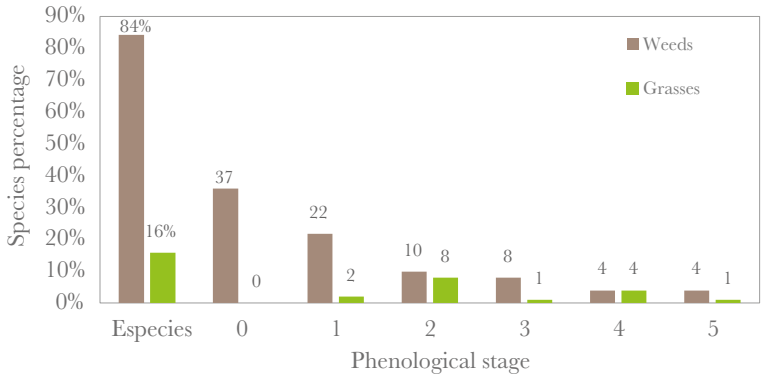

Figure 4. Frequency of phenological stages of grasses and associated species in a pasture invaded by forbs (WeedInv) at the optimal rest period. Numbers above the bars indicate the number of species corresponding to each percentage.

At the time of determining the optimal rest period (ORP) in all evaluated paddocks, most plant species were in the vegetative state, although distributed across different stages of development. This phenological variability is attributed to intrinsic differences among species regarding their growth and developmental rates (Rua, 2015). Additionally, paddock recovery may vary even within the same site due to the influence of abiotic factors such as soil moisture, solar radiation, microrelief, and soil fertility (Brizuela *et al*., 2015).

Forb species selected by cattle

Cattle selected different plant species depending on the floristic composition of each grazing site. Within each environment, certain species were consumed more frequently than others, although the observed diets were diverse overall. At the WeedDom site, the most frequently selected species were *Sida spinosa*, *Trianthema portulacastrum* L., and *Ruellia nudiflora* (Engelm. & A. Gray) Urb. In the WoodVeg site, *Gomphrena globosa* L., *S. spinosa*, *Lagascea mollis* Cav., and *Zornia diphylla* (L.) Pers. were prominent. In the SecVeg site, the most consumed species were *L. mollis*, *Ipomoea purpurea* (L.) Roth, and *Cleome viscosa* L., while in the WeedInv site, *Andropogon gayanus*, *L. mollis*, and *Borreria laevis* (Lam.) Griseb. constituted a significant portion of the diet (Table 1).

A notable diversity of forb species included in the cows' diet was observed across all study sites. Variations in dietary composition were mainly influenced by the differential presence and availability of species in the various paddocks (Table 1). According to Soto-Calderón *et al.* (2018), even when floristic diversity is high, dominant species in the cattle diet are commonly identified, with herbaceous plants being the most representative across different grazing environments.

Chemical composition of selected forbs

The chemical composition of the species consumed by cattle was diverse. Crude protein (CP) content showed wide variation, ranging from 5.7% to 20.3%. *Indigofera thibaudiana* DC. stood out with the highest CP concentration and the lowest neutral detergent fiber (NDF) content, positioning it as a species of high nutritional quality (Table 2).

Table 1. Frequency at which plant species were selected by cattle in each grazing environment.

Species	Freq	Species	Freq
WeedDom		**WoodVeg**	
Sida spinosa	178	*Gomphrena globosa*	74
Trianthema portulacastrum	109	*Sida spinosa*	41
Ruellia nudiflora	37	*Lagascea mollis*	39
Tridax procumbens	32	*Zornia diphylla*	34
Cleome viscosa	23	*Desmodium procumbens*	30
Croton argenteus	18	*Dalea cliffortiana*	29
Lagascea mollis	15	*Cleome viscosa*	23
Mimosa pudica	13	*Solanum adscendens*	23
SecVeg		**WeedInv**	
Lagascea mollis	63	*Lagascea mollis*	24
Ipomoea purpurea	43	*Borreria laevis*	15
Cleome viscosa	32	*Diphysa minutifolia*	15
Gomphrena globosa	19	*Sida spinosa*	12
Solanum adscendens	17	*Desmodium procumbens*	8
Cracca greenmanii	11	*Cleome viscosa*	8
Sida acuta	11	**Andropogon gayanus*	7
Chamaecrista nictitans	10	*Sida acuta*	5
Randia punctata	10	*Tridax procumbens*	3

Only the most frequently selected species were included.

In contrast, *Andropogon gayanus* showed the highest values of NDF and acid detergent fiber (ADF), typical characteristics of grasses that have not yet reached full physiological maturity (Velázquez-Martínez *et al*., 2011).

Crude protein values recorded in this study fall within the range reported by Soto-Calderón *et al*. (2018), indicating that the species consumed by cattle possess adequate nutritional quality. In general, forb species exhibited higher CP content than grasses, suggesting that these plants complement the cattle diet by providing essential nutrients that improve overall nutritional balance. Regarding secondary compounds, total phenolic concentrations of up to 14.48% and total tannins up to 13.78% were observed in the evaluated species. *Randia punctata* showed the highest concentrations of both compounds, while grasses exhibited the lowest levels of phenolics and tannins (Table 3).

Broadleaf species tended to exhibit higher concentrations of phenolic compounds compared to grasses. These results highlight that all species selected by cattle contained phenolic compounds, although with notable variability among them. Nevertheless, the presence of these secondary metabolites did not prevent ingestion by cattle, which aligns with the findings of Villalba and Provenza (2007), who indicate that herbivores possess physiological and behavioral mechanisms that allow them to self-regulate the intake of such compounds. When present in moderate concentrations, phenolic compounds may offer metabolic benefits and contribute to the overall well-being of livestock (Avella *et al*., 2008). In this study, no adverse effects were observed associated with the consumption of

Table 2. Chemical composition (%) of the collected species.

Species	CP	NDF	ADF	Lig	CC	Hemicel	Cel
Sida spinosa	14.33	41.35	20.52	5.58	58.65	20.83	14.94
Indigofera thibaudiana	20.3	31.35	21.03	8.8	68.65	10.32	12.23
Chamaecrista nictitans	17.04	47.04	31.5	13.55	52.96	15.54	17.95
Ruellia nudiflora	13.2	40.99	26.73	11.03	59.01	14.26	15.7
Tamonea curassavica	10.44	49.87	30.87	11.27	50.13	19.0	19.6
Zornia diphylla	10.77	47.7	27.21	8.77	52.3	20.49	18.44
Desmodium procumbens	17.28	49.43	30.92	8.13	50.57	18.51	22.79
Gliricidia sepium	19.14	48.74	41.34	29.4	51.26	7.4	11.94
Gomphrena globosa	11.66	44.75	26.32	4.16	55.25	18.43	22.16
Guazuma ulmifolia	12.53	54.04	32.8	18.01	45.96	21.24	14.79
Ipomea purpurea	8.69	38.99	26.89	6.17	61.01	12.1	20.72
Randia punctata	9.13	57.66	38.09	24.31	42.34	19.57	13.78
Solanum adscendens	11.84	36.74	27.2	8.34	63.26	9.54	18.86
Grass sample	8.0	68.52	31.88	4.24	31.48	36.64	27.64
Aeschynomene americana	13.12	45.5	30.79	8.69	54.5	14.71	22.1
Andropogon gayanus	5.65	72.97	40.06	4.05	27.03	32.91	36.01
Borreria laevis	7.55	47.1	39.71	18.35	52.9	7.39	21.36
Lagascea mollis	13.3	51.13	38.28	21.78	48.87	12.85	16.5

CP=Crude Protein, NDF=Neutral Detergent Fiber, ADF=Acid Detergent Fiber, Lig=Lignin, CC=Cell Content, Hemicel=Hemicellulose, Cel=Cellulose.

Table 3. Total phenolic and tannin concentrations in forb species selected by grazing cattle.

Scientific Name	Total Phenolics (%)	Total Tannins (%)
Sida spinosa	3.11	2.44
Indigofera thibaudiana	4.76	3.38
Chamaecrista nictitans	13.76	13.19
Ruellia nudiflora	1.44	1.35
Tamonea curassavica	7.15	6.05
Zornia diphylla	1.5	1.15
Desmodium procumbens	2.45	1.8
Gliricidia sepium	2.16	1.53
Gomphrena globosa	1.58	1.24
Guazuma ulmifolia	8.59	8.03
Ipomoea purpurea	9.18	8.22
Randia punctata	14.48	13.78
Solanum adscendens	2.69	2.00
Grass sample	1.28	1.18
Aeschynomene americana	3.13	2.74
Andropogon gayanus	4.27	3.92
Borreria laevis	4.23	2.94
Lagascea mollis	1.39	1.24

species with higher phenolic content, which may be attributed to the animals' varied and selective feeding behavior under grazing.

CONCLUSIONS

The Voisin grazing system promotes the inclusion, by cattle, of a diversity of forb and browse species present in various phenological stages, with equally variable chemical-nutritional composition. These species constitute part of the available forage in the paddocks and provide nutrients that complement cattle diets, enhancing their nutritional balance under extensive grazing conditions. Beyond their nutritional value, this dietary selection may represent an ecological mechanism for weed control particularly in invaded sites by reducing their relative dominance through targeted consumption. In the long term, this strategy could contribute to the restoration of the botanical composition of pastures, promoting greater grass predominance and thereby improving the structure and functionality of the forage system.

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