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# Local herbaceous forage species for sustainable and resilient agropastoral systems in Benin

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ABSTRACT

Livestock farming is a vital component of agricultural economies in tropical countries, contributing significantly to food security, household income, and the resilience of rural communities. However, the livestock production is increasingly facing challenges related to the availability, quality and resilience of forage resources. This study aims to prioritize local herbaceous forage species to strengthen the sustainability and resilience of agropastoral systems in Benin. Ethnobotanical surveys were conducted with 330 randomly selected herders across Agricultural Development Poles 2 and 4. Additionally, the field-based tracking of cattle herds was carried out in collaboration with local communities to confirm the presence of the species reported during interviews and to assess the reliability of the information collected. Four criteria were used to prioritize the inventoried species: life form, palatability index, species availability, and nutritional composition. In total, 42 herbaceous forage species were recorded. Species abundance in grazing areas proved to be the main factor influencing their frequency of use, whereas perceived palatability showed no significant effect. The prioritization approach led to the identification of six priority herbaceous species (*Andropogon chinensis, Andropogon gayanus, Andropogon tectorum, Brachiaria falcifera, Hyparrhenia smithiana*, and *Panicum maximum* local). Nutritional analysis confirmed the superiority of *H. smithiana* and *P. maximum* local in crude protein (12.18% DM and 7.12% DM, respectively) as well as in calcium (0.25% DM and 0.34% DM), magnesium (0.11% DM and 0.31% DM), potassium (0.76% DM and 1.37% DM), and phosphorus (0.14% DM and 0.19% DM). These results highlight the potential of certain local high-nutritional-value species to improve livestock feeding and support the transition toward more sustainable and resilient agropastoral systems in the face of current environmental challenges.

## Introduction

Livestock farming is a major component of the agricultural economy in West Africa, particularly in Benin. It plays a key role in food security, income generation, and the resilience of rural communities [1–3]. However, the livestock production sector is increasingly

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constrained by limitations in the availability, quality, and resilience of forage resources [4,5]. Natural rangelands remains the dominant feed source for ruminants [6,2,7]. These pastures are mostly dominated by annual plant species, characterized by a short growth cycle that occurs entirely during the rainy season. During this period, grazing ensures adequate animal nutrition, but in the dry season, only straw remains, which is both qualitatively poor and quantitatively insufficient [8,9]. This seasonal feed shortage is exacerbated by the combined effects of climate change and anthropogenic pressures [10]. In this context, the low productivity of pastures significantly limits livestock performance, particularly in terms of meat and milk production. It is therefore crucial to provide herders with sustainable solutions to improve the availability and quality of livestock feed resources [11,12].

Some local forage species offer the potential to increase the crude protein content of livestock diets [9,13,6], and can be used fresh during the growing season or harvested, dried, and stored as hay for feeding during feed shortage periods [14–16]. However, the nutritional value of these species varies considerably depending on the species and their physiological stage of maturity, affecting their fiber, lignin, mineral, and protein content, as well as the proportion of digestible tissues for ruminants [17,18]. These nutritional characteristics are key determinants of animal growth rates, reproductive success, and behavior [19,13,20]. Furthermore, with population growth, urbanization, and increased purchasing power in many developing countries, global demand for livestock products is expected to rise sharply by 2050, particularly in developing nations [21,22].

This evolving demand requires sustainable intensification of animal production, particularly through improvements in livestock nutrition. In this context, local forage resources represent a strategic yet underexploited lever [23]. Thus, identifying and prioritizing the most suitable forage species is essential to ensure the sustainability of livestock systems and to effectively respond to the growing needs of herders [24,22]. Previous studies have explored the diversity of forage species in West Africa, often focusing on their identification and traditional use by livestock farmers [25,26,9,2,27]. However, few studies have addressed the issue of the availability of root splits in natural rangelands, a critical factor for establishing sustainable forage plots [28]. Most local species still lack certified seeds or seed production programs, limiting their scalability in dedicated forage production plots.

Other research, focused on scientific evaluation of forage species, has highlighted their nutritional potential and contribution to animal productivity [19,6,29–31,20], without addressing the life form of forage species. Yet, such characteristics are essential to understand species resilience to intensive grazing and drought. For example, hemicryptophytes exhibit strong resistance to grazing and drought [32,33], making them well-suited for areas under high pastoral pressure and climatic variability, particularly in West African agropastoral systems. Therefore, treating scientific and indigenous knowledge separately does not allow for harnessing the complementarity between these two approaches [34,35]. Combining them offers a unique opportunity to develop more effective forage species prioritization strategies that meet herders' real needs while considering ecological and economic imperatives. This enables

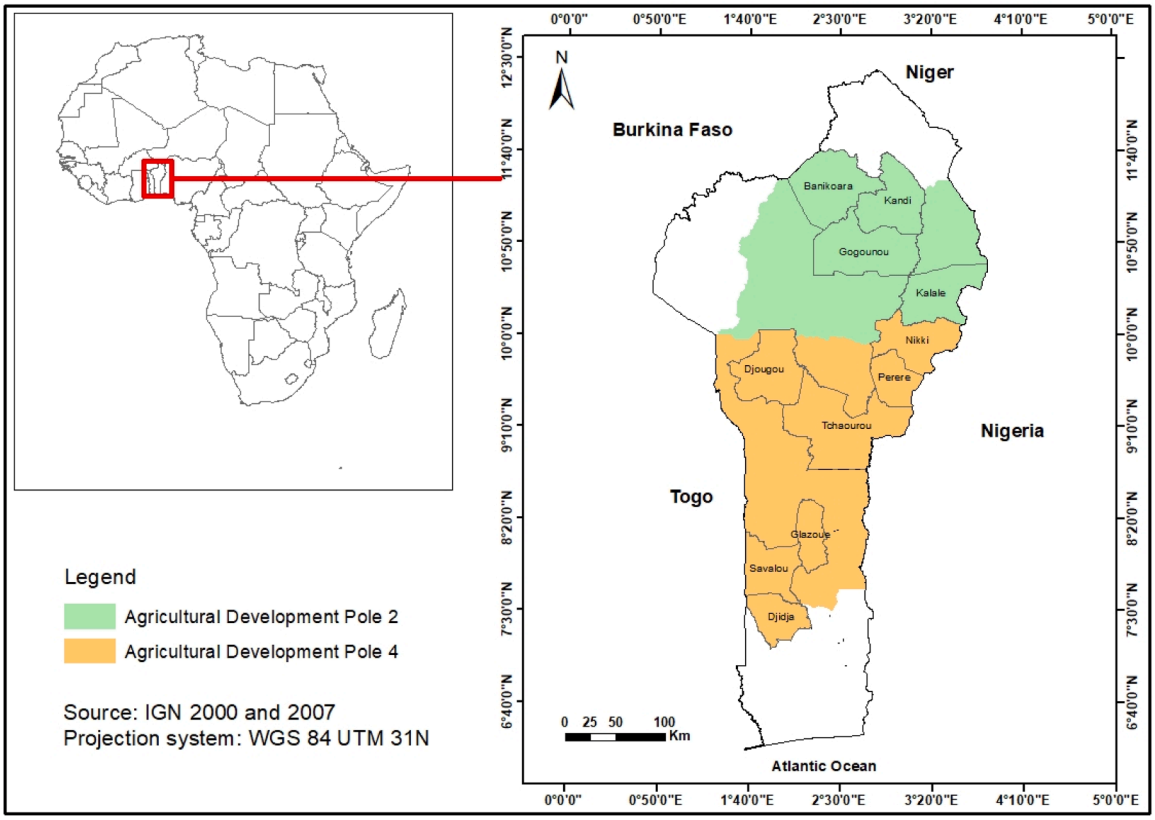



**Fig. 1.** Map of the study area.

more sustainable management of forage resources, thereby enhancing the resilience of production systems in the face of local challenges.

This study aims to prioritize local herbaceous forage species exploited by domestic livestock in Benin, to contribute to the development of a sustainable strategy for the production and utilization of these resources in agropastoral systems. Specifically, the study seeks to: (i) inventory the herbaceous forage species used by domestic livestock in Benin, (ii) prioritize these species according to agroecological criteria of interest, (iii) determine the criteria used by herders to select these species, and (iv) evaluate the nutritional composition of priority species to identify herbaceous forage species to integrate into forage production systems under climate change conditions.

## Materials and methods

### *Study area*

The study was conducted in Agricultural Development Poles (ADP) 2 and 4 (Fig. 1). ADP 2 includes the municipalities of Kandi, Banikoara, Ségbana, Gogounou, Kouandé, Kérou, Péhunco, Sinendé, Kalalé, and Bembérékè. ADP 4 covers Tchaourou, Parakou, N'Dali, Nikki, Pèrèrè, Djidja, Savalou, Bantè, Dassa-Zoumè, Glazoué, Savè, Ouèssè, Djougou, Ouaké, Bassila, and Copargo municipalities. According to data from the National Agricultural Census, these two ADPs have the largest livestock numbers in Benin [36]. ADP 2 experiences a Sudanian climate, with a dry season from November to April and a rainy season from June to September, annual precipitation below 1000 mm, and temperatures ranging from 24 °C to 31 °C. ADP 4 has a Sudano-Guinean climate, with a transitional rainfall pattern (bimodal-unimodal), average annual precipitation between 900 mm and 1110 mm, and temperatures from 25 °C to 29 °C [37]. Vegetation in both ADPs consists mainly of fallow lands, savannahs, woodland and dense dry forests, and riparian forests.

### *Sampling*

Data from the National Agricultural Census conducted by the Ministry of Agriculture, Livestock, and Fisheries [36] served as the basis for identifying the municipalities to be surveyed. First, livestock numbers (cattle, goats, and sheep) were compiled for each municipality within the study area (Table 1). A threshold of 2/5 was then applied within each ADP to select the municipalities with the highest livestock numbers. In total, four municipalities were selected from ADP 2 (Banikoara, Kalalé, Kandi, and Gogounou) and seven from ADP 4 (Tchaourou, Djougou, Savalou, Nikki, Djidja, Pèrèrè, and Glazoué) (Fig. 1). In each municipality, respondents were selected using simple random sampling. Interviews were conducted with herders with proven experience in domestic livestock farming (at least 20 years). A total of 330 herders were surveyed.

**Table 1**
Livestock numbers by municipality (Source: MAEP, 2019; https://dsa.agriculture.gouv.bj; accessed on April 5, 2024).

| ADP | Number | Municipalities | Livestock numbers by category | | | Total livestock numbers |
|---|---|---|---|---|---|---|
| | | | Cattle | Goats | Sheep | |
| 2 | 1 | Banikoara | 204 638 | 177 382 | 176 522 | 558 542 |
| | 2 | Kalalé | 198 625 | 81 210 | 125 178 | 405 013 |
| | 3 | Kandi | 112 744 | 78 713 | 75 224 | 266 681 |
| | 4 | Gogounou | 123 887 | 57 540 | 56 909 | 238 336 |
| | 5 | Ségbana | 64 233 | 41 493 | 34 352 | 140 078 |
| | 6 | Kérou | 42 329 | 41 782 | 39 114 | 123 225 |
| | 7 | Bembérékè | 45 314 | 33 117 | 26 078 | 104 509 |
| | 8 | Péhunco | 38 006 | 28 695 | 31 428 | 98 129 |
| | 9 | Sinendé | 39 933 | 28 035 | 28 820 | 96 788 |
| | 10 | Kouandé | 35 113 | 27 962 | 30 916 | 93 991 |
| 4 | 1 | Tchaourou | 87 724 | 40 181 | 48 234 | 176 139 |
| | 2 | Djougou | 56 086 | 82 762 | 74 831 | 213 679 |
| | 3 | Savalou | 43 228 | 95 453 | 47 689 | 186 370 |
| | 4 | Nikki | 72 102 | 45 972 | 54 988 | 173 062 |
| | 5 | Djidja | 35 831 | 40 397 | 58 371 | 134 599 |
| | 6 | Pèrèrè | 50 397 | 25 558 | 28 825 | 104 780 |
| | 7 | Glazoué | 24 179 | 44 848 | 31 449 | 100 476 |
| | 8 | Bassila | 36 837 | 26 062 | 36 677 | 99 576 |
| | 9 | N'Dali | 34 224 | 34 224 | 29 735 | 98 183 |
| | 10 | Dassa-Zoumè | 29 515 | 39 882 | 24 695 | 94 092 |
| | 11 | Copargo | 12 589 | 42 735 | 19 197 | 74 521 |
| | 12 | Ouaké | 20 996 | 22 077 | 30 220 | 73 293 |
| | 13 | Ouèssè | 28 144 | 20 307 | 20 732 | 69 183 |
| | 14 | Bantè | 16 339 | 33 990 | 13 979 | 64 308 |
| | 15 | Savè | 26 208 | 24 329 | 13 118 | 63 655 |
| | 16 | Parakou | 8 760 | 9 328 | 7 656 | 25 744 |

ADP = Agricultural Development Pole.

*Data collection*

We combined ethnobotanical surveys and field-based tracking of cattle herds to collect data on forage herbaceous species between July and December 2024. In this paper, we use the term "forage herbaceous species" to refer both to herbaceous plants that are directly grazed by livestock in natural pastures and those that are cut or harvested and then brought to the animals. Data collected during the ethnobotanical surveys included the socio-demographic characteristics of respondents, the forage herbaceous species used in feeding domestic livestock, grazing or harvesting areas, trends in the availability of each species (e.g., species becoming increasingly rare in pastures and reasons for this decline), and the reasons for choosing each species for livestock feeding (e.g., meat production, milk production, draft animals, or biodiversity conservation). The age categories of the respondents were defined as follows: youth (18–30 years), adults (30–60 years), and elders ($\geq$ 60 years) [38,39]. We defined three levels of species availability using scores, and each herder was asked to assign a score for each species: Rare = 1, Less abundant = 2, Abundant = 3. To ensure proper identification of species, local names for each were recorded.

Field-based tracking of cattle herds was carried out in collaboration with herders to confirm the presence of the reported species during interviews and to verify the accuracy of the collected information. During these field-based tracking, livestock grazing monitoring were conducted to determine the Palatability Index (PI) of each forage herbaceous species. This grazing monitoring involved directly observing the feeding behavior of free-ranging animals on natural pastures, to identify the herbaceous species they consume spontaneously. This method allowed us to assess both the frequency and preference of consumption for each species, and to estimate their palatability level. A PI score was assigned to each species on a scale from 1 to 4, based on its attractiveness to livestock: PI = 1 (species poorly grazed by livestock), PI = 2 (moderately grazed species), PI = 3 (well-grazed species), PI = 4 (highly preferred species). Samples of the confirmed forage species were collected and stored in newspaper sheets for botanical identification in the laboratory after returning from the field. Identification was carried out by experienced botanists using the dried specimens and based on dichotomous keys and morphological descriptions from the *Flore du Bénin* [40,41].

*Data analysis*

Initially, the survey data were analyzed to verify whether the mentioned forage species were truly indigenous or local species. The geographical origin of each species was checked using scientific literature to confirm their status as local species. Next, we used four criteria to rank the confirmed local forage herbaceous species: life form, palatability index, species availability, and nutritional composition. The life form used were those defined by Raunkiaer [42] for herbaceous species: Geophytes (perennial plants whose renewal buds are located below the soil surface), Hydrophytes (aquatic plants with persistent buds located at the bottom of water bodies), Hemicryptophytes (perennials with renewal buds at the soil surface), Therophytes (annual plants that produce spores or seeds during a single life cycle). Each life form was assigned a score based on its resistance to grazing and drought: Hydrophytes = 0, Geophytes = 1, Therophytes = 2, Hemicryptophytes = 3. Similarly, the Citation Frequency (CF) for each availability level was calculated, and only the level with the highest frequency was considered for each species. CF = NC / NTC, where NC is the Number of Citations for a given availability level, and NTC is the Total Number of Citations for the species. The sum of scores for life form, palatability index, and availability level was then calculated for each forage herbaceous species, and only those with higher scores were considered. Based on this ranking, the top six forage grasses were selected for nutritional composition analysis in the laboratory.

Data analyses were performed using R 4.3.3 software [43]. A generalized linear model with a beta error structure was used to test the effect of the palatability index and abundance on the citation frequency of species by respondents. This analysis was performed using the betareg package [44]. To determine whether there was a relationship between the forage species used and the reasons behind their selection, an exact Fisher's test was conducted.

*Nutritional composition analysis*

Samples of prioritized forage grasses were collected, sub-sampled, and then oven-dried at 60 °C for 72 h. The resulting powder obtained after grinding was used to determine the contents of total nitrogen, crude protein, calcium (Ca), magnesium (Mg), potassium (K), sodium (Na), and phosphorus (P) at the *Laboratoire d'Appui à l'Amélioration de la Santé des Sols, de la Qualité des Eaux et de la Sauvegarde l'Environnement (L2A2S2E)* of the National Institute of Agricultural Research of Benin (INRAB). Nitrogen content was measured using the micro-Kjeldahl method. This method involves hot digestion with concentrated sulfuric acid in the presence of a potassium sulfate-based catalyst, followed by steam micro-distillation using a normal sodium hydroxide solution. The distillate was collected in a boric acid solution and then titrated with sulfuric acid in the presence of a methyl red indicator. The nitrogen content obtained was multiplied by the factor 6.25 to calculate the crude protein content. For the analysis of mineral elements (Ca, Mg, K, Na, P), the ground samples were incinerated in a muffle furnace at 450 °C for 24 h. The resulting ash was dissolved in 5 mL of 6 N hydrochloric acid (HCl), then evaporated to dryness on a hot plate at 125 °C [45]. The residue was re-dissolved in diluted nitric acid. Metal concentrations (Ca, Mg, K, Na) were determined by atomic absorption spectrophotometry (AAS). Total phosphorus was quantified by colorimetry, following hot formation of a colored complex using ammonium molybdate and ascorbic acid [46,47].

## Results

### *Diversity and abundance of forage herbaceous species*

In total, 42 herbaceous forage species were identified during the surveys and confirmed through pasture walks (Table 2). These species are distributed across three botanical families: Poaceae, Cyperaceae, and Iridaceae, with Poaceae representing the vast majority of species (95.24%; Fig. 2).

The palatability index did not have a significant effect on the citation frequency of the species ($\beta = 0.018 \pm 0.150$, $P = 0.904$, Table 2). In contrast, the abundance of species in grazing areas had a negative influence on their citation frequency, particularly for less abundant species ($\beta = 1.915 \pm 0.387$, $P < 0.001$, Table 2) and rare species ($\beta = 2.623 \pm 0.383$, $P < 0.001$, Table 2). The most abundant species received the highest citation frequency.

### *Prioritization of forage herbaceous species*

The prioritization method used made it possible to identify the top six local forage herbaceous species (Table 3), which are: *Andropogon chinensis, Andropogon gayanus, Andropogon tectorum, Brachiaria falcifera, Hyparrhenia smithiana,* and *Panicum maximum* local.

### *Criteria for selecting local forage herbaceous species for livestock feeding*

The results of the Fisher's exact test show that there is no significant relationship between the forage species used in livestock feeding and the reasons behind their selection (p-value = 1). All six prioritized species are used as dietary supplements, not only to compensate for forage shortages, but also due to their strong ability to improve milk and meat production (Fig. 3). In addition to enhancing animal productivity, *A. gayanus* (7.59%), *A. chinensis* (5.06%), and *A. tectorum* (3.79%) are also used for the valorization of local biodiversity.

### *Nutritional composition of prioritized forage herbaceous specie*

Among the six prioritized local forage herbaceous species, *H. smithiana* has the highest crude protein content (12.18% DM), followed by *P. maximum* local (7.12% DM) and *A. gayanus* (6.95% DM) (Table 4). In contrast, *A. tectorum* exhibits the lowest crude protein content (3.61% DM). Total nitrogen levels follow a similar trend, confirming the superior nutritional value of *H. smithiana* and *P. maximum* local.

Regarding mineral content, *P. maximum* local stands out with higher concentrations of calcium (0.34% DM), magnesium (0.31% DM), and potassium (1.37% DM). *H. smithiana* also shows good levels of calcium (0.25% DM) and potassium (0.76% DM), along with a high sodium content (698.53% DM). Phosphorus levels remain relatively low for most species, except for *P. maximum* local (0.19% DM) and *H. smithiana* (0.14% DM), which display the highest concentrations of this key element in animal metabolism.

## Discussion

The sustainability of agropastoral systems in West Africa, and particularly in Benin, is currently threatened by the degradation of natural pastures, climate variability, and increasing pressure on forage resources [48–50]. In this context, the identification and promotion of local herbaceous species used in livestock feeding emerge as a key solution to enhance the resilience and productivity of agropastoral farms [2,23]. This study aims to contribute to that sustainability by prioritizing local forage species based on their agroecological value, nutritional content, and relevance to herders' practices. By integrating indigenous knowledge with scientific data, it seeks to provide a strong foundation for the development of adapted forage production strategies capable of addressing livestock feed challenges while ensuring the sustainable management of natural resources.

### *Diversity and abundance of forage herbaceous species*

We identified 42 herbaceous forage species in the studied grazing areas. This species richness can be influenced by several factors,

**Table 2**
Beta regression testing the effect of palatability index and abundance on species citation frequency.

| Variables | β | SE | T | P |
|---|---|---|---|---|
| Intercept | −1.588 | 0.683 | −2.325 | 0.020* |
| Less abundant | −1.915 | 0.387 | −4.955 | 7.23e-07*** |
| Rare | −2.623 | 0.382 | −6.853 | 7.25e-12*** |
| Palatability index | 0.018 | 0.150 | 0.121 | 0.904 |

β = Estimate, SE = Standard Error, T = T-student, P = probability value, * = $P < 0.05$,
** = $P < 0.01$, *** = $P < 0.001$.

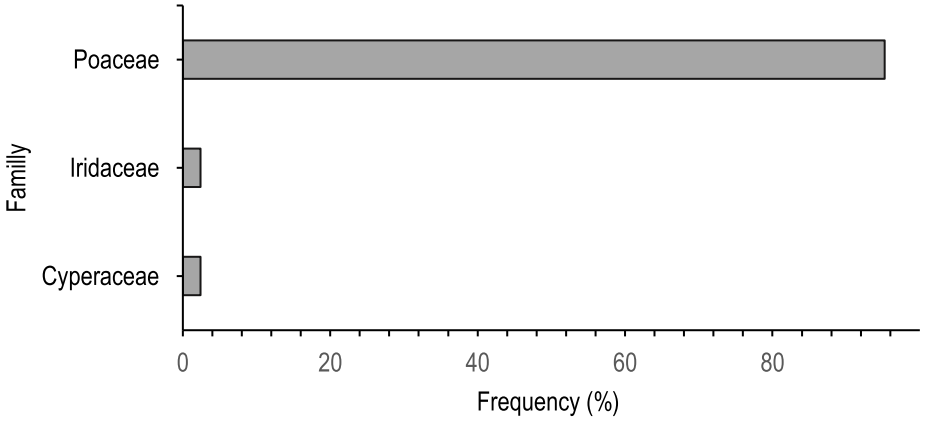



**Fig. 2.** Distribution of forage herbaceous species by botanical family.

**Table 3**
Prioritization of identified forage herbaceous species.

| Species | Familly | Life form | Palatability index | Species availability | Total score |
|---|---|---|---|---|---|
| *Andropogon chinensis* | Poaceae | 3 | 4 | 2 | 9 |
| *Andropogon gayanus* | Poaceae | 3 | 4 | 2 | 9 |
| *Andropogon tectorum* | Poaceae | 3 | 4 | 2 | 9 |
| *Brachiara falcifera* | Poaceae | 3 | 4 | 2 | 9 |
| *Hyparrhenia smithiana* | Poaceae | 3 | 4 | 2 | 9 |
| *Panicum maximum* local | Poaceae | 3 | 4 | 2 | 9 |
| *Pennisetum polystachion* | Poaceae | 2 | 3 | 3 | 8 |
| *Andropogon fastigiatus* | Poaceae | 3 | 4 | 1 | 8 |
| *Andropogon schirensis* | Poaceae | 3 | 4 | 1 | 8 |
| *Brachiaria jubata* | Poaceae | 3 | 4 | 1 | 8 |
| *Brachiaria lata* | Poaceae | 3 | 4 | 1 | 8 |
| *Cymbopogon giganteus* | Poaceae | 3 | 4 | 1 | 8 |
| *Hyparrhenia involucrata* | Poaceae | 3 | 4 | 1 | 8 |
| *Hyparrhenia rufa* | Poaceae | 3 | 4 | 1 | 8 |
| *Hyparrhenia tamba* | Poaceae | 3 | 4 | 1 | 8 |
| *Paspalum notatum* | Poaceae | 3 | 4 | 1 | 8 |
| *Saccharum ravennae* | Poaceae | 3 | 4 | 1 | 8 |
| *Setaria megaphylla* | Poaceae | 3 | 3 | 2 | 8 |
| *Acroceras amplectens* | Poaceae | 3 | 3 | 1 | 7 |
| *Cynodon dactylon* | Poaceae | 3 | 3 | 1 | 7 |
| *Digitaria ciliaris* | Poaceae | 3 | 3 | 1 | 7 |
| *Digitaria horizontalis* | Poaceae | 3 | 3 | 1 | 7 |
| *Echinochloa stagnina* | Poaceae | 3 | 3 | 1 | 7 |
| *Gladiolus gregarius* | Iridaceae | 3 | 3 | 1 | 7 |
| *Heteropogon contortus* | Poaceae | 3 | 3 | 1 | 7 |
| *Ischaemum rugosus* | Poaceae | 3 | 3 | 1 | 7 |
| *Loudetiopsis ambiens* | Poaceae | 3 | 3 | 1 | 7 |
| *Panicum capillare* | Poaceae | 3 | 3 | 1 | 7 |
| *Pennisetum pedicellatum* | Poaceae | 2 | 4 | 1 | 7 |
| *Pennisetum unisetum* | Poaceae | 2 | 4 | 1 | 7 |
| *Schizachyrium sanguineum* | Poaceae | 3 | 3 | 1 | 7 |
| *Setaria parviflora* | Poaceae | 3 | 3 | 1 | 7 |
| *Sorghastrum bipennatum* | Poaceae | 3 | 3 | 1 | 7 |
| *Sorghum arundinaceum* | Poaceae | 3 | 3 | 1 | 7 |
| *Chasmopodium caudatum* | Poaceae | 2 | 3 | 1 | 6 |
| *Eragrostis tremula* | Poaceae | 3 | 2 | 1 | 6 |
| *Rottboellia cochinchinensis* | Poaceae | 3 | 2 | 1 | 6 |
| *Sporobolus pyramidalis* | Poaceae | 3 | 2 | 1 | 6 |
| *Imperata cylindrica* | Poaceae | 1 | 2 | 2 | 5 |
| *Paspalum scrobiculatum* | Poaceae | | 4 | 1 | 5 |
| *Fimbristylis hispidula* | Cyperaceae | 1 | 1 | 2 | 4 |
| *Monocymbium ceresiiforme* | Poaceae | | 3 | 1 | 4 |

including local ecological conditions, grazing management practices, and the empirical knowledge of herders regarding available resources [2,3,49,51]. Anthropogenic pressures such as overexploitation, overgrazing, and land-use changes, combined with invasive species and the effects of climate change, have led to a significant reduction in the biodiversity of natural pastures [52–56]. These

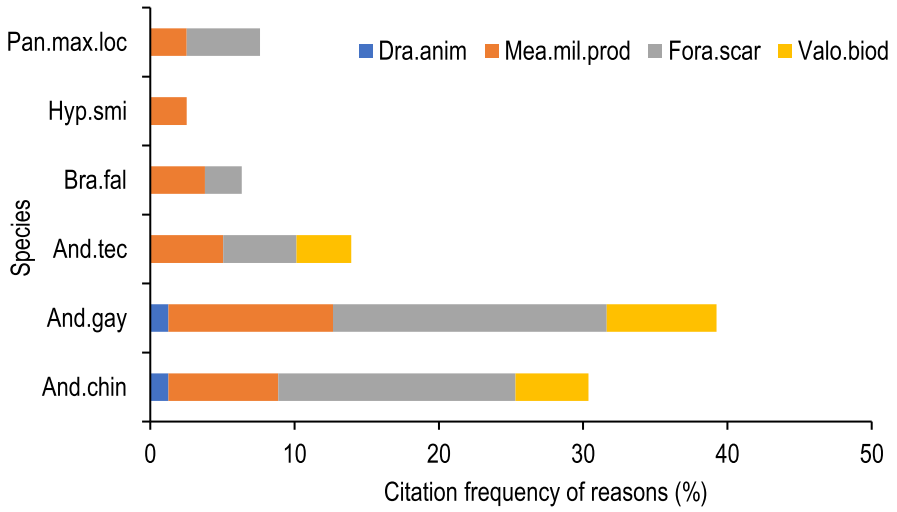



**Fig. 3.** Criteria for selecting species in livestock feeding. Dra.anim = Draft animals, Mea.mil.prod = Meat and milk production, Fora.scar = Forage scarcity, Valo.biod = Valorization of biodiversity, And.chin = Andropogon chinensis, And.gay = Andropogon gayanus, And.tec = Andropogon tectorum, Bra.fal = Brachiara falcifera, Hyp.smi = Hyparrhenia smithiana, Pan.max.loc = Panicum maximum local.

**Table 4**
Nutritional composition of prioritized local forage herbaceous species.

| Nutritional elements | *Andropogon chinensis* | *Andropogon gayanus* | *Andropogon tectorum* | *Brachiara falcifera* | *Hyparrhenia smithiana* | *Panicum maximum* local |
|---|---|---|---|---|---|---|
| Total Nitrogen (% DM) | 0.97 | 1.11 | 0.58 | 0.91 | 1.95 | 1.14 |
| Crude Protein (% DM) | 6.07 | 6.95 | 3.61 | 5.72 | 12.18 | 7.12 |
| Total Calcium (% DM) | 0.08 | 0.21 | 0.24 | 0.16 | 0.25 | 0.34 |
| Total Magnesium (% DM) | 0.11 | 0.11 | 0.12 | 0.16 | 0.11 | 0.31 |
| Total Potassium (% DM) | 0.86 | 1.33 | 0.27 | 0.96 | 0.76 | 1.37 |
| Total Sodium (mg/kg DM) | 436.64 | 379.02 | 258.61 | 408.43 | 698.53 | 670.65 |
| Total Phosphorus (% DM) | 0.04 | 0.07 | 0.07 | 0.08 | 0.14 | 0.19 |

Ca = Calcium, P = Phosphorus, K = Potassium, Mg = Magnesium, Na = Sodium, DM = Dry Matter.

degradation processes may favor the gradual disappearance of the most vulnerable species, particularly those most preferred by animals due to high consumption [57,58]. Likewise, herders' knowledge plays a crucial role in perceiving and identifying available forage species. Local knowledge, often transmitted empirically, varies by region, community, and livestock practices, which can influence the recognition and use of forage resources [51]. Thus, limited familiarity with certain species could explain why some are not mentioned or used [2,59]. Ouachinou et al. [2] identified and confirmed 52 herbaceous forage species in a similar context in Benin. This difference could reflect a better knowledge of local resources in their study area or a more favorable conservation status of the grazing lands [24,51]. It could also result from methodological differences in data collection or in the criteria for selecting species included [60].

We observed that species abundance in grazing areas had a significant influence on their citation frequency, with the most abundant species recording the highest citation rates. This can be explained by the fact that species with low abundance in pastures are less visible and less accessible to herders on a daily basis [12,61]. Indeed, herders tend to favor species they encounter frequently and that are abundant, as these immediately meet the nutritional needs of their livestock [12,60]. Rare species, although sometimes highly nutritious or highly palatable, are often underutilized due to their unavailability [61,62]. Herders may avoid mentioning these species either due to a lack of familiarity or because of the difficulty in collecting or preserving them within grazing systems [62,60]. These findings highlight the importance of considering not only species abundance in the field but also herders' perceptions and practices when evaluating and prioritizing forage species [51,59,61,63].

The prioritization method applied led to the selection of six herbaceous forage species, including *A. gayanus*. The prioritization of *A. gayanus* for the establishment of forage plots was also highlighted by Ousseina et al. [28] and Ekeocha et al. [64]. This species is well adapted to local climatic and soil conditions and possesses traits that make it a top choice for animal feeding [65,66]. Its high drought

tolerance and ability to produce abundant biomass make it a key species in grazing systems in West Africa [28,64]. Similar characteristics are also observed in species such as *A. chinensis, A. tectorum*, and *P. maximum* local [67,68].

*Link between local knowledge and the nutritional composition of priority species*

The results from ethnobotanical surveys and nutritional composition analysis of prioritized local forage herbaceous species reveal an intriguing consistency, highlighting the integration of empirical knowledge in the management of forage resources in Benin. Indeed, although Fisher's exact test indicates no statistically significant relationship between the species used and the motivations of herders (p-value = 1), all prioritized species are unanimously valued for their ability to enhance milk and meat production. This observation reflects a shared recognition of the nutritional qualities of these plants, regardless of the specific reasons behind their individual selection [2,67]. This local perception is supported by the results of nutritional composition analysis. The forage grasses ranked as highly prioritized by local communities also contained adequate amounts of protein. For instance, *H. smithiana*, locally acknowledged as highly effective for animal productivity, exhibits the highest crude protein content (12.18%), a key nutritional criterion to support growth and lactation in ruminants [6,69]. Similarly, *P. maximum* local and *A. gayanus* show crude protein contents above 6%, confirming their relevance for animal feeding [28]. Conversely, *A. tectorum*, despite its lower protein content, is also valued for its contribution to local biodiversity. This suggests that selection criteria are not based solely on nutritional value, but also on ecosystem and cultural functions [68].

Moreover, the mineral richness observed in *P. maximum* local (notably in calcium, magnesium, potassium, and phosphorus) and in *H. smithiana* (with a high sodium content) confirms the usefulness of these species in formulating balanced rations to optimize animal production [70]. This complementarity between local knowledge and laboratory analysis indicates that herders, through experience, have naturally identified species that offer a good nutritional balance, even if their selection is not always based on explicitly stated motivations. These findings align with the data reported by Harun et al. [69], who supported the positive association between the results of forage species' nutritional composition analyses and herders' ethnobotanical knowledge. Therefore, traditional knowledge should not be overlooked and must be leveraged as an approach for better understanding the nutritional potential of local forage resources under prevailing environmental conditions. However, laboratory-derived nutritional compositions remain essential for formulating nutrient-rich diets in order to optimize the use of local feed resources and promote both livestock health and environmental sustainability.

*Implications for sustainable and resilient agropastoral systems*

The selection of local herbaceous forage species with high nutritional value, such as *H. smithiana* and *P. maximum* local, significantly enhances milk and meat production. This directly addresses the needs of herders facing forage shortages during dry seasons, while promoting sustainable zootechnical performance [5,23]. Similarly, the valorization of locally available species in grazing areas, particularly those that are abundant, perennial, and well adapted to local ecological conditions, offers a credible alternative to pastoral mobility. This mobility is often associated with land conflicts, land degradation, and climate variability [16,71]. As a result, it encourages a safer and more controlled form of partial sedentarization. Moreover, the convergence between herders' perceptions and the nutritional composition of prioritized grasses shows that empirical knowledge is relevant for informing technical decisions. This reinforces the legitimacy of a participatory approach in the management of pastoral resources, encouraging local ownership of agroecological innovations [72].

The ranking of species using multivariate approaches such as life form, palatability indices, the availability of species in grazing areas, and nutritional composition helps guide forage production policies toward the most effective and widely accepted species by herders. These data are essential for establishing forage cultivation programs that are adapted to climate change, reducing yield losses and nutritional deficiencies [69]. Furthermore, some of the identified species, particularly *P. maximum* local and *H. smithiana*, exhibit good nutritional value and broad ecological adaptability, making them strategic resources for production systems facing climatic stress. Their integration into forage practices could help stabilize yields during drought periods and diversify animal feed resources, thereby contributing to the overall resilience of agropastoral systems. Additionally, the complementary use of *A. chinensis, A. gayanus*, and *A. tectorum* for enhancing local biodiversity highlights their multifunctional role and their contribution to the sustainability of pastoral practices. This supports conservation-through-use strategies that align with the principles of agroecology and sustainable development [73].

## Conclusion

This study provided a better understanding of the diversity of herbaceous forage species utilized by domestic livestock in Benin and identified those with the greatest potential for sustainable integration into forage production systems. A total of 42 herbaceous forage species were recorded. Using a multivariate approach, six herbaceous species were prioritized, among which *H. smithiana* and *P. maximum* local stood out for their richness in crude protein and essential mineral elements. These species therefore offer strong potential to enhance milk and meat productivity while reducing the vulnerability of livestock systems to seasonal forage shortages. The consistency between the uses reported by herders and the nutritional composition of priority species shows that local knowledge, though intuitive, is based on careful observation of the zootechnical performance of plant resources. This complementarity between indigenous knowledge and scientific data represents a key lever for guiding policies aimed at the ecological intensification of livestock farming. It would thus be useful to deepen research on the agronomic performance of priority species in different agroecological

contexts, particularly regarding their drought resistance, biomass yield, and natural regeneration. Experimental trials should also be conducted to evaluate the direct effects of these species on digestibility, weight gain, and milk production in order to consolidate their zootechnical relevance. The development of techniques for the production, harvesting, storage, and conservation of seeds from these local species is also a research priority to ensure their availability and promote their widespread adoption in large-scale farming systems. Additionally, varietal selection and genetic improvement efforts could help enhance their performance and adaptability to climatic variability. These research avenues would contribute to the strengthening of more sustainable and resilient agropastoral systems based on the valorization of local plant resources.

## Credit authorship contribution statement

**A.M. Koutchoro:** Conceptualization, Data curation, Formal analysis, Project Administration, Funding acquisition, Methodology, investigation, Validation, Software, Visualization, Resources, Writing – original draft, Writing – review & editing. **L.G. Houessou:** Conceptualization, Methodology, Validation, Supervision, Writing – original draft, Writing – review & editing. **A.S. Yaoitcha:** Conceptualization, Methodology, Supervision, Writing – review & editing. **N.V.F.G. Dedehou:** Methodology, Validation, Writing – review & editing. **T.D. Houehanou:** Methodology, Writing – review & editing.

## Data availability statement

Data will be made available on request.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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