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Characterization and Valorization of Fodder Plants Consumed by Ruminants in the Far North Region of Cameroon

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Abstract

This study characterizes fodder plants consumed by ruminants in five departments of Cameroon's Far North region through farmer interviews and direct observation. It identifies 65 herbaceous and 29 woody species, with Poaceae and Fabaceae being the dominant families. The findings indicate that leaves are the primary plant part consumed and highlight key forage species such as *Pennisetum purpureum* and *Faidherbia albida*.

Keywords

Cameroon, Characterization, Far North, Fodder, Ruminants, Valorization

1. Introduction

In the quest to achieve food self-sufficiency and reduce expenses related to the importation of animal products, Cameroon is leveraging the potential of its Sudano-Sahelian regions. The Far North region of Cameroon, located in the Sudano-Sahelian agro-ecological zone, is characterized by an arid climate and a long dry season that significantly affect livestock production systems and the availability of forage resources. An accelerated degradation of vegetation cover, a decrease in forage productivity, a decline in perennial nutritious species, and a proliferation of non-palatable or invasive species are observed [1]-[3]. This degradation leads to an imbalance between forage supply and livestock needs, resulting in decreased animal productivity (low weight gains, increased mortality), growing conflicts be-

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tween herders and farmers, and increased economic vulnerability of pastoral populations. In this context, understanding the diversity, productivity, and nutritional value of local forage plants is crucial for ensuring the sustainability of ruminant farming. This study aims to characterize forage resources—both herbaceous and woody—in five departments of the region (Diamaré, Mayo-Sava, Mayo-Tsanaga, Mayo-Danay, and Mayo-Kani), by assessing their species diversity, abundance, biomass productivity, and carrying capacity. The ultimate goal is to establish a reliable database for rational pastoral management and optimized animal feeding in a challenging environment.

2. Materials and Methods

2.1. Study Area Presentation

The study covered the Far North Region of Cameroon. The region covers an area of 34,260 km^2 (Figure 1). The annual rainfall in this region varies from 500 to 900 mm per year, with averages between 750 and 800 mm. The rainy season lasts only four to five months. The Mandara Mountains are wetter with an average annual rainfall of 900 mm; the less rainy areas are the Diamaré (750 mm) and Logone (450 mm) plains. The vegetation consists of wooded savannah, a poorly developed herbaceous cover, and forest galleries.

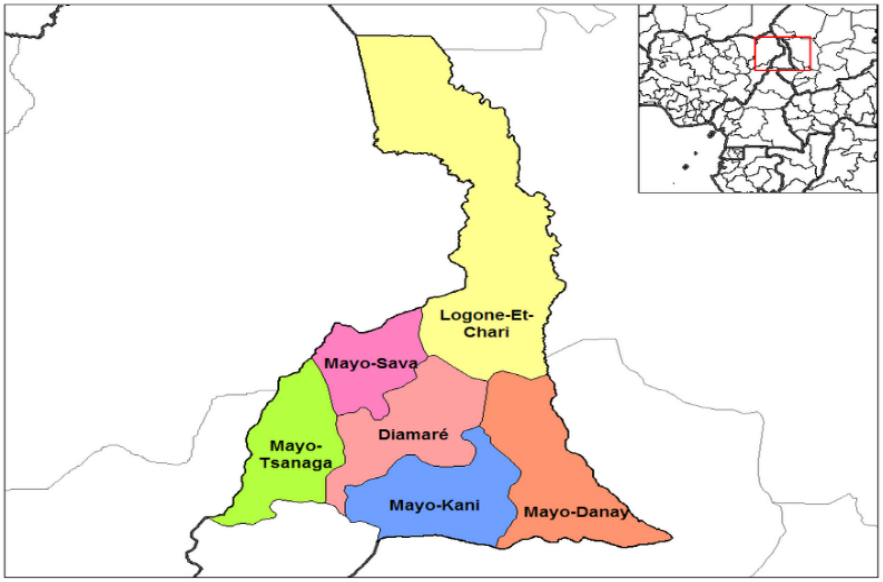

Figure 1. Map of the Far North region.

2.2. Satellite Imagery of the Study Area

The choice of satellite imagery focused on the Landsat vector, whose sensor characteristics include channels in the visible and mid-infrared, useful for discriminating land cover classes [4]. These images were selected based on visual assessment and the metadata of cloud cover available in the image download package for the area of interest. The cloud cover percentage values range from 0.09% to

29%. Percentages below 5% cloud cover are the most dominant. The resolution of the Landsat images used is 30 m in multispectral for the year 2025. The acquisition periods are from September to October of the year. Thus, for the year, the selected images have the following characteristics: Image ID (image identification code), Image Date (date of image acquisition by the satellite sensor), % Cloud Cover, WRS Path/Row (location characteristics of the image on a Landsat grid), Satellite Sensor (instrument measuring electromagnetic radiation reflected by objects on the ground in different wavelengths), Service Years (year of satellite commissioning and decommissioning). Based on visual analysis, the set of color composites, and the analysis of different spectral signatures of objects on the image, we detected a number of land cover classes. The retained classes are as follows (Figure 2):

- Herbaceous savannah: light green and lemon green
- Wooded savannah
- Bare soil and built-up areas
- Water surface
- Cropland

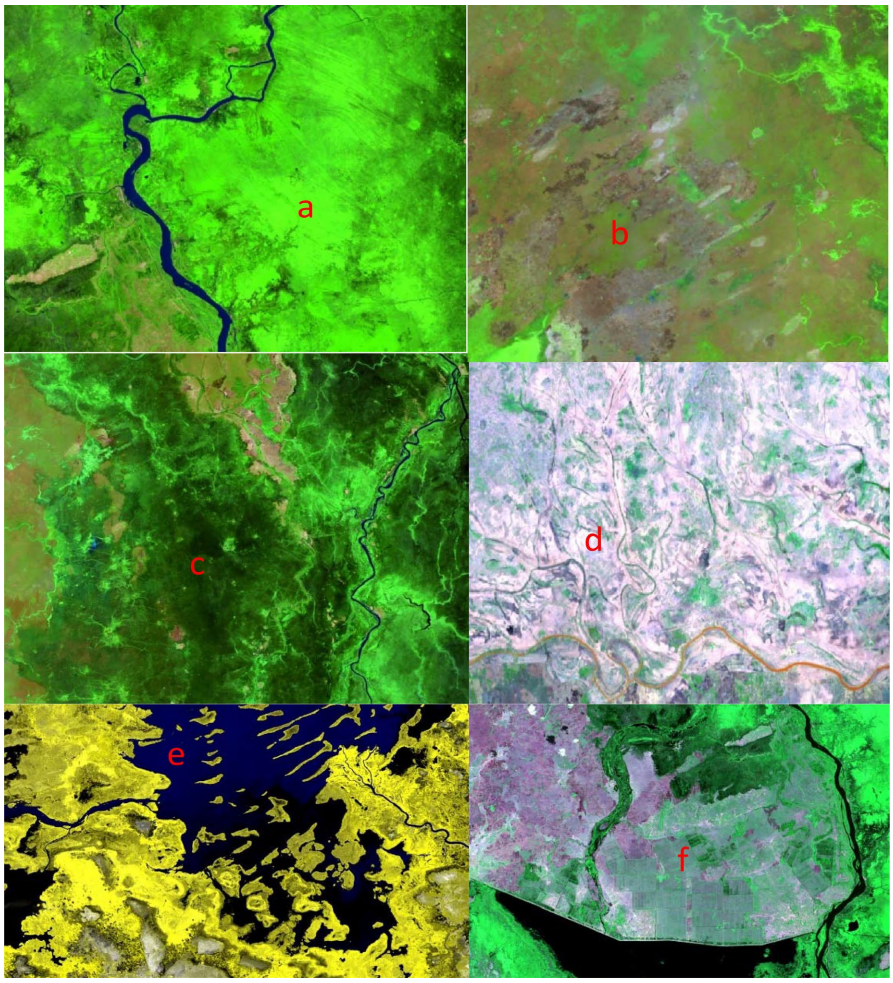

Figure 2. Herbaceous savannah (a) (b), Wooded savannah (c), Bare soil and built-up areas (d), Water surface (e), and Cropland (f).

The spectral signatures and land cover classes, such as herbaceous savanna and cropland, were directly correlated with field-verified data on forage species abundance, where classes like "herbaceous savanna" were found to be dominated by key forage grasses such as *Pennisetum purpureum*, *Cynodon dactilon*, *Eragrostis tef*, *Dactylis glomerata*, *Dactyloctenium aegyptium* and *Panicum repens*, while "wooded savanna" indicated the prevalence of browse species like *Acacia albida*, *Paliostigma reticulatum*, *Faidherbia albida* and *Balanites aegyptiaca*.

2.3. Sampling

The departments where cattle, goat, and sheep rearing were most representative were identified at the Regional Delegation of Livestock, Fisheries, and Animal Industries of the Far North Cameroon. These were the departments of Mayo-Tsanaga, Mayo-Kani, Mayo-Danay, Mayo-Sava, and Diamaré. In these different departments, the snowball principle was used to identify the various breeders with a minimum of two years of experience in the field and having a significant herd (minimum 10 head). Based on a data collection form, breeders were asked to provide information on the forage species consumed by livestock, their vernacular names, the parts of plants consumed, their level of palatability to the animals. Subsequently, with the permission of the breeders, direct observation of animals on the range was conducted to identify the grazed resources and their phenological stage at the time of grazing. The number of breeders surveyed, broken down by department, I summarized in the following Table 1.

Table 1. Questionnaire distributions in the different Divisions of Far North Cameroon.

Department	No. of Questionnaires
Mayo-Tsanaga	48
Mayo-Kani	50
Mayo-Danay	45
Mayo-Sava	36
Diamaré	30

2.4. Species Identification

Forage species were identified based on botanical guides and by consulting researchers specialized in the field. The botanical guides used were Geerling's guide to woody plants [5], Van der Zon's Grasses of Cameroon [6], Merlier and Montegut's Tropical Weeds [7]. According to the different guides listed, the identification of forage plants is based on their morphological characteristics, which differ from one plant to another by the shape of flowers, stems, and leaves. Species that could not be identified on site were taken to the National Herbarium of Cameroon (H.N.C) for taxonomic identification.

2.5. Herbaceous Biomass Productivity

To assess herbaceous biomass productivity, the complete harvest method [8] was

used. The harvest was done inside unit plots of 1 m^2 (**Figure 3**). About ten plots were distributed randomly on the rangeland as recommended by [9]. Thus, on each vegetation unit, the randomly distributed unit plots were completely mowed using shears at a height of 5 cm from the ground. For each vegetation unit, a total of 3 mowings were performed. After mowing, the following operations were carried out: recording the wet weight of the total biomass using a 5 kg ± 50 g spring balance; performing manual sorting by separating consumed forage species from non-consumed species. Subsequently, a 100 g forage sample was taken, then dried in an oven at 60˚C until a constant dry weight was obtained after two or three weighings in the laboratory. From the dry weights of the samples, the biomass production in dry matter per hectare was obtained by extrapolation. To obtain the average biomass production per plot, divide the productions obtained during the three successive mowings by three, which gives the average phytomass per vegetation unit.

Figure 3. Installation of a 1 m^2 plot.

2.6. Woody Biomass Productivity

The leaf biomass of woody forages consumed by cattle was assessed in the different survey areas. The method used is known as the non-destructive method as described by [10]. It first consists of determining the density of a species using the following formula:

$$D = \frac{N}{S}$$

With N: the number of individuals of a species in the survey and S the sampled area (0.25 ha = 2500 m^2).

Then, two individuals of each woody forage were chosen at random to assess the leaf biomass. The total number of branches per individual was counted (Nbr) and the leaf biomass of two randomly chosen branches were cut and weighed (BMbr) using a 5 kg capacity spring balance (**Figure 4**). Samples of 150 g of leaves were taken per branch and placed in an oven at 60˚C for 72 hours for the determination of dry matter using the formula:

$$\%DM = \frac{\text{Dry weight of the Sample}}{\text{Fresh weight of the sample}} * 100$$

The dry leaf biomass of each individual (LBInd) of woody species was calculated using the formula:

$$LBInd\ (kg\ DM/plant) = BMbr \times Nbr \times \%DM$$

With LBInd: Leaf biomass per individual; BMbr: average biomass of the cut branches; NBr: Total number of branches counted and DM: Dry Matter.

The estimation of the average dry leaf biomass (LBA) per hectare for a species was calculated using the density of individuals of the corresponding woody forage species using the formula:

$$LBA\ (kg\ DM/ha) = LBInd \times D$$

With LBInd: Leaf biomass per individual and D: the density of individuals for the considered woody species.

Figure 4. Pruning branches and weighing leaf biomass.

2.7. Carrying Capacity

According to [11], the weight of tropical cattle ranges between 200 to 400 kg, which allows defining the tropical livestock unit (TLU) as corresponding to a maintenance bovine of 250 kg. Also, according to the same author, it is estimated that 1/3 of the biomass is the actual forage available for consumption by cattle, and 6.25 kg is the daily dry matter consumption of the TLU on pasture. The animal load (CC) for a given period, expressed in T.L.U./ha/year, is calculated as follows:

$$CC\left(TLU/ha/year\right) = \frac{\text{Production}\left(kg\ DM/ha\right) \times k}{6.25\left(kg\frac{DM}{TLU}\right) \times \text{utilization period}}$$

With 6.25 = daily consumption of one TLU (TLU: Tropical Livestock Unit); k = utilization coefficient (k = 0.33); DM: dry matter.

2.8. Statistical Analyses

Data on biomass and carrying capacity were subjected to one-way ANOVA. Duncan's test at a 5% significance level was used for mean separation. SPSS 20.0 software was used to perform the ANOVA [12].

3. Results

3.1. Fodder Plants Listed in the Far North Regions of Cameroon

3.1.1. Herbaceous Plants

In the Far North region, a total of 16 herbaceous plant species were listed in the Diamaré department. These species belong to 2 families, namely Poaceae (13 species) and Fabaceae (3 species) (Table 2). In the Mayo-Sava department, a total of 6 herbaceous plant species were listed, belonging to 3 families: Poaceae (4 species), Fabaceae (1 species), and one species of Malvaceae. In the Mayo-Tsanaga department, a total of 10 herbaceous plant species were listed, belonging to 3 families: Poaceae (8 species), Juncaceae (1 species), and one species of Cyperaceae. The Mayo-Danay department listed a total of 16 herbaceous plant species belonging to 3 families: Poaceae (14 species), Fabaceae (1 species), and one species of Cyperaceae. The Mayo-Kani department listed a total of 17 herbaceous plant species belonging to 3 families: Poaceae (13 species), Cyperaceae (3 species), and one species of Juncaceae.

Table 2. Herbaceous species listed in the far north region.

Departments	Family	Scientific Names	Local Name
Diamare	Poaceae	*Setaria pumila*	Wissoh wadou
	Poaceae	*Dactyloctenium aegyptium*	/
	Poaceae	*Oryza barthii*	/
	Poaceae	*Hordeum vulgare*	Nyigasoua
	Poaceae	*Hyparrhenia papillipes*	Aquiq
	Poaceae	*Cymbopogon citratus*	Maba
	Poaceae	*Eragrostis tef*	Dadja/Fagurde
	Poaceae	*Dactylis glomerata*	Marzezen/Sargalde
	Poaceae	*Eleusina indica*	/
	Poaceae	*Panicum amarum*	/
	Fabaceae	*Zorniah latifolia*	Dengedenge
	Poaceae	*Pennisetum purpureum*	Selbo
	Poaceae	*Digitaria ciliaris*	Tropiad
	Fabaceae	*Grona triflora*	Senkelle

Continued

	Fabaceae	*Zornia glochidiata*	Dengere
	Fabaceae	*Echinochloa crus galli*	Pagguri
Mayo-Sava	Fabaceae	*Zorniah latifolia*	Dengedenge
	Malvaceae	*Althae officinalis*	/
	Poaceae	*Melinis repens*	/
	Poaceae	*Eragrostis tef*	Dadja/Fagurde
	Poaceae	*Cynodon dactilon*	/
	Poaceae	*Hyparrhenia hirta*	Figourde
Mayo-Tsanaga	Poaceae	*Aira earyophyllea*	/
	Poaceae	*Urochloa plantaginea*	Nzone
	Poaceae	*Setaria pumita*	Wissoh wadou
	Poaceae	*Setaria verticillata*	Ntirkida
	Poaceae	*Eleusina indica*	/
	Poaceae	*Brachiaria brizantha*	/
	Juncaceae	*Juncus bufonius*	Ngene sede
	Poaceae	*Digitaria sanguinalis*	Zaliyaou
	Cyperaceae	*Cyperus costatus*	Sababou
	Poaceae	*Aira caryophyllea*	
Mayo-Danay	Poaceae	*Digitaria longiflora*	
	Poaceae	*Setaria pumila*	Wissoh wadou
	Poaceae	*Eragrostis curvula*	/
	Poaceae	*Eragrostis spectabilis*	Ngene
	Poaceae	*Dactyloctenium aegyptium*	/
	Poaceae	*Oryza barthii*	/
	Poaceae	*Sebria pumila*	/
	Poaceae	*Panicum repens*	Fiibi
	Poaceae	*Poa nemorelis*	Bouwilli
	Poaceae	*Eragrostis tennifolia*	/
	Poaceae	*Pteris catoptera*	/
	Poaceae	*Chloris virgata*	/
	Fabaceae	*Zornia glochidiata*	Dengere
	Poaceae	*Paspalum conjugatum*	/
	Cyperaceae	*Cyperus brevifolius*	Salake
	Poaceae	*Urochloa plantaginea*	Nzone
Mayo-Kani	Poaceae	*Setaria pumila*	Wissoh wadou
	Poaceae	*Eragrostis curvula*	Fii
	Poaceae	*Eragrostis tannifolia*	Burdi

Continued

	Poaceae	*Eragrostis spectabilis*	Ngene
	Poaceae	*Eragrostis unioloides*	Androfo
	Poaceae	*Oryza barthii*	/
	Poaceae	*Panicum repens*	Fiibi
	Poaceae	*Cenchrus ciliaris*	Dnacapre
	Poaceae	*Brachypodium sylvaticum*	Tannii
	Cyperaceae	*Isolepus cernua*	Dengere
	Cyperaceae	*Bulbostylis hispidula*	Aayal
	Cyperaceae	*Cyperus brevifolius*	Salake
	Poaceae	*Urochloa plantaginea*	Nzone
	Poaceae	*Panicum miliaceum*	Ngene soudou
	Poaceae	*Althae officinalis*	Ngelewki
	Poaceae	*Cymbogon citratus*	Naïge
	Juncaceae	*Juncus bufonius*	Berrberre

3.1.2. Woody Plants

In the pastures of the Far North, a total of 7 woody species belonging to 7 families were listed in the Diamaré department: Fabaceae (3 species), Zygophyllaceae (1 species), and one species each of Meliaceae, Apiaceae, and Malvaceae (Table 3). In the Mayo-Sava department, a total of 7 woody species belonging to 6 families were listed: Fabaceae (2 species), Cannabaceae (1 species), Capparaceae (1 species), Apiaceae (1 species), Meliaceae (1 species), and Rhamnaceae (1 species). In the Mayo-Tsanaga pastures, a total of 5 woody species belonging to 4 families were listed: Fabaceae (2 species), Apiaceae (1 species), Meliaceae (1 species), and Zygophyllaceae (1 species). In the Mayo-Danay department, a total of 6 woody species belonging to 4 families were listed: Fabaceae (3 species), Combretaceae (1 species), Capparaceae (1 species), and Meliaceae (1 species). Four woody species belonging to 3 families were listed in the Mayo-Kani department: Fabaceae (2 species), Zygophyllaceae (1 species), and Combretaceae (1 species).

Table 3. List of woody species listed in the far north region.

Departments	Family	Scientific Names	Local Name
	Zygophyllae	*Balanites aegyptiaca*	Jabe
	Meliaceae	*Azadirachta indica*	Neem
	Fabaceae	*Faidherbia albida*	Chaski/Nganne
Diamaré	Apiaceae	*Steganotaenia araliacea*	Nelbi
	Fabaceae	*Paliostigma reticulatum*	Nkege
	Fabaceae	*Acacia albida*	Ngagne
	Malvaceae	*Adonsonia digitata*	Baobab

Continued

Mayo-Sava	Cannabaceae	*Fiscus platyphylla*	Doumdege
	Capparaceae	*Caparis sepiaria*	Tanne
	Fabaceae	*Faidherbia albida*	Chaski/Nganne
	Apiaceae	*Steganotaenia araliacea*	Nelbi
	Meliaceae	*Khaya senegalensis*	Nkege
	Fabaceae	*Acacia albida*	Ngagne/Chasde/Dumbi
	Rhamnaceae	*Zizipus mauritiana*	Baobab
Mayo-Tsanaga	Fabaceae	*Faidherbia albida*	Chaski/Nganne
	Apiaceae	*Steganotaenia araliacea*	Nelbi
	Meliaceae	*Khaya senegalensis*	Nkege
	Fabaceae	*Acacia albida*	Ngagne/Chasde/Dumbi
	Zygophyllae	*Balanites aegyptiaca*	Jabe
Mayo-Danay	Fabaceae	*Faidherbia albida*	Chaski/Nganne
	Combretaceae	*Guiera senegalensis*	Nkege
	Fabaceae	*Tamarindus indica*	Nkege
	Fabaceae	*Acacia albida*	Ngagne
	Malvaceae	*Waltheria indica*	Baobab
	Capparaceae	*Caparis sepiaria*	Tanne
Mayo-Kani	Zygophyllae	*Balanites aegyptiaca*	Jabe
	Fabaceae	*Faidherbia albida*	Chaski/Nganne
	Fabaceae	*Acacia albida*	Ngagne
	Combretaceae	*Terminalia leiocarpa*	Ncojoli

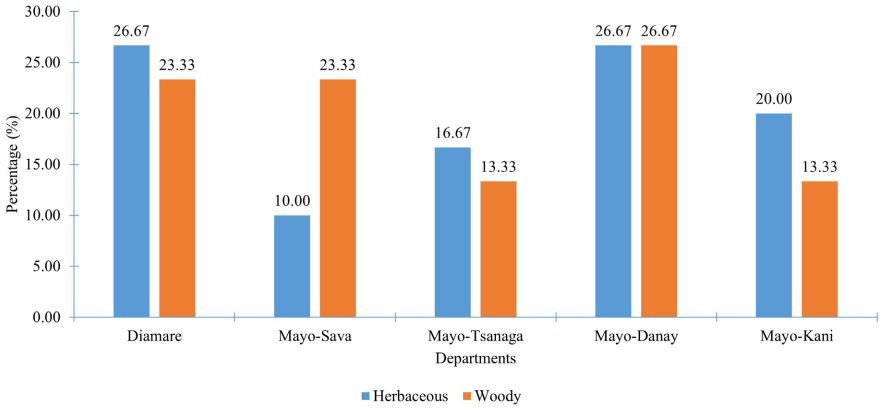

Figure 5. Proportion of Herbaceous and woody species listed by department in the far north region.

Figure 5 illustrates the proportion of herbaceous and woody species listed by department in the Far North region. It shows that the proportion of herbaceous species is higher in the Diamaré, Mayo-Tsanaga, and Mayo-Kani departments

(26.67%, 16.67%, and 20% respectively). In contrast, the pastures in the Mayo-Sava department of the Far North of Cameroon are predominantly populated by woody species (23.33%). In the Mayo-Danay department, the proportions of herbaceous and woody species are similar.

3.2. Parts and Preferences of Herbaceous Plants Consumed by Livestock

Table 4 presents the parts of herbaceous plants consumed, their preferences, and the type of livestock that consume these resources. It shows that the plant parts consumed are leaves, stems, flowers, and fruits. The herbaceous plants most consumed by livestock in the Diamaré department are *Pennisetum purpureum*, *Zornia glochidiata*, *Zornia latifolia*, and *Echinochloa crus-galli*. *Zornia latifolia* is the most consumed herbaceous plant by livestock in the Mayo-Sava department. In the Mayo-Danay department, the herbaceous plants most consumed by livestock are *Digitaria longiflora*, *Eragrostis curvula*, *Eragrostis spectabilis*, *Dactyloctenium aegyptium*, and *Zornia glochidiata*.

Table 4. Parts and preferences of herbaceous plants consumed by livestock scientific names PCP preferences livestock type.

Departments	Scientific Names	PCP	Preferences	Livestock Type
Diamare	*Setaria pumila*	Leaves + stems + flower	**	Cattle, goats, sheep
	Dactyloctenium aegyptium	Leaves + stems + flower	**	Cattle, goats, sheep
	Oryza barthii	Leaves + stems + flower	**	Cattle, goats, sheep
	Hordeum vulgare	Leaves + stems + flower	**	Cattle, goats, sheep
	Hyparrhenia papillipes	Leaves + stems + flower	**	Cattle, goats, sheep
	Cymbopogon citratus	Leaves + stems + flower	**	Cattle, goats, sheep
	Eragrostis tef	Leaves + stems + flower	**	Cattle
	Dactylis glomerata	Leaves + stems + flower	**	Cattle, goats, sheep
	Eleusina indica	Leaves + stems + flower	**	Cattle, goats
	Panicum amarum	Leaves + stems + flower	**	Cattle, goats, sheep
	Zorniah latifolia	Leaves + stems + flower	***	Cattle, goats, sheep
	Pennisetum purpureum	Leaves + stems	***	Cattle, goats, sheep
	Digitaria ciliaris	Leaves + stems + flower	**	Cattle, goats, sheep
	Grona triflora	Leaves + stems + flower	**	Cattle, goats, sheep
	Zornia glochidiata	Leaves + stems + flower	***	Cattle, goats, sheep
	Echinochloa crus galli	Leaves + stems + flower	***	Cattle, goats, sheep
Mayo-Sava	*Zorniah latifolia*	Leaves + stems + fruit	***	Cattle, goats, sheep
	Althae officinalis	Leaves + stems + fruit	**	Cattle, goats, sheep
	Melinis repens	Leaves + stems + fruit	**	Cattle
	Eragrostis tef	Leaves + stems + fruit	**	Cattle

Continued

	Cynodon dactylon	Leaves + stems + fruit	**	Cattle
	Hyparrhenia hirta	Leaves + stems + fruit	**	Cattle, goats, sheep
Mayo-Tsanaga	*Aira earyophyllea*	Leaves + stems + flower	**	Cattle, goats, sheep
	Urochloa plantaginea	Leaves + stems + flower	*	Cattle, goats, sheep
	Setaria pumita	Leaves + stems + flower	**	Cattle, goats, sheep
	Setaria verticillata	Leaves	**	Cattle, goats, sheep
	Eleusina indica	Leaves + stems + flower	**	Cattle, goats, sheep
	Brachiaria brizantha	Leaves + stems + flower	**	Cattle, goats, sheep
	Juncus bufonius	Leaves + stems + flower	**	Cattle, goats, sheep
	Digitaria sanguinalis	Leaves + stems + flower	**	Cattle, goats, sheep
	Cyperus costatus	Leaves + stems + flower	**	Cattle, goats, sheep
	Aira caryophyllea	Leaves + stems + flower	**	Cattle, goats
Mayo-Dnay	*Digitaria longiflora*	Leaves + stems	***	Cattle, goats, sheep
	Setaria pumila	Leaves + stems	**	Cattle, goats, sheep
	Eragrostis curvula	Leaves + stems	***	Cattle
	Eragrostis spectabilis	Leaves + stems	***	Cattle
	Dactyloctenium aegyptium	Leaves + stems	***	Cattle, goats, sheep
	Oryza barthii	Leaves + stems	**	Cattle, goats, sheep
	Sebria pumila	Leaves + stems	**	Cattle, goats, sheep
	Panicum repens	Leaves + stems	*	Cattle, goats, sheep
	Poa nemorelis	Leaves + stems	**	Cattle, goats, sheep
	Eragrostis tennifolia	Leaves	**	Cattle
	Pteris catoptera	Leaves	**	Cattle, goats, sheep
	Chloris virgata	Leaves + stems	**	Cattle, goats, sheep
	Zornia glochidiata	Leaves + stems	***	Cattle, goats, sheep
	Paspalum conjugatum	Leaves + stems + flower	**	Cattle, goats, sheep
	Cyperus brevifolius	Leaves + stems + flower	**	Cattle, goats, sheep
	Urochloa plantaginea	Leaves + stems + flower	**	Cattle, goats
Mayo-Kani	*Setaria pumila*	Leaves + stems + flower	**	Cattle, goats, sheep
	Eragrostis curvula	Leaves + stems + flower	**	Cattle
	Eragrostis spectabilis	Leaves + stems + flower	**	Cattle
	Eragrostis unioloides	Leaves + stems + flower	**	Cattle
	Oryza barthii	Leaves + stems + flower	**	Cattle, goats, sheep
	Panicum repens	Leaves + stems	**	Cattle, goats, sheep
	Cenchrus ciliaris	Leaves + stems + flower	**	Cattle, goats, sheep
	Brachypodium sylvaticum	Leaves + stems + flower	**	Cattle, goats, sheep
	Isolepus cernua	Leaves + stems + fruit	**	Cattle, goats, sheep

Continued

Bulbostylis hispidula	Leaves + stems + fruit	**	Cattle, goats, sheep
Cyperus brevifolius	Leaves + stems + fruit	**	Cattle, goats, sheep
Urochloa plantaginea	Leaves + stems + fruit + flower	**	Cattle, goats, sheep

PCP: Part of Plant Consumed; *: Low consumption; **: Medium consumption; ***: High consumption.

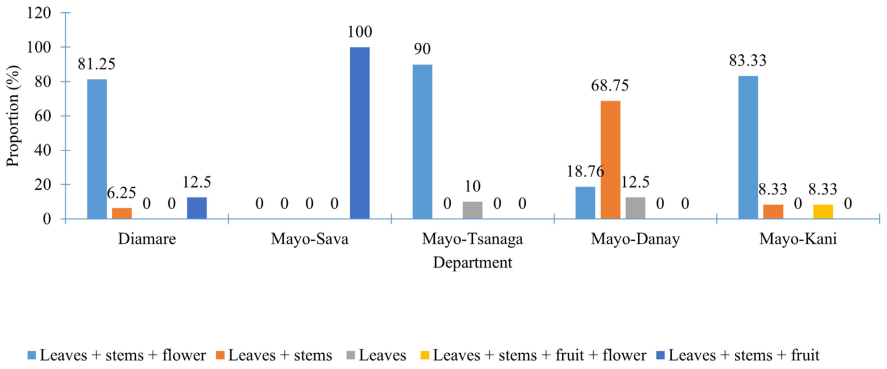

Figure 6. Proportion of herbaceous plant parts consumed by livestock.

Figure 6 illustrates the proportion of plant parts consumed by livestock according to department in the Far North region. It shows that regarding herbaceous plants in the Diamaré department, the majority of livestock consume leaves + stems + flower (81.25%), followed by leaves + stems + fruit (12.50%), and finally leaves + stems (6.25%). In the Mayo-Sava department, livestock consume only leaves + stems + fruit (100%). In the Mayo-Tsanaga department, livestock predominantly prefer leaves + stems + flower (90%) and, to a lesser extent, leaves (10%). In the Mayo-Danay department, livestock consume leaves + stems (68.75%), followed by leaves + stems + flower (18.76%), and finally leaves (12.50%). Leaves + stems + flower are more consumed by livestock in the Mayo-Kani department (83.33%), followed by leaves + stems (8.33%) and leaves (8.33%).

3.3. Parts and Preferences of Woody Plants Consumed by Livestock

Table 5 presents the parts of woody plants consumed, their preference, and the type of livestock that consume these resources. It follows that leaves, flowers, fruits, and stems are the parts of woody plants consumed by livestock. In the Diamaré department, the woody plants most consumed by livestock are *Balanites aegyptiaca*, *Faidherbia albida*, *Piliostigma reticulatum*, *Acacia albida*. *Faidherbia albida*, *Khaya senegalensis*, *Acacia albida*, and *Ziziphus mauritiana* are the most consumed woody plants in the Mayo-Sava department. In the Mayo-Tsanaga department, the same trend is observed where *Faidherbia albida*, *Khaya senegalensis*, and *Acacia albida* are the most consumed woody plants. Similarly, the most consumed woody plants in the Mayo-Danay department are *Balanites aegyptiaca*, *Khaya senegalensis*, *Faidherbia albida*, and *Acacia albida*. In the Mayo-Kani de-

partment, the most consumed woody plants are *Balanites aegyptiaca*, *Faidherbia albida*, and *Acacia albida*.

Table 5. Parts and preferences of woody plants consumed by livestock.

Departments	Scientific Names	PCP	Preferences	Livestock Type
Diamare	*Balanites aegyptiaca*	Leaves	***	Cattle,
	Azadirachta indica	Leaves	**	Cattle, goats, sheep
	Faidherbia albida	Leaves	***	Cattle,
	Steganotaenia araliacea	Leaves	**	Cattle,
	Paliostigma reticulatum	Leaves	***	Cattle,
	Acacia albida	Leaves	***	Cattle, goats, sheep
	Adonsonia digitata	Leaves	**	Cattle, goats
Mayo-Sava	*Fiscus platyphylla*	Leaves	**	Cattle,
	Caparis sepiaria	Leaves	**	Cattle, goats
	Faidherbia albida	Leaves	***	Cattle, goats, sheep
	Steganotaenia araliacea	Leaves	**	Cattle, goats, sheep
	Khaya senegalensis	Leaves + stems	***	Cattle, goats, sheep
	Acacia albida	Leaves	***	Cattle, goats, sheep
	Zizipus mauritiana	Leaves + stems	***	Cattle
Mayo-Tsanaga	*Faidherbia albida*	Leaves	***	Cattle, goats, sheep
	Steganotaenia araliacea	Leaves	**	Cattle
	Khaya senegalensis	Leaves + stems	***	Cattle, goats, sheep
	Acacia albida	Leaves	***	Cattle, goats, sheep
Mayo-Danay	*Balanites aegyptiaca*	Leaves	***	Cattle, goats, sheep
	Khaya senegalensis	Leaves + stems	***	Cattle
	Faidherbia albida	Leaves	***	Cattle, goats, sheep
	Guiera senegalensis	Leaves	**	Cattle
	Tamarindus indica	Leaves + stems + fruit	**	Cattle
	Acacia albida	Leaves	***	Cattle, goats, sheep
	Waltheria indica	Leaves	**	Cattle, goats, sheep
	Caparis sepiaria	Leaves	**	Cattle, goats, sheep
Mayo-Kani	*Balanites aegyptiaca*	Leaves + stems + fruit	***	Cattle
	Faidherbia albida	Leaves	***	Cattle, goats, sheep
	Acacia albida	Leaves	***	Cattle, goats, sheep
	Terminalia leiocarpa	Leaves + stems	**	Cattle, goats, sheep

PCP: Part of Plant Consumed; *: Low consumption; **: Medium consumption; ***: High consumption.

Figure 7 illustrates the proportion of plant parts consumed by livestock according to department in the Far North region. It shows that regarding woody plants

in the Diamaré department, the majority of livestock consume leaves (100%). In the Mayo-Sava department, livestock consume leaves (74.42%), followed by leaves + stems (14.28%) and leaves + flower (14.28%). In the Mayo-Tsanaga department, livestock predominantly prefer leaves (75%) and, to a lesser extent, leaves + stems (25%). In the Mayo-Danay department, livestock consume leaves (80%), followed by leaves + stems (10%) and leaves + stems + fruits (10%). Leaves are more consumed by livestock in the Mayo-Kani department (50%), followed by leaves + stems (25%) and leaves + stems + fruits (25%).

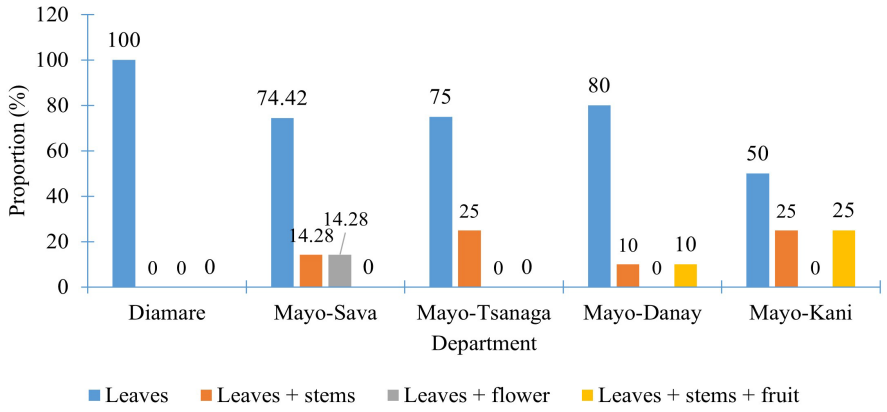

Figure 7. Proportion of woody plants according to their preference by livestock.

3.4. Biomass Productivity

In the departments of the Far North region, the different pastures studied showed that pastures P2, P3, and P4, rich in *Eragrostis tef*, *Dactylis glomerata*, and *Zornia latifolia* respectively, have the highest biomass productivities (2146.80 ± 79.03^{a} kg DM/ha, 2638.60 ± 400.36^{a} kg DM/ha, and 2345.60 ± 129.22^{a} kg DM/ha), while plots P1 and P5, rich in *Dactyloctenium aegyptium* and *Cynodon dactylon*, present the lowest values (Table 6).

Table 6. Biomass Productivity of different pastures in the departments of the far north region.

Pasture	Biomass					Productivity (kg DM/ha)
	MS	**MT**	**MD**	**MK**	**D**	
P1	1726	1701	1852	1852	1701	1766.40 ± 80.93^{b}
P2	2000	2100	2156	2356	2122	2146.80 ± 79.03^{a}
P3	2112	2896	2645	2645	2895	2638.60 ± 400.36^{a}
P4	2504	2482	2270	2121	2351	2345.60 ± 129.22^{a}
P5	1504	1602	1520	1852	1701	1635.80 ± 52.57^{b}

Legend: a, b: means with different letters are significantly different ($P < 0.05$). P1: Pasture rich in *Dactyloctenium aegyptium*; P2: Pasture rich in *Eragrostis tef*; P3: Pasture rich in *Dactylis glomerata*; P4: Pasture rich in *Zornia latifolia*; P5: Pasture rich in *Cynodon dactylon*. MS: Mayo-Sava; MT: Mayo-Tsanaga; MD: Mayo-Danay; MK: Mayo-Kani; D: Diamaré.

Regarding woody species, Table 7 presents the biomass production per hectare for each species, obtained based on their leaf biomass. It shows that the woody species with significantly the highest biomass are *Faidherbia albida* (138.00 ± 2.12[a] kg DM/ha) and *Piliostigma reticulatum* (135.83 ± 0.28[a] kg DM/ha), followed by *Balanites aegyptiaca* (117.58 ± 7.63[b] kg DM/ha), *Steganotaenia araliacea* (118.42 ± 6.61[b] kg DM/ha), and *Acacia albida* (117.01 ± 2.44[b] kg DM/ha). *Azadirachta indica* and *Adansonia digitata* present the lowest values (11.64 ± 1.71[c] kg DM/ha; 11.90 ± 1.22[c] kg DM/ha respectively).

Table 7. Biomass productivity of woody species in the far north Cameroon.

Species	Biomass (kg DM/ha)
Balanites aegyptiaca	117.58 ± 7.63[b]
Azadirachta indica	11.64 ± 1.71[c]
Faidherbia albida	138.00 ± 2.12[a]
Steganotaenia araliacea	118.42 ± 6.61[b]
Paliostigma reticulatum	135.83 ± 0.28[a]
Acacia albida	117.01 ± 2.44[b]
Adonsonia digitata	11.90 ± 1.22[c]

Legend: a, b, c: means with different letters are significantly different (P < 0.05).

3.5. Carrying Capacity

In the Far North region, regardless of the department concerned, pastures P1 rich in *Dactyloctenium aegyptium*, P2 rich in *Eragrostis tef*, and P3 rich in *Dactylis glomerata* have significantly (p < 0.05) higher carrying capacities than those of pastures P4 rich in *Zornia latifolia* and P5 rich in *Cynodon dactylon* (Table 8).

Table 8. Carrying capacity of pastures rich in herbaceous plants by department.

Pastures	Carrying Capacity				
	MS	**MT**	**MD**	**MK**	**D**
P1	0.24 ± 0.04[a]	0.20 ± 0.04[a]	0.20 ± 0.04[a]	0.21 ± 0.04[a]	0.19 ± 0.04[a]
P2	0.22 ± 0.04[a]	0.19 ± 0.04[a]	0.20 ± 0.04[a]	0.21 ± 0.04[a]	0.19 ± 0.04[a]
P3	0.20 ± 0.04[a]	0.20 ± 0.04[a]	0.20 ± 0.04[a]	0.21 ± 0.04[a]	0.19 ± 0.04[a]
P4	0.10 ± 0.04[b]	0.12 ± 0.04[b]	0.11 ± 0.04[b]	0.10 ± 0.04[b]	0.10 ± 0.04[b]
P5	0.10 ± 0.04[b]	0.12 ± 0.04[b]	0.11 ± 0.04[b]	0.10 ± 0.04[b]	0.10 ± 0.04[b]

Legend: a, b: means with different letters are significantly different (P < 0.05). P1: Pasture rich in *Dactyloctenium aegyptium*; P2: Pasture rich in *Eragrostis tef*; P3: Pasture rich in *Dactylis glomerata*; P4: Pasture rich in *Zornia latifolia*; P5: Pasture rich in *Cynodon dactylon*. MS:Mayo-Sava; MT: Mayo-Tsanaga; MD: Mayo-Danay; MK: Mayo-Kani; D: Diamaré.

Regarding pastures rich in woody plants, the carrying capacity is very low (Table 9) compared to herbaceous plants. Nevertheless, the highest carrying capacities were recorded for *Faidherbia albida* (0.0169 ± 0.0068[a]) and *Piliostigma retic-*

ulatum (0.0165 ± 0.0068[a]), followed by *Balanites aegyptiaca* (0.0079 ± 0.0042[b] kg DM/ha), *Steganotaenia araliacea* (0.0079 ± 0.0042[b] kg DM/ha), and *Acacia albida* (0.0079 ± 0.0042[b] kg DM/ha). *Azadirachta indica* and *Adansonia digitata* present the lowest values (0.0016 ± 0.0018[c] kg DM/ha; 0.0016 ± 0.0018[c] kg DM/ha respectively).

Table 9. Carrying capacity of fodder woody plants in the far north region.

Species	Carrying Capacity (UBT/ha/an)
Balanites aegyptiaca	0.0079 ± 0.0042[b]
Azadirachta indica	0.0016 ± 0.0018[c]
Faidherbia albida	0.0169 ± 0.0068[a]
Steganotaenia araliacea	0.0079 ± 0.0042[b]
Paliostigma reticulatum	0.0165 ± 0.0068[a]
Acacia albida	0.0079 ± 0.0042[b]
Adonsonia digitata	0.0016 ± 0.0018[c]

4. Discussion

Regardless of the department, the number of herbaceous species recorded in the Far North region ranged between 8 and 17. This low number of herbaceous species in the Far North region could be due to the fact that this region is located in the Sudano-Sahelian agro-ecological zone, characterized by a harsh climate and a long dry season that impacts agricultural and livestock activities. The various interviews conducted by [13] with ruminant breeders in the Bénoué department of Northern Cameroon identified 14 herbaceous species. The observed decline in the floristic diversity of fodder resources would be due to climate change, the shrinking of grazing lands, and poor agricultural practices such as excessive wood cutting and bush fires. Similar observations were made by [1] in the North-West region of Cameroon, noting the disappearance of certain fodder species due to uncontrolled use of fire (32.2%), overexploitation (26.6%), and herbicide use (16.7%).

In all the departments of the Far North region studied, the majority of herbaceous fodder belonged to the Poaceae family. This result is comparable to those of [1] [13] [14], who reported 57%, 31%, and 48.8% of species belonging to the Poaceae family, respectively. [15] stated that in tropical Africa, the majority of species consumed by livestock mainly belong to two families, namely Poaceae and Fabaceae.

Among the herbaceous species recorded in the Far North region (*Pennisetum purpureum*, *Zornia glochidiata*, *Zornia latifolia*, *Echinochloa crus-galli*, *Digitaria longiflora*, *Eragrostis curvula*, *Eragrostis spectabilis*, *Dactyloctenium aegyptium*, and *Zornia glochidiata*), two were identified as fodder plants by [13] in the Bénoué department (*Pennisetum purpureum* and *Echinochloa crus-galli*). This would be explained by the fact that the Far North and the North are located in the same agro-ecological zone, thus offering fairly similar climatic conditions for the growth

of certain fodder plants.

Regardless of the department, the number of woody species recorded in the Far North region ranged between 4 and 7. These results are low compared to those obtained by [14] in Ghana, who recorded 32 woody species, by [3] in DR Congo, [16] in Côte d'Ivoire, [17] in Ethiopia, and [18] in the Himalayas, who recorded 43, 68, 50, and 61 woody fodder species, respectively. These differences observed between localities could be due to the fact that the floristic composition of an area's vegetation is strongly linked to its climate, edaphic factors (soil type, depth, texture, moisture), as well as its degree of human impact [19].

The woody species recorded in the Far North, such as *Balanites aegyptiaca*, *Faidherbia albida*, *Piliostigma reticulatum*, *Acacia albida*, *Faidherbia albida*, *Khaya senegalensis*, *Acacia albida*, and *Ziziphus mauritiana*, were mostly identified by [13] in Northern Cameroon. This would be explained by the fact that the Far North and the North are located in the same agro-ecological zone, thus offering fairly similar climatic conditions for the growth of certain woody species.

In the Far North region, the most consumed herbaceous fodder species, regardless of the department, are *Pennisetum purpureum*, *Zornia glochidiata*, *Zornia latifolia*, *Echinochloa crus-galli*, *Digitaria longiflora*, *Eragrostis curvula*, *Eragrostis spectabilis*, *Dactyloctenium aegyptium*, and *Zornia glochidiata*. In Northern Cameroon, [13] identified from breeders that *Acroceras amplectens and Pennisetum pedicellatum* are the herbaceous species most appreciated by livestock. Animal preferences vary from one area to another. This could be explained by the fact that preferences depend on the feeding habits of the livestock and the presence of these fodder species in the different localities. According to [20], in Niger, the diet of cattle consists of 90% grasses; for goats, it consists of nearly 80% tree and shrub leaves and less than 20% grasses; whereas for sheep, it consists of 20% woody plants, 60% grasses, and 20% other herbs. [15] also stated that the palatability of grasses for livestock is explained by the relatively soft texture of their tissues, their mild taste, their odor not marked by unpleasant or repulsive substances, the absence or low content of toxic substances or tannins, and the richness in digestible carbohydrates (celluloses, soluble sugars, etc.) and fats.

It was found that the proportion of herbaceous fodder species highly consumed by livestock is relatively low compared to those moderately consumed. These observations are similar to those of [13] and [21]. Indeed, when certain animals focus on consuming a certain category of plants, it promotes the growth of other species that may turn out to be moderately, weakly, or not at all consumed by livestock. Furthermore, if their consumption is uncontrolled, the latter could disappear over the years [22].

For herbaceous plants, the parts of the plants consumed by livestock, regardless of the department, are the leaves. This result is similar to that obtained by [2] [14] [18], who reported that leaves are the parts most consumed by livestock. Similarly, [17] noted that livestock have a preference for leaves compared to other parts of the plant because they are easily accessible, highly palatable, and very rich in nu-

trients.

In the Far North region, the most consumed woody fodder species, regardless of the department, are *Balanites aegyptiaca*, *Faidherbia albida*, *Piliostigma reticulatum*, *Acacia albida*, *Khaya senegalensis*, and *Ziziphus mauritiana*. In Bénoué, [13] identified from breeders that *Prosopis africana*, *Daniella oliveri*, *Acacia sieberiana*, *Stereospermum kunthianum*, and *Balanites aegyptiaca* are the woody species most appreciated by livestock.

For woody plants, livestock consume leaves, fruits, flowers, and stems. Similar results were obtained by [14] and [17], who noted that in addition to leaves, animals also consume roots and pods, such as in *Acacia nilotica* and *Piliostigma reticulatum*. This could be explained by the livestock's choice of organs from fodder species, which depends on the animal species, the season, the phenological stage of the plant, and the availability and quality of the fodder species [21]. [17] stated that livestock consume leaves much more during the rainy season, seeds and pods at the beginning of the dry season, and stems and bark towards the end of the dry season.

It was also observed that biomass production is higher in herbaceous plants compared to woody plants. In this regard, [15] stated that legumes, due to C3 photosynthesis, are approximately two to three times less productive than tropical grasses which possess C4 photosynthesis. C3 plants only produce carbon chains in the presence of light, whereas C4 plants store energy to enable the plant to produce carbon chains at night, hence their faster growth.

In the Far North region, regardless of the department concerned, the rangelands P1 (rich in *Dactyloctenium aegyptium*), P2 (rich in *Eragrostis tef*), and P3 (rich in *Dactylis glomerata*) have higher carrying capacities. This capacity is a function of biomass production; the higher it is, the more livestock the rangeland can support [13].

Among the woody species in the Far North region, the highest carrying capacities were recorded for *Faidherbia albida* (0.0169 ± 0.0068a) and *Piliostigma reticulatum* (0.0169 ± 0.0068a). [10] obtained a carrying capacity of 0.003 to 0.185 LSU/ha (Livestock Unit per hectare) for a biomass production ranging from 5 to 346.90 kg DM/ha (Dry Matter per hectare) among woody plants in the rangelands of the Guinea-Sudanian zone of Benin.

The promotion of the identified forage species could involve the adoption of resilient fodder crops such as *Pennisetum purpureum*, which is particularly well-suited to arid zones, or through the protection and regeneration of woody species like *Balanites aegyptiaca*, whose leaves and fruits are highly valued by livestock. Forage conservation techniques could also be promoted to address seasonal shortages.

5. Conclusion

At the end of this study, which aimed to contribute to a better understanding of ruminant nutrition in Cameroon through the creation of a database on local fod-

der resources, it appears that 16 species of herbaceous plants were recorded in the Diamaré department, 6 in the Mayo-Sava department, 10 in the Mayo-Tsanaga department, 16 in the Mayo-Danay department and 17 in the Mayo-Kani department, making a total of 65 species in the Far North region. Similarly, a total of 29 woody species were identified. Leaves are the parts of the plants most consumed by livestock. Herbaceous species were predominantly from the Poaceae family, while Fabaceae dominated among woody plants. The species most consumed by livestock (cattle, goats, sheep) included *Pennisetum purpureum*, *Zornia glochidiata*, *Echinochloa crus galli*, *Balanites aegyptiaca*, *and Faidherbia albida*. Leaves were the most consumed plant part for both herbaceous and woody species and the biomass production is higher in herbaceous plants compared to woody plants.

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Author Contributions

Annie Claire Ngo Ongla: Formal analysis; investigation; methodology; writing—original draft. Mama Mouchili: Formal analysis; investigation; methodology; writing—original draft. Honoré Beyegueh Djonko: Conceptualization; methodology; supervision; validation. Christopher Tankou Mubeteneh: Conceptualization; methodology; supervision; validation.

Data Availability Statement

Data generated during this study are available from the corresponding author upon reason able request.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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