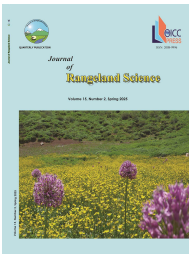

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Assessment of productivity, grazing capacity and rangeland value of grazed herbages of Falmey Rangelands South Western part of Niger Republic

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Abstract:

This study was presented for a better understanding of the current condition of the herbages following flora and vegetation sampling in four rangelands along the axis of transhumance in Falmey department (Dosso Region), southwest part of Niger Republic. It was aimed to determine the phytodiversity of each herbage plant community; classify and describe herbage communities along an ecological gradient; and assess the productivity and the grazing capacity of the herbage plant communities. A total of 85 plots, measuring 50×20 m, were established for the phytosociological inventory and the distance between transects was 500 m and the distance between plots was 300 m. The line-point intercept method was used to inventory floristics vegetation and herbaceous phytomass was collected from each plot of 1000 m^2 at the five different places. On each plot, five square plots of 1 m^2 were placed (one square plot at the four corners and one in the middle of the plot of 1000 m^2). A total of 72 vegetal herbaceous species were recorded in the four rangelands, belonging to 53 genera and 20 families. Among the families, Poaceae was the most abundant, followed by Fabaceae. The life forms spectrum of the four grazing lands was dominated by Therophytes with 75%. The phytogeophical was dominated by the paleotropical and pantropical species, covering 25% and 21% of the chorological spectrum, respectively. Following Agglomerative hierarchical cluster and detrended correspondence analysis (DCA), five herbage communities were discriminated against. The biodiversity estimates with Richness, Shannon index and Pielou Equitability respectively, ranged from 49 to 60; 3.31 to 3.75 bits and 0.56 to 0.64. The herbage communities had produced phytomass with a mean of 1230 ± 300 kg.DM/ha. In total, rangeland value ranged from 24.80% to 44.11%, indicating the lower quality of the pasture of Falmey four rangelands.

Keywords: Productivity; Rangeland value; Grazing capacity; Index of Specific Quality (ISQ); Relative Abundance of Species (SRA)

Introduction

Herbages cover almost 26% of the earth's land surface, the majority (approximately 68%) are located in tropical developing countries where they are among the wide ecosystems used extensively for livestock production and to provide vital goods and services for the livelihood of over a billion low-income people (Boval and Dixon, 2012; Peters et al., 2013). Furthermore, the multifunctional roles of herbage as well as rangelands are well acknowledged, including climate change mitigation by terrestrial carbon sequestration, housing biodiversity, and providing food, fiber, wood, etc. Livestock breeding to supply meat and milk continues to be the main land use practice of herbage. It constitutes the basis and the totality of the feed resources of ruminants in extensive or semi-intensive livestock breeding systems (Idrissa et al., 2016).

In recent years, with recurrent droughts, grazing areas have gradually decreased due to the conversion of rangelands to croplands, with the enlightenment of pasturelands and a reduction of phytomass availability (Morou, 2010; Soumana, 2011). Although the surface of the grazing decreased, livestock numbers increased enormously, from approximately 20 million heads in 2001 to approximately 70 million in 2019 (Ministry and Livestock, 2020). These conditions combined with climate change have substantially been changing the condition of the herbage, which results in habitat modification and biodiversity loss. These changes, plant composition modification, biodiversity loss, soil surface

trampling and instability, biomass removal of and barren surface appearing, etc. can affect profoundly the structure, the composition and the proper functioning of the herbage. These have the potential to exhibit rangelands to desertification and eventually to affect providing many important ecosystems goods and services. Therefore, it's particularly important to assess the present condition of Niger herbage vegetation, the effects of crop and urban land expansion, climate changes and livestock pressure. This information is critical to developing sustainable measures of management that can preserve herbage from degradation.

The present study was carried out to better understand the current condition of the herbages following flora and vegetation sampling. It aims to classify and describe herbage communities along an ecological gradient, to determine phytodiversity of each herbage plant community, and to assess the productivity, the pastoral value and the carrying capacity of the herbage plant community.

Material and methods

Study area

The study was carried out in the department of Falmey, which is located between 12°35′38″ and 12°50′00″ North latitude, 2°35 and 3°00 East longitude (figure 1) in the western part of the Dosso region, and in the south of Dallol Bosso (Dosso, 2015). The relief is mainly dominated by the great valley of Dallol Bosso (dry valley commonly called Boboye) which predominates in almost all the southern part of the department of Kollo in the region of Tillabéri. The climate of Falmey department is straddled between the climate tropical and arid in the northern part with scarce precipitation, irregular and relatively low, between 600 and 700 mm (generally less than 500 mm). It is spread over a short period of the year, from June to the end of September, with high rainfall in July and August. The high annual mean temperature was recorded in April and May, generally 33.8 °C and 33.7 °C and the lowest, was recorded in December and January with an annual mean of 25.6 °C and 24.9 °C, slightly in the southern part. The climate is tropical sub-humid. The highest rainfall was recorded in July and August with annual means of 136 mm and 220 mm. The warmest months of the year are April and May with annual mean temperatures of 34 °C and 33 °C, and the coolest months are December and January with mean annual temperatures of 26.2 °C and 26 °C.

Phytogeographically, the northern part of the study area has been largely described by (Saadou, 1990), it was classified in the western southern Sahalian, characterized by "tiger bush" on the lateritic plateau, and steppes vegetation on the sandy terrace and the dry valleys. According to Saadou (1990), this area belongs to the north-western Sudanian, characterized by dry forests on the lateritic plateau, riparian forests along the rivers, open forests on the sandy terrace and Savannah in the dry valleys. In the riparian forests, the flora was characterized by *Combretum micranthum*, *Combretum nigricans*, *Combretum collinum*, *Crossopteryx febrifuga*, among others. On the plateau, there are *Albizia zygia*, *Acacia dudgeonii*, *Nauclea latifolia*, *Daniellia oliveri*, *Kigelia Africana*, *Albizia chevalieri* among others. The flora of the dry valleys was dominated by *Butyrospermum para-*

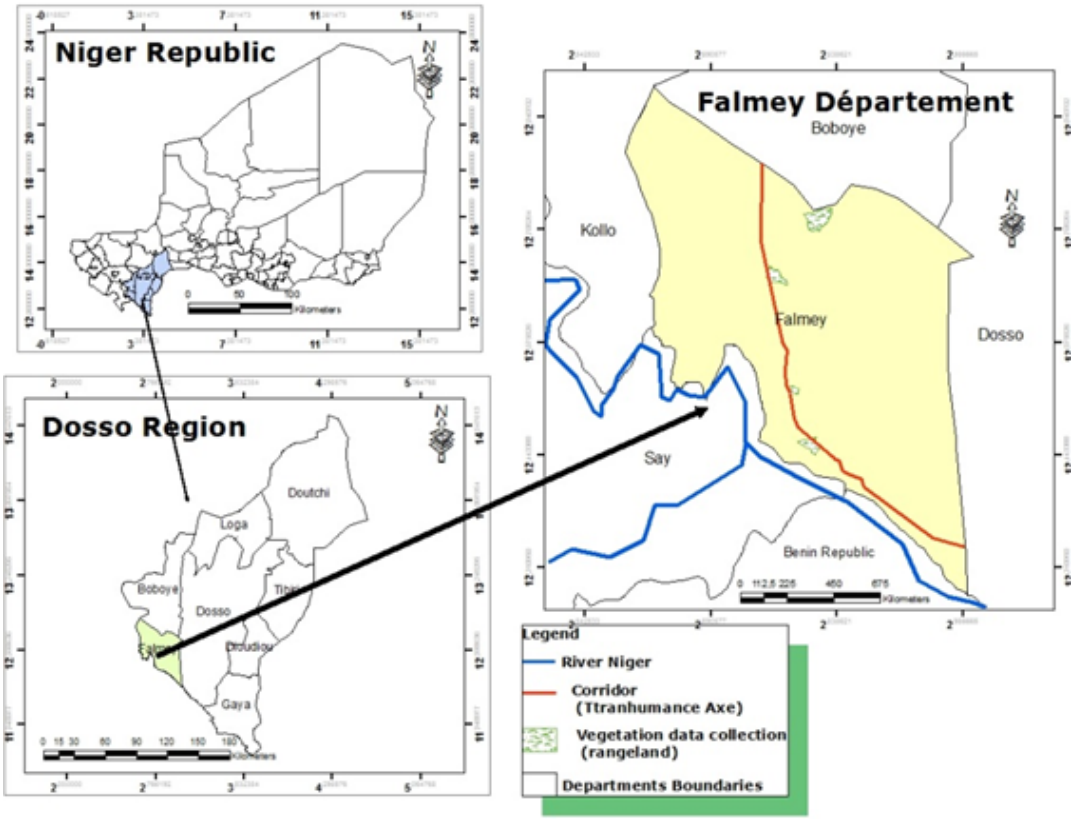

Figure 1. Location and extension of the study area; Falmey Department.

doxum, *Neocarya macrophylla*, *Borassus aethiopium*, and *Andropogon gayanus*. On the sandy terrace, *Vitex doniana*, *Sterculia setigera*, *Parkia biglobosa* and *Cymbopogon giganteus* dominated the flora.

Sandy soils of Dallol are the most dominant soils of the area. These are remobilized wind drift formations and belong to the subclass of ferruginous tropical and leached soils. The texture of these soils is generally sandy on the surface and the sand content is between 90% and 97%.

The hydrography is marked by the presence of a permanent water course, which is the Niger River, over a distance of about 70 km away with a multitude of permanent and semi-permanent water flows and ponds which, extended to settle habited areas.

The population of Falmey department was estimated at 103,271 in 2012, based on the general population census of 2012 (Dosso, 2015), with a growth rate of 2.4% in 2012. The present population density is about 72 inhabitants per km^2. This situation of higher density leads to a higher pressure on natural resources in the area. In terms of pastoral arrangements, there are 16,100 ha of pasture areas concentrated in the departments of Dogondoutchi (14,960 ha) and Falmey (1,140 ha). The Falmey department has the most numerous and longest pastoral corridors, at 470.54 km long.

Herbage vegetation assessing

The vegetation study was carried out in four rangelands according to a north-south climatic gradient along the transhumance axis in Falmey department. To analyze the composition and the structure of the plant communities of the communal rangelands, vegetation and site characteristics were recorded in rectangular plots of 1000 m^2 (50×20 m) (Ali, 2006; Soumana, 2011; Thiombiano et al., 2010), from the end of August to the beginning of September when the Sahelian herbs cover was at maximal development, with grasses and forbs easily identifiable (Ali and Saadou, 2008; Saadou, 1990; Soumana, 2011). Through this study, stratified sampling with clustering was adopted (Soumana et al., 2012). The stratification was based on the topography of each rangeland. The plots were placed on each topographic unit (plateau, glacis and valley) based on the homogeneity of the vegetation and the soil surface feature (Guinochet, 1973; Gounot, 1969). For the assessment of the herbage, on each rectangle plot of 1000 m^2 (20×50 m), herbaceous plant composition and foliar cover were assessed along four parallel 10 m transects with a minimum of 10 m between each transect. These transects served as within-plot replicates. Data was recorded every 10 cm along each transect, for a total of 100 points/transect and 400 points/plot. A metal rod (1 mm diameter) was dropped at each 10 cm, and all plant species contacted by the rod were recorded (Daget and Poissonet, 1971). Plant species were recorded only once, and no attempt was made to distinguish between live and dead leaves and stems. Since occasional species are often missed by this method, a complete list of all other plant species included within a 1 m buffer area around the transect line (vegetation plot) was also recorded (Pittarello et al., 2016). Contacts at the soil surface level such as litter, barren soil and rock were also recorded. Foliar cover based on line point intercept methods was estimated by dividing the total number of plant intercepts in the top canopy layer (first pin hit) by the total number of points per transect or quadrat, respectively. Non-floristic parameters were noted in each plot: geographic coordinates, topography and soil type using the tactile method. 72 plots have been investigated with a total of 288 linear transects.

The list of botanic families covered in this study was arranged according to the Linear Angiosperm Phylogeny Group (LAPG) IV (2016), while species were arranged alphabetically within families. Author citation and binomial nomenclature of collected species followed Lebrun and Stork (1991-2015) and were verified with the International Plant Name Index (IPNI). Plant life forms were determined according to Raunkiaer (1934) biological types classification method which, was adopted by many (Soumana et al., 2012; Ouedraogo, 2009; Ali and Saadou, 2008; Ali, 2005, 2006; Houinato, 2001; Sinsin, 1994). The phytogeographical rank of the plant species was determined based on White (1986) classification. This classification is widely accepted and applied largely in vegetation studies in Africa (Gnoumou, 2013; Idrissa et al., 2016; Nacoulma, 2012; Ouoba, 2013; Sinsin, 1993; Soumana et al., 2012; Soumana, 2011; Morou, 2010). The herbaceous biomass was collected by the integral harvest method, considered particularly reliable (Issoufa et al., 2020). Five biomasses of one square meter each, including four at the corners and one in the center, were harvested per plot. The samples were dried only in the sun for several days and then transported to the laboratory. They were weighed to determine the dry matter content.

Data analysis

For each plant species recorded in the vegetation surveys, the frequency of occurrence (Fi), which is an estimate of species canopy cover (**Probo2013**), was calculated as $Fi =$ number of occurrences/100 points.

Species Relative Abundance (SRAi) was computed on each transect then averaged for the plots and used to detect the proportion of different species according to the equation of Daget and Poissonet (1971):

$$\mathrm{SRA} = \frac{Fi}{\sum_{i=1}^{n} Fi};$$

where $Fi =$ number of occurrences/100 points

A SRA value $= 0.3$ was attributed to all occasional plant species found within vegetation plots but not along linear transects (Vacchiano et al., 2016). Herbage plant communities have been discriminated using multivariate analyses. The matrix of plots/species relative abundance (SRA) data was developed with Excel to carry out ordination and cluster analysis.

First, floristic data with 85 plots and 72 species in relative abundance was subjected to Agglomerative Hierarchical Clustering (AHC) using Ward's minimum variance clustering methods. This directly classifies both plots and species into plant communities. Then, ordination via Detrended correspondence Analysis (DCA) (Legendre and Legendre, 1998) was applied to assess the rate of changes in plant

composition and the main gradient that explains plant communities and species distribution patterns. Indicator species were identified by using the Indicator Species Analysis (ISA) (Dufrêne and Legendre, 1997) available on PC-ORD 5 (McCune and Grace, 2002).

The Indicator Species Analysis (ISA) combined both the relative frequency and abundance to calculate the indicator value of each species whose significance was tested by the Monte Carlo test. All the species with a probability of less than 0.05 were retained as characteristic species of the community (Ouoba, 2006). To designate each community, the combination of the names of the two species with high IV and ($P < 0.05$) were used to name plant communities (Soumana et al., 2012) according to the degree of fidelity and constancy (Braun-Blanquet, 1932).

Each plant community has been described following alpha diversity by computing richness (R), Shannon diversity index (H') and evenness (E), pastoral value (PV), phytomass production (P) and carrying capacity (CC).

The specific richness and the indices of diversity and regularity were determined in the rangeland to characterize the grassland resources:

Richness (R) is the total number of species in the plant community studied;

H' is used to measure the order (or disorder = entropy) of a system. It takes into account the relative abundance of species, and it is computed as follows:

$$H' = -\sum_{i=1}^{n}\{\frac{SRAi}{100}\log 2\frac{SRAi}{100}\}$$

E assesses the weight of each species in terms of space occupation of space. The higher it is, the more species participate in recovery. It is expressed by the equation: $E = H/\log_2 S$.

To estimate the PV of each herbage plant community, we attributed each species to an Index of specific quality (ISQ) (Daget and Poissonet, 1971; Cavallero et al., 2007). PV ranges from 0 to 100 and estimates the forage potentiality of a pasture area (Lozano et al., 2021).

The ISQ depends on the preference, morphology, structure, and productivity of the plant species and it ranges from 0 (low) to 5 (high) (Daget and Poissonet, 1971). The ISQ used in this study has been advanced by Soumana (2011). Species with ISQ equal to 5 mean very high-quality forage species.

Species with ISQ = 4 indicate high-quality forage.

Species with ISQ = 3 means species with quality forage.

Species with ISQ = 2 means species with low-quality forage.

Species with ISQ = 1 means species with very low-quality forage,

Species with ISQ = 0 means no palatable species.

The PV, which ranges from 0 to 100, was calculated as follows (Daget and Poissonet, 1971):

$$PV = \sum_{i=1}^{n}\frac{(SRAi.ISQi)}{5}; \quad \text{or} \quad PV = \sum_{i=1}^{n}(SRAi.ISQi)\times 0.2$$

where:

SRA is the percentage presence of each occurring species. *i* s previously reported.

ISQi is a synthetic index (ranging from 0 to 5) that summarises the overall forage importance of each species (Roggero et al., 2002).

CC of a pasture was measured by the number of animals fed relative to the pasture area and to the residence time (Daget et al., 2010).

It is calculated based on the productivity of the pasture and the daily feed requirements of the Tropical Livestock Unit (TLU). This reference animal was cattle with a living weight of 250 kg and a daily consumption of 6.25 kg of dry matter (DM) (see (Rothman-Ostrow et al., 2020)).

The carrying capacity of each herbage plant community is expressed by:

CC (TLU/ha/year) = productivity [kg DM/ha]) × U/(6.25 × period of use [180 days]), Where: Productivity is productivity annual average phytomass of the pasture,

U = 1/3 the coefficient of potential use of biomass is the Consumable component of the total biomass and one-third is retained during the maturation phase of the grasses (Ouedraogo, 2009), 6 months (180 days) is maintained period of use in this study.

Results

Taxonomy, life forms and chronological types of the herbages

A total of 72 vegetal species (herbaceous) were recorded in the four (4) rangelands, belonging to 53 genera and 19 families. Among the families, Poaceae was the most abundant family, having 22 species (31% of the total species), followed by Fabaceae, Cyperaceae Lamiaceae, Acanthaceae, Convolvulaceae Rubiaceae, Amaranthaceae, Tiliaceae and Scrophulariacea. The remaining families have only one species (Table 1).

Raunkiaer (1934) defined the life form of a plant in terms of the position and degree of protection of its perennating bud. His system provides a means of classifying floras which focuses on the natural selection of vegetative organs in response to environmental pressures and the ultimate morphological adaptations that enable the plant to survive unfavorable conditions (**Chapman1981**). The life forms spectrum of the four grazing lands was dominated by Therophytes at 75%, followed by hemicryptophytes at 8%, chamaephyte and Geophytes at 4% each, tuberous Geophytes 1%, Liana Therophytes, at 6% and Nanophanerophytes with 1% (figure 2).

Biogeography type is the geographic distribution of plants, animals, and other forms of life. It concerned not only habitation patterns but also with the factors responsible for variations in distribution. The phytogeographical types spectrum was dominated by the paleotropical, 25%, pantropical 21%

Table 1. Species life forms, chorological types and families of plant communities.

Species	Chronological types	Life forms	Families	Species No.	species %	Genera No.	Genera %
Zornia glochidiata Reichb. Ex DC.	PA	Th	Fabaceae	10	14	8	15
Tephrosia lupunifolia DC.	SZ	CH					
Alysicarpus ovalifolius (Schum. Et Thonn.) J. Léonard.	Pan	Th					
Tephrosia purpurea (L.) Pers. Ssp. Leptostachya (DC.) Brum. Var Leptostachya	PA	Th					
Cassia mimosoides L.	Pal	Th					
Indigofera nummulariifolia (L.) Liv. ex Alston	Pal	Th					
Indigofera tinctoria L.	PA	NnPh					
Cassia tora L.	Pan	Th					
Desmodium hirtum Guill. et Perr.	AT	Th					
Vigna gracilis (Guill. & Perr.) Hook.f.	PA	Th					
Commelina forskoalei Vahl.	Pal	Th	Commelinaceae	1	1	1	2
Microchloa indica (L. f.) P. Beauv.	Pan	Th	Poaceae	22	31	15	28
Eragrostis pilosa (L.) P. Beauv.	Cos	Th					
Schoenefeldia gracilis Kunth.	Pal	Th					
Dactyloctenium aegyptium (L.) Willd.	Pal	Th					
Brachiaria xantholeuca (Schinz.) Stapf.	SZ	Th					
Brachiaria ramosa (L.) Stapf.	Pal	Th					
Eragrostis tremula Steud.	Pan	Th					
Cenchrus biflorus Roxb.	Pal	Th					
Brachiaria villosa (Lam.) A. Camus.=Brachiaria distichophylla	AT	Th					
Aristida mutabilis Trin. et Rupr. = *A. meccana* Hochst. ex. Trin Rpr.	Pan	Th					
Sporobolus regularis.	AA	Th					
Andropogon pseudapricus Stapf.	AA	Th					
Borreria radiata	SZ	Th					
Digitaria gayana (Kunth.) A.Chev.	AT	Th					
Pennisetum pedicellatum Trin.	Pan	Th					
Schizachyrium nodulosum (Hack.) Stapf.	PA	Th					
Schizachyrium exile (Hochst.) Pilger.	Pal	Th					
Aristida kerstingii Pigler	GC-SZ	Th					
Aristida sieberiana Trin. = A. pallida Steud.	PA	H					
Andropogon gayanus var bisquamulatus (Hochst.) Hack.	S	H					
Aristida stipoïdes Lam.	AT	Th					
Ctenium elegans Kunth.	S	Th					
Cyperus conglomeratus Rottb.	Pal	H	Cyperaceae	9	13	4	8
Fimbristylis hispidula (Vahl.) Kunth. subsp. Hispidula	S	Th					
Cyperus alopecuroides Rottb.	Pal	Th					
Cyperus haspans L.	Pan	H					
Bulbostylis barbata (Rottb.) C.B.Cl.	Pal	Th					
Cyperus esculentus L.	Cos	Gt					
Killinga debilis	SZ	Th					
Cyperus amabilis Vahl.	Pan	Th					
Cyperus bulbosus Vahl.	Pal	Th					
Sida cordifolia L.	Pan	CH	Malvaceae	4	4	3	6
Corchorus fascicularis Lam.	Pal-	Th					
Corchorus tridens L.	Pal	Th					
Waltheria indica L.	Pan	CH					
Mitracarpus villosus (Sw.) DC.=M. scaber Zucc.	AT	Th	Rubiaceae	3	4	2	4
Borreria scabra (Schum. et Thonn.)	SZ	Th					
Borreria chaetocephala	S	Th					
Ceratotheca sesamoides Endl.	PA	Th	Pedaliaceae	1	1	1	2
Englerastrum nigericum Alston.	AT	Th	Lamiaceae	4	6	3	6
Leucas martinicensis (Jacq.) R. Br.	Pan	Th					
Solenostemon rotundifolius (Poir) J. K. Moiton.	Pal	G					
Englerastrum gracillimum TH.C.E.Fries.	SZ	Th					

Paleotropical (Pal); Afro American (AA); Cosmopolitan (Cos); Pluri Regional African (PA); Pantropical (Pan); Sudanian (S); Sudano-Zambesian (SZ); Afro-Tropical (AT); Guineo-Congolian- Sudano-Zambesian (GC-SZ); Afro Malgache (AM).
Therophytes (Th); Chamephytes (CH); Geophytes (G); Hemicryptophytes (H); Liana Therophytes (LTh); nanophanerophytes (NnPh); Tuberous Geophytes (Gt).

Continued of Table 1.

Species	Chronological types	Life forms	Families	Species No.	species %	Genera No.	Genera %
Momordica balsamina L.	Pal	LTh	Cucurbitaceae	1	1	1	2
Polygala arenaria Willd.	PA	Th	Polygalaceae	1	1	1	2
Pupalia lappacea (L.) Juss.	Pal	Th	Amaranthaceae	2	3	2	4
Amaranthus graecizans L.	Cos	Th					
Hygrophila senegalensis (Nees) T. Anders.	SZ	H	Acanthaceae	4	6	3	6
Monechma ciliatum (Jacq.) Miln. Red	AT	Th					
Achyranthes aspera L.	Pan	Th					
Achyranthes sicula	Pal	Th					
Polycarpea corymbosa	Pan	Th	Caryophyllaceae	1	1	1	2
Ipomoea vagans Bak.	S	LTh	Convolvulaceae	4	6	4	8
Merremia pinnata (Choisy.) f.	AT	LTh					
Jacquemontia tamnifolia (L.) Griseb.	AA	LTh					
Evolvulus alsinoides (L.) L.	Pan	Th					
Striga bilabiata (Thun.) O.Ktze.	PA	H	Scrophulariaceae	2	3	1	2
Striga hermonthica	AM	Th					
Stylochiton lancifolius Kotschy. et Peyr.	S	G	Araceae	1	1	1	2
Mollugo nudicaulis Lam	Pan	Th	Molluginaceae	1	1	1	2
Dipcadi longifolium (Lindl.) Baker	AT	G	Liliaceae	1	1	1	2
Total				72	100	53	100

Paleotropical (Pal); Afro American (AA); Cosmopolitan (Cos); Pluri Regional African (PA); Pantropical (Pan); Sudanian (S); Sudano-Zambesian (SZ); Afro-Tropical (AT); Guineo-Congolian- Sudano-Zambesian (GC-SZ); Afro Malgache (AM).
Therophytes (Th); Chamephytes (CH); Geophytes (G); Hemicryptophytes (H); Liana Therophytes (LTh); nanophanerophytes (NnPh); Tuberous Geophytes (Gt).

species of chorological spectrum (figure 3). They were followed by Afro-tropical (13%), Pluri-regional African (13%), Sudano-zambesian (10%), Sudanian (8%), Cosmopolitan and Afro-American (4%) each, Guineo-congolese/Soudano-zambezian, 1% and Afro-Malgasy, 1% (figure 3). The biogeography types of the plant communities of the Falmey rangelands indicate that the flora is essentially tropical. The most dominant chrorotypes are the widely distributed elements such as Palaeotropicals (Pal) and Pantropicals (Pan) species, followed by the Afro-tropical species.

Typology of the herbages plants communities

Following Agglomerative Hierarchical Clustering (AHC), the 72 sample plots and 72 species were arranged in five plant communities (figure 4). The Multi-Response Permutation Procedure (MRPP) test indicates a significant difference in the floristic compositions among the five plant communities ($A = 0.26$; $p < 0.00$; $T = -27$).

Each pair-wise comparison by MRPP (Table 2) showed that plant communities differed significantly. The small difference between the excepted (0.61) and observed delta (0.45) values confirms the strong variation in species composition between communities. The high chance-corrected within-group agreement ($A = 0.26$) and T statistic test showed ($T = -27$) that the five plant communities were distributed in different regions of the species space and related spatial heterogeneity of the herbage plant communities. The average within-group distance showed that the five plant communities of the herbages have relatively high dispersions, with an average distance of between 0.38 and 0.52 (figure 4).

Detrended correspondence Analysis (DCA) axis 1 and 2

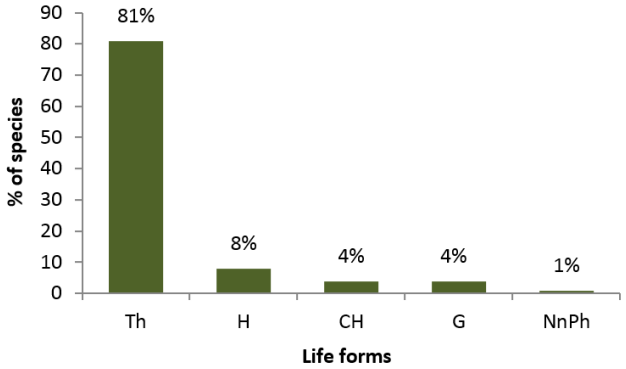

Figure 2. Life forms spectrum of the herbaceous species of Sahelian rangelands vegetation of the South-western part of Niger Republic according to Raunkiaer (1934) Therophytes (Th); Chamephytes (CH); Geophytes (G); Hemicryptophytes (H); Liana Therophytes (LTh); nanophanerophytes (NnPh); Tuberous Geophytes (Gt).

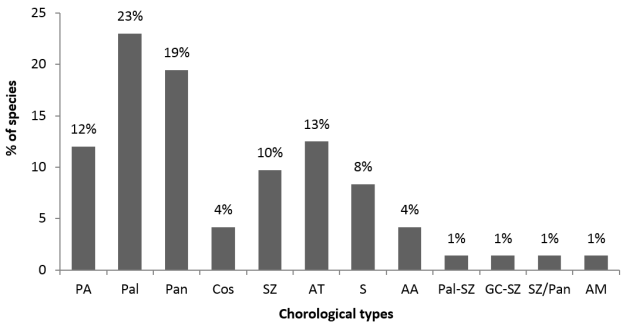

Figure 3. Chorotype spectrum of the species of Sahelian rangelands vegetation of the Southwestern part of Niger Republic according to White (1986) Paleotropical (Pal); Afro American (AA); Cosmopolitan (Cos); Pluri Regional African (PA); Pantropical (Pan); Sudanian (S); Sudano-Zambesian (SZ); Afro-Tropical (AT); Guineo-Congolian-Sudano-Zambesian (GC-SZ); Afro Malgache (AM).

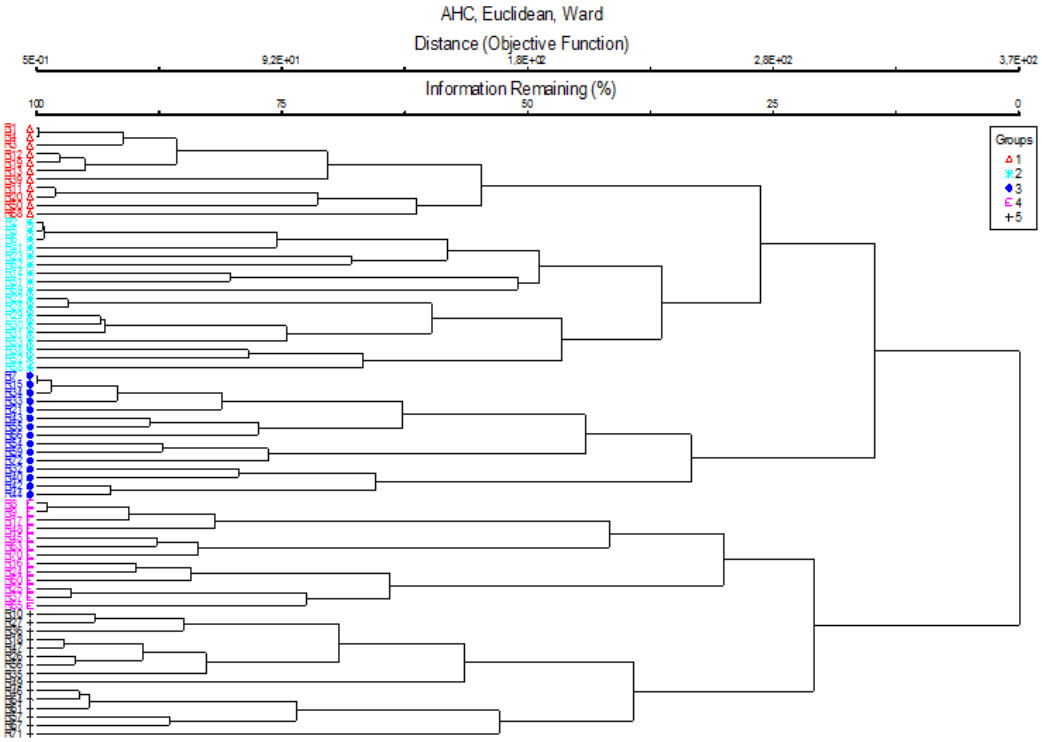

Figure 4. Agglomerative hierarchical cluster of plant communities. Plant communities dendrogram and MRPP test indicates a significant difference in the floristic composition among the 5 plant communities. 1 = *Schoenefeldia gracilis–Brachiaria ramosa community*; 2 = *Brachiaria xantholeuca–Mitracarpus villosus community*; 3 = *Zornia glochidiata–Solenostemon rotundifolius community*; 4 = *Schizachyrium exile–Walteria indica community* and 5 = *Commelina forskoalei–Englerastrum gracillium community*.

contrasted at right herbage plant communities from the southern part of the study area, in the Sudanian area and at the left, herbage plants communities from the northern part of the study area, the Sahelian area, thus DCA axis indicate a latitudinal gradient (figure 5 (A)). Sudanian plants communities were associated to *Commelina forskoalei*, *Borreria chaetocephala*, *Englerastrum gracillimum*, *Cyperus alopecuroides*, *Desmodium hirtum*, *Leucas martinicensis*, *Pupalia lappacea*, *Walteria indica*, *Schizachyrium exile*; While sahelian herbages were dominated by Commelina forskoalei, Schoenefeldia gracilis, Brachiaria ramose, *Andropogon pseudapricus Brachiaria xantholeuca*, *Cyperus haspans*, *Polycarpea corymbosa*, *Mitracarpus villosus*, *Sida cordifolia*, *Zornia glochidiata*, *Borreria scabra*, *Englerastrum nigericum* et *Solenostemon rotundifolius* (figure 5 (B)).

Group1: *Schoenefeldia gracilis–Brachiaria ramosa* herbage plants community

The community was described from 11 plots and 60 species, the majority recorded in the Sahelian bioclimatic area. The geomorphology is typically a flat plain with loamy crusted rocky soil. According to the Indicator Species Analysis (ISA), the community was characterized by *Commelina forskoalei*, *Schoenefeldia gracilis*, *Brachiaria ramosa*, *Alysicarpus ovalifolius*, *Microchloa indica*. The carrying capacity of the rangeland was 0.43 AU per month/ha and

Table 2. Summary of the Multi-Response Permutation Procedure (MRPP) of the Herbages Plant Communities on the Sahelian Rangelands (pairwise comparisons of the squared Euclidean distance).

Plants communistes	T value	A	P value
1 vs 2	−9.23	0.09	0.00
1 vs 3	−11.89	0.17	0.00
1 vs 4	−11.08	0.19	0.00
1 vs 5	−15.26	0.29	0.00
2 vs 3	−11.07	0.10	0.00
2 vs 4	−12.44	0.14	0.00
2 vs 5	−18.92	0.25	0.00
3 vs 4	−12.55	0.18	0.00
3 vs 5	−16.53	0.24	0.00
4 vs 5	−10.39	0.13	0.00

The test statistic: T = −27, Observed delta = 0.45 Expected delta = 0.61, Variance of delta = 0.32 Skewness of delta = −0.58, P ≤ 0.000 T value = difference between the observed and expected deltas. A = change-corrected within-group agreement; (A = 0.26) 1, 2, 3, 4, and 5 = Herbage plant communities.

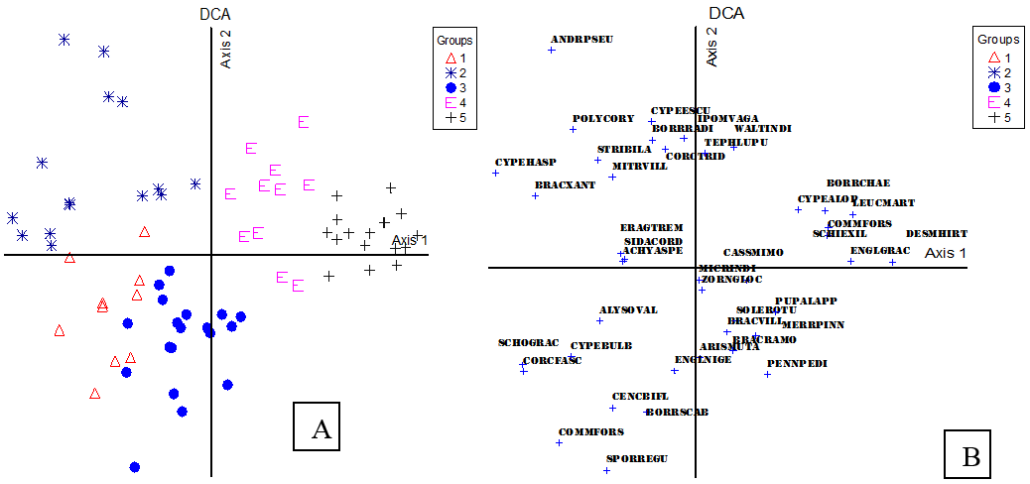

Figure 5. Ordination by Detrended Correspondence Analysis (DCA) of 72 relevés from the herbages. Eigenvalue for axis 1 and axis 2 were 40.69 and 22.57 respectively phytosociological description, DCA with plots (A) and DCA with species (B).

the pastoral value was 40.65%, thus *Schoenefeldia gracilis–Brachiaria ramosa* herbage plants community has relatively low pastoral value (Table 3). The low pastoral value results in the dominance of *Microchloa indica* (SRA = 32.09) and *Sida cordifolia* (SRA = 24.85) which are respectively low-quality forage species and non-palatable species.

Group2: *Brachiaria xantholeuca–Mitracarpus villosus* plants community

This community was described from 18 plots and 58 species, the majority recorded in Sahelian bioclimatic area. The geomorphology is slope, shallow, and in majority flat plain, with sandy loam, sandy clay, lateritic with stone, and crusted rocky soil. According to Indicator Species Analyisis (ISA) basing on the species relative frequency and relative abundance, this community is characterized by *Andropogon pseudapricus*, *Brachiaria xantholeuca*, *Cyperus haspans*, *Polycarpea corymbosa*, *Mitracarpus villosus*, *Sida cordifolia*.

The carrying capacity of the rangeland was 0.33 AU/month/ha/ and the pastoral value was 43.44%, thus *Brachiaria xantholeuca–Mitracarpus villosus* herbage plants community has relatively low pastoral value (Table 4). The low pastoral value results in the dominance of *Microchloa indica* (SRA = 30.29) and *Sida cordifolia* (SRA = 14.13), which are respectively low-quality forage species and non-

Table 3. Species relative abundance (SRA), Index of specific quality (ISQ) and Pastoral value (PV) of *Schoenefeldia gracilis–Brachiaria ramosa* herbage plants community.

Species	ISQ	SRA	PV	Species	ISQ	SRA	PV
Zornia glochidiata Reichb. Ex DC.	5	2.72	2.72	*Corchorus fascicularis* Lam.	1	0.15	0.03
Microchloa indica (L. f.) P. Beauv.	2	32.09	12.84	*Monechma ciliatum* (Jacq.) Miln. Red	2	0.19	0.08
Schoenefeldia gracilis Kunth.	4	7.46	5.97	*Borreria radiata*	1	0.30	0.06
Dactyloctenium aegyptium (L.) Willd.	5	0.18	0.18	*Digitaria gayana* (Kunth.) A.Chev.	2	0.05	0.02
Brachiaria xantholeuca (Schinz.) Stapf.	5	0.82	0.82	*Waltheria indica* L.	0	0.26	0.00
Cyperus conglomeratus Rottb.	2	0.09	0.04	*Killinga debilis*	1	0.13	0.03
Tephrosia lupunifolia DC.	1	4.35	0.87	*Polycarpea corymbosa*	0	0.24	0.00
Sida cordifolia L.	0	24.85	0.00	*Corchorus tridens* L.	3	0.42	0.25
Mitracarpus villosus (Sw.) DC.	1	6.74	1.35	*Ipomoea vagans* Bak.	4	0.11	0.09
Brachiaria ramosa (L.) Stapf.	5	0.92	0.92	*Commelina forskoalei* Vahl.	3	0.58	0.35
Fimbristylis hispidula (Vahl. Kunth.subsp. Hispidula	0	0.09	0.00	*Striga bilabiata* (Thun.) O.Ktze.	0	0.05	0.00
Ceratotheca sesamoides Endl.	2	0.11	0.04	*Cyperus amabilis* Vahl.	1	0.18	0.04
Alysicarpus ovalifolius (Schum. Et Thonn.) J. Léonard.	5	0.15	0.15	*Cyperus bulbosus* Vahl.	0	0.05	0.00
Cyperus alopecuroides Rottb.	1	0.07	0.01	*Leucas martinicensis* (Jacq.) R. Br.	3	8.72	5.23
Eragrostis pilosa (L.) P. Beauv.	4	0.14	0.11	*Borreria scabra* (Schum. et Thonn.)	1	0.10	0.02
Eragrostis tremula Steud.	4	6.04	4.83	*Solenostemon rotundifolius* (Poir) J. K. Moiton.	2	0.05	0.02
Tephrosia purpurea (L.) Pers.	2	0.23	0.09	*Merremia pinnata* (Choisy.) f.	3	0.08	0.05
Cenchrus biflorus Roxb.	5	0.08	0.08	*Englerastrum gracillimum* TH.C.E.Fries.	2	0.05	0.02
Cassia mimosoides L.	2	0.33	0.13	*Achyranthes aspera* L.	1	0.13	0.03
Brachiaria villosa (Lam.) A. Camus.	5	0.10	0.10	*Pennisetum pedicellatum* Trin.	5	0.11	0.11
Cyperus haspans L.	1	0.17	0.03	*Stylochiton lancifolius* Kotschy. et Peyr.	0	0.03	0.00
Englerastrum nigericum Alston.	2	0.18	0.07	*Schizachyrium exile* (Hochst.) Pilger.	5	0.60	0.60
Aristida mutabilis Trin. et Rupr.	5	1.94	1.94	*Jacquemontia tamnifolia* (L.) Griseb.	3	0.11	0.07
Bulbostylis barbata (Rottb.) C.B.Cl.	1	0.03	0.01	*Borreria chaetocephala*	1	0.10	0.02
Sporobolus regularis.	2	0.08	0.03	*Aristida kerstingii* Pigler	2	0.05	0.02
Polygala arenaria Willd.	0	0.03	0.00	*Mollugo nudicaulis* Lam	1	0.03	0.01
Andropogon pseudapricus Stapf.	3	0.16	0.10	*Andropogon gayanus* var bisquamulatus (Hochst.) Hack.	3	0.05	0.03
Pupalia lappacea (L.) Juss.	0	0.19	0.00	*Desmodium hirtum* Guill. et Perr.	2	0.07	0.03
Hygrophila senegalensis (Nees) T. Anders.	0	1.51	0.00	*Evolvulus alsinoides* (L.) L.	0	0.11	0.00
Cyperus esculentus L.	1	0.16	0.03	*Ctenium elegans*	2	0.03	0.01
Total							**40.68**

Table 4. Species relative abundance (SRA), Index of specific quality (ISQ) and Pastoral value (PV) of *Brachiaria xantholeuca–Mitracarpus villosus* herbage plants community.

Species	SRA	ISQ	PV	Species	SRA	ISQ	PV
Zornia glochidiata Reichb. Ex DC.	8.08	5	8.08	*Digitaria gayana* (Kunth.) A.Chev.	0.02	2	0.01
Microchloa indica (L. f.) P. Beauv.	30.29	2	12.12	*Waltheria indica* L.	0.52	0	0.00
Schoenefeldia gracilis Kunth.	4.31	4	3.45	*Killinga debilis*	0.03	1	0.01
Dactyloctenium aegyptium (L.) Willd.	0.10	5	0.10	*Polycarpea corymbosa*	0.10	0	0.00
Brachiaria xantholeuca (Schinz.) Stapf.	0.63	5	0.63	*Corchorus tridens* L.	0.03	3	0.02
Tephrosia lupunifolia DC.	1.11	1	0.22	*Ipomoea vagans* Bak.	0.14	4	0.12
Sida cordifolia L.	14.13	0	0.00	*Commelina forskoalei* Vahl.	0.87	3	0.52
Mitracarpus villosus (Sw.) DC. = M. scaber Zucc.	4.33	1	0.87	*Striga bilabiata* (Thun.) O.Ktze.	0.02	0	0.00
Brachiaria ramosa (L.) Stapf.	1.77	5	1.77	*Cyperus amabilis* Vahl.	0.04	1	0.01
Fimbristylis hispidula (Vahl.) Kunth.subsp. Hispidula	0.07	0	0.00	*Cyperus bulbosus* Vahl.	0.04	0	0.00
Ceratotheca sesamoides Endl.	0.07	2	0.03	*Leucas martinicensis* (Jacq.) R. Br.	0.94	3	0.57
Alysicarpus ovalifolius (Schum. Et Thonn.) J. Léonard.	0.26	5	0.26	*Borreria scabra* (Schum. et Thonn.)	0.28	1	0.06
Cyperus alopecuroides Rottb.	0.03	1	0.01	*Solenostemon rotundifolius* (Poir) J. K. Moiton.	4.56	2	1.82
Eragrostis tremula Steud.	1.56	4	1.25	*Merremia pinnata* (Choisy.) f.	0.06	3	0.04
Tephrosia purpurea (L.) Pers. Ssp. Leptostachya (DC.) Brum. Var Leptostachya	0.36	2	0.14	*Englerastrum gracillimum* TH.C.E.Fries.	0.08	2	0.03
Cenchrus biflorus Roxb.	1.95	5	1.95	*Achyranthes aspera* L.	0.02	1	0.00
Cassia mimosoides L.	3.50	2	1.40	*Pennisetum pedicellatum* Trin.	0.47	4	0.38
Brachiaria villosa (Lam.) A. Camus.=Brachiaria distichophylla	0.43	5	0.43	*Stylochiton lancifolius* Kotschy. et Peyr.	0.04	0	0.00
Cyperus haspans L.	0.06	1	0.01	*Schizachyrium nodulosum* (Hack.) Stapf.	0.02	4	0.01
Englerastrum nigericum Alston.	1.35	2	0.54	*Schizachyrium exile* (Hochst.) Pilger.	3.83	5	3.83
Aristida mutabilis Trin. et Rupr. = A. meccana Hochst. ex. Trin Rpr.	0.02	5	0.02	*Jacquemontia tamnifolia* (L.) Griseb.	0.03	3	0.02
Bulbostylis barbata (Rottb.) C.B.Cl.	0.02	1	0.00	*Borreria chaetocephala*	1.49	1	0.30
Sporobolus regularis.	0.33	2	0.13	*Aristida kerstingii* Pigler	0.39	2	0.16
Polygala arenaria Willd.	0.03	0	0.00	*Aristida pallida*	0.03	3	0.02
Andropogon pseudapricus Stapf.	1.52	3	0.91	*Andropogon gayanus var bisquamulatus* (Hochst.) Hack.	0.04	3	0.03
Pupalia lappacea (L.) Juss.	0.56	0	0.00	*Desmodium hirtum* Guill. et Perr.	1.50	2	0.60
Hygrophila senegalensis (Nees) T. Anders.	0.02	0	0.00	*Dipcadi longifollium*	0.04	0	0.00
Cyperus esculentus L.	0.18	1	0.04	*Evolvulus alsinoides* (L.) L.	0.07	0	0.00
Borreria radiata	2.66	1	0.53	*Vigna gracilis*	0.06	2	0.02
Total							**43.44**

palatable species.

Group 3: *Zornia glochidiata–Solenostemon rotundifolius* plants community

The community was described from 15 plots and 57 species, recorded from the Sahelian bioclimatic area to sudanian bioclimatic area. The geomorphology is a flat plain, plateaus slope, plateaus with sandy loam, sandy clay, and encrusted sandy rocky soil. According to ISA, community is characterized by *Zornia glochidiata*, *Borreria scabra*, *Englerastrum nigericum*, *Solenostemon rotundifolius*.

The carrying capacity of the rangeland was 0.49 AU/ha/-month and the pastoral value was 44.11%, thus *Zornia glochidiata–Solenostemon rotundifolius* herbage plants community has relatively low pastoral value (Table 5). The low pastoral value results in the dominance of *Microchloa indica* (SRA = 35.43) and *Sida cordifolia* (SRA = 20.74), which are respectively low-quality forage species and non-palatable species.

Group 4: *Schizachyrium exile–Walteria indica* plants community

This community was described from 13 plots and 55 species, recorded from sahelian bioclimatic area to sudanian bioclimatic area. The geomorphology is flat plain, slope and ravines, with sandy loam, sandy clay and lateritic, encrusted sand soil. According to Indicator Species Analysis (ISA) basing on the species relative frequency and relative abundance, this community is characterized by *Walteria indica and Schizachyrium exile*.

The carrying capacity of the rangeland was 0.26 AU/-month/ha/ and the pastoral value was 24.80%, thus *Schizachyrium exile–Walteria indica* herbage plants community has relatively low pastoral value (Table 6). The low pastoral value results in the dominance of *Microchloa indica* (SRA = 20.66) and *Sida cordifolia* (SRA = 14.96), which are respectively low-quality forage species and non-palatable species.

Group 5: *Commelina forskoalei–Englerastrum gracillium* plants community

This community was described from 15 plots and 49 species, recorded from sudanian bioclimatic area. The geomorphology is flat plain with sandy loam, sandy clay, lateritic, encrusted sand soil. According to Indicator Species Analysis (ISA) basing on the species relative frequency and relative abundance, this community is characterized by *Commelina forskoalei*, *Borreria chaetocephala*, *Englerastrum gracillimum*, *Cyperus alopecuroides*, *Desmodium hirtum*, *Leucas martinicensis*, *Pupalia lappacea*.

The grazing capacity of the rangeland was 0.32 AU/ha/year and the pastoral value was 39.02%, thus *Commelina forskoalei – Englerastrum gracillium* herbage plants community has relatively low pastoral value (Table 7). The low pastoral value results in the dominance of *Microchloa indica* (SRA = 26.47) and *Zornia glochidiata* (SRA = 15.21), which are respectively low-quality forage species and very high-quality forage species.

Diversity, Life forms, chorotypes and phytomass of community

The total number of species recorded in ***Schoenefeldia gracilis–Brachiaria ramosa community*** was 60 (Table 8) with a mean number of 19.72 ± 6.03 per plot, ranging from 9 to 29 species. The Shannon diversity index (H′) of the community was 3.31 bits and the evenness was 0.56 (Table 8). The life forms spectrum of this community was dominated by Therophytes with 82% of the total number

Table 5. Species relative abundance (SRA), Index of specific quality (ISQ) and Pastoral value (PV) of *Zornia glochidiata–Solenostemon rotundifolius* herbage plants community.

Species	SRA	ISQ	PV	Species	SRA	ISQ	PV
Zornia glochidiata Reichb. Ex DC.	13.81	5	13.81	*Digitaria gayana* (Kunth.) A.Chev.	0.21	2	0.08
Microchloa indica (L. f.) P. Beauv.	35.43	2	14.17	*Waltheria indica* L.	1.45	0	0.00
Schoenefeldia gracilis Kunth.	1.65	4	1.32	*Polycarpea corymbosa*	0.21	0	0.00
Dactyloctenium aegyptium (L.) Willd.	0.02	5	0.02	*Corchorus tridens* L.	0.32	3	0.19
Brachiaria xantholeuca (Schinz.) Stapf.	0.20	5	0.20	*Ipomoea vagans* Bak.	0.07	4	0.06
Cyperus conglomeratus Rottb.	0.02	2	0.01	*Commelina forskoalei* Vahl.	0.18	3	0.11
Tephrosia lupunifolia DC.	0.82	1	0.16	*Striga bilabiata* (Thun.) O.Ktze.	0.82	0	0.00
Sida cordifolia L.	20.74	0	0.00	*Cyperus amabilis* Vahl.	0.02	1	0.00
Mitracarpus villosus (Sw.) DC. = M. scaber Zucc.	1.46	1	0.29	*Cyperus bulbosus* Vahl.	0.02	0	0.00
Brachiaria ramosa (L.) Stapf.	0.58	5	0.58	*Leucas martinicensis* (Jacq.) R. Br.	0.69	3	0.41
Alysicarpus ovalifolius (Schum. Et Thonn.) J. Léonard.	0.02	5	0.02	*Borreria scabra* (Schum. et Thonn.)	0.13	1	0.03
Cyperus alopecuroides Rottb.	0.04	1	0.01	*Solenostemon rotundifolius* (Poir) J. K. Moiton.	0.09	2	0.03
Eragrostis tremula Steud.	0.45	4	0.36	*Merremia pinnata* (Choisy.) f.	0.05	3	0.03
Tephrosia purpurea (L.) Pers. Ssp. *Leptostachya* (DC.) Brum. Var *Leptostachya*	0.02	2	0.01	*Englerastrum gracillimum* TH.C.E.Fries.	0.15	2	0.06
Cenchrus biflorus Roxb.	0.02	5	0.02	*Achyranthes aspera* L.	0.03	1	0.01
Cassia mimosoides L.	3.71	2	1.48	*Pennisetum pedicellatum* Trin.	0.10	4	0.08
Brachiariavillosa (Lam.)A.Camus. = *Brachiaria distichophylla*	1.88	5	1.88	*Stylochiton lancifolius* Kotschy. et Peyr.	0.13	0	0.00
Cyperus haspans L.	0.07	1	0.01	*Schizachyrium nodulosum* (Hack.) Stapf.	0.03	4	0.03
Englerastrum nigericum Alston.	0.51	2	0.20	*Schizachyrium exile* (Hochst.) Pilger.	3.23	5	3.23
Aristida mutabilis Trin. et Rupr. = A. *meccana* Hochst. ex. Trin Rpr.	1.45	5	1.45	*Jacquemontia tamnifolia* (L.) Griseb.	0.02	3	0.01
Bulbostylis barbata (Rottb.) C.B.Cl.	0.17	1	0.03	*Borreria chaetocephala*	1.83	1	0.37
Sporobolus regularis.	0.06	2	0.02	*Aristida kerstingii* Pigler	0.04	2	0.02
Andropogon pseudapricus Stapf.	2.37	3	1.42	*Desmodium hirtum* Guill. et Perr.	3.79	2	1.51
Pupalia lappacea (L.) Juss.	2.33	0	0.00	*Aristida stipoïdes* Lam.	0.07	2	0.03
Hygrophila senegalensis (Nees) T. Anders.	0.03	0	0.00	*Striga hermonthica*	0.13	0	0.00
Cyperus esculentus L.	0.07	1	0.01	*Dipcadi longifollium*	0.02	0	0.00
Corchorus fascicularis Lam.	0.10	1	0.02	*Evolvulus alsinoides* (L.) L.	0.07	0	0.00
Monechma ciliatum (Jacq.) Miln. Red	0.02	2	0.01	*Ctenium elegans*	0.42	2	0.17
Borreria radiata	0.62	1	0.12				
Total							**44.11**

of species. Chorotype spectrum was dominated by The Paleotropical and Pantropical, with 25% and 23% of total species.

The annual phytomass productivity of the herbaceous ranged from 1040 kg.DM/ha to 2680 kg.DM/ha with an average of 1450 ± 470 kg.DM/ha (Table 8).

The total number of species recorded in ***Brachiaria xantholeuca–Mitracarpus villosus*** **plants community** was 58 (Table 8) with a mean number of 16.05 ± 5.41 per plot, ranged from 0 to 29 species. The Shannon diversity index (H') of the community is 3.75 bits and the evenness is 0.64 (Table 8) Life forms spectrum of this group was dominated

Table 6. Relative abundance Species, Index of specific quality and Pastoral value of *Schizachyrium exile–Walteria indica* herbage plants community.

Species	SRA	ISQ	PV	Species	SRA	ISQ	PV
Zornia glochidiata Reichb. Ex DC.	2.14	5	2.14	*Polycarpea corymbosa*	0.28	0	0.00
Microchloa indica (L. f.) P. Beauv.	20.66	2	8.26	*Corchorus tridens* L.	0.07	3	0.04
Schoenefeldia gracilis Kunth.	4.04	4	3.23	*Ipomoea vagans* Bak.	0.05	4	0.04
Dactyloctenium aegyptium (L.) Willd.	0.07	5	0.07	*Commelina forskoalei* Vahl.	1.98	3	1.19
Brachiaria xantholeuca (Schinz.) Stapf.	0.08	5	0.08	*Striga bilabiata* (Thun.) O.Ktze.	0.23	0	0.00
Tephrosia lupunifolia DC.	0.02	1	0.00	*Cyperus amabilis* Vahl.	0.08	1	0.02
Sida cordifolia L.	14.96	0	0.00	*Cyperus bulbosus* Vahl.	0.08	0	0.00
Mitracarpus villosus (Sw.) DC.= M. scaber Zucc.	0.26	1	0.05	*Leucas martinicensis* (Jacq.) R. Br.	1.37	3	0.82
Brachiaria ramosa (L.) Stapf.	0.75	5	0.75	*Borreria scabra* (Schum. et Thonn.)	1.05	1	0.21
Alysicarpus ovalifolius (Schum. Et Thonn.) J. Léonard.	0.07	5	0.07	*Solenostemon rotundifolius* (Poir) J. K. Moiton.	0.20	2	0.08
Cyperus alopecuroides Rottb.	0.04	1	0.01	*Merremia pinnata* (Choisy.) f.	0.07	3	0.04
Eragrostis tremula Steud.	2.27	4	1.82	*Englerastrum gracillimum* TH.C.E.Fries.	0.02	2	0.01
Tephrosia purpurea (L.) Pers. Ssp. *Leptostachya* (DC.) Brum. *Var Leptostachya*	0.02	2	0.01	*Indigofera nummulariifolia* (L.) Liv. ex Alston	0.04	0	0.00
Cenchrus biflorus Roxb.	0.19	5	0.19	*Achyranthes aspera* L.	0.22	1	0.04
Cassia mimosoides L.	1.02	2	0.41	*Pennisetum pedicellatum* Trin.	1.35	5	1.35
Brachiaria villosa (Lam.) A. Camus.=*Brachiaria distichophylla*	0.08	5	0.08	*Stylochiton lancifolius* Kotschy. et Peyr.	0.09	0	0.00
Cyperus haspans L.	0.04	1	0.01	*Schizachyrium exile* (Hochst.) Pilger.	0.26	5	0.26
Englerastrum nigericum Alston.	4.48	2	1.79	*Jacquemontia tamnifolia* (L.) Griseb.	0.12	3	0.07
Sporobolus regularis.	1.38	2	0.55	*Borreria chaetocephala*	0.92	1	0.18
Momordica balsamina L.	0.19	0	0.00	*Aristida kerstingii* Pigler	0.07	2	0.03
Polygala arenaria Willd.	0.04	0	0.00	*Mollugo nudicaulis* Lam	0.02	1	0.00
Pupalia lappacea (L.) Juss.	1.95	0	0.00	*Desmodium hirtum* Guill. et Perr.	1.92	2	0.77
Cyperus esculentus L.	0.02	1	0.00	*Aristida stipoïdes* Lam.	0.05	2	0.02
Corchorus fascicularis Lam.	0.15	1	0.03	*Achyranthes sicula*	0.06	1	0.01
Borreria radiata	0.05	1	0.01	*Dipcadi longifollium*	0.14	0	0.00
Digitaria gayana (Kunth.) A.Chev.	0.04	2	0.02	*Evolvulus alsinoides* (L.) L.	0.02	0	0.00
Waltheria indica L.	0.15	0	0.00	*Vigna gracilis*	0.02	2	0.01
Killinga debilis	0.02	1	0.00				
Total							**24.80**

Table 7. Relative abundance Species, Index of specific quality and Pastoral value of *Commelina forskoalei – Englerastrum gracillium* herbage plants community.

Species	SRA	IS	PV	Species	SRA	IS	PV
Zornia glochidiata Reichb. Ex DC.	15.21	5	15.21	*Borreria radiata*	0.47	1	0.09
Microchloa indica (L. f.) P. Beauv.	26.47	2	10.59	*Waltheria indica* L.	0.22	0	0.00
Schoenefeldia gracilis Kunth.	0.06	4	0.05	*Polycarpea corymbosa*	0.19	0	0.00
Dactyloctenium aegyptium (L.) Willd.	0.08	5	0.08	*Corchorus tridens* L.	0.09	3	0.06
Brachiaria xantholeuca (Schinz.) Stapf.	0.02	5	0.02	*Ipomoea vagans* Bak.	0.07	4	0.06
Cyperus conglomeratus Rottb.	0.02	2	0.01	*Commelina forskoalei* Vahl.	0.44	3	0.26
Tephrosia lupunifolia DC.	0.11	1	0.02	*Striga bilabiata* (Thun.) O.Ktze.	0.05	0	0.00
Sida cordifolia L.	7.03	0	0.00	*Leucas martinicensis* (Jacq.) R. Br.	6.27	3	3.76
Mitracarpus villosus (Sw.) DC. = M. *scaber* Zucc.	0.44	1	0.09	*Borreria scabra* (Schum. et Thonn.)	0.07	1	0.01
Brachiaria ramosa (L.) Stapf.	0.59	5	0.59	*Solenostemon rotundifolius* (Poir) J. K. Moiton.	1.07	1	0.21
Fimbristylis hispidula (Vahl.) Kunth.subsp. *Hispidula*	0.02	0	0.00	*Merremia pinnata* (Choisy.) f.	0.19	3	0.11
Alysicarpus ovalifolius (Schum. Et Thonn.) J. Léonard.	0.02	5	0.02	*Englerastrum gracillimum* TH.C.E.Fries.	0.35	2	0.14
Cyperus alopecuroides Rottb.	0.69	1	0.14	*Achyranthes aspera* L.	1.62	1	0.32
Eragrostis tremula Steud.	4.01	4	3.21	*Pennisetum pedicellatum* Trin.	0.13	5	0.13
Cenchrus biflorus Roxb.	0.09	5	0.09	*Stylochiton lancifolius* Kotschy. et Peyr.	0.02	0	0.00
Cassia mimosoides L.	0.55	2	0.22	*Schizachyrium exile* (Hochst.) Pilger.	1.31	5	1.31
Brachiaria villosa (Lam.) A. Camus.=*Brachiaria distichophylla*	0.63	5	0.63	*Borreria chaetocephala*	2.35	1	0.47
Cyperus haspans L.	0.13	1	0.03	*Aristida kerstingii Pigler*	0.02	2	0.01
Englerastrum nigericum Alston.	0.96	2	0.38	*Mollugo nudicaulis* Lam	0.25	1	0.05
Aristida mutabilis Trin. et Rupr. = *A. meccana* Hochst. ex. Trin Rpr.	0.02	5	0.02	*Desmodium hirtum* Guill. et Perr.	1.21	2	0.48
Sporobolus regularis.	0.09	2	0.03	*Aristida stipoïdes* Lam.	0.02	2	0.01
Andropogon pseudapricus Stapf.	0.13	3	0.08	*Striga hermonthica*	0.03	0	0.00
Pupalia lappacea (L.) Juss.	6.51	0	0.00	*Dipcadi longifollium*	0.10	0	0.00
Cyperus esculentus L.	0.02	1	0.00	*Evolvulus alsinoides* (L.) L.	0.05	0	0.00
Monechma ciliatum (Jacq.) Miln. Red	0.02	2	0.01				
Total							**39.02**

by Therophytes with 79%, followed by Hydrophytes with 9% of the total number of species. Chorotype spectrum is dominated by Paleotropical and Pantropical with 22% of species each.

The annual phytomass productivity of the herbaceous ranged from 510 kg.DM/ha to 2610 kg.DM/ha with an average of 1120 ± 550 kg.DM/ha (Table 8).

The total number of species of ***Zornia glochidiata – Solenostemon rotundifolius*** **plants community** recorded is 57 (Table 8) with a mean number of 15.13 ± 2.44 per plot, ranged from 8 to 19 species. The Shannon diversity index (H′) of the community is 3.33 bits and the evenness is 0.57. The life forms spectrum of this group was dominated by Therophytes at 81%, followed by Hydrophytes and Geophytes at 7% each and Chamephytes at 5%. Chorotype spectrum is dominated by Paleotropical and Pantropical with respectively 26% and 23% of total species followed by Afro-tropical 16%, Sudano-zambezian 12%.

The annual phytomass productivity of the herbaceous ranged from 1010 kg.DM/ha to 2550 kg.DM/ha with an average of 1640 ± 510 kg.DM/ha (Table 8).

In ***Schizachyrium exile–Walteria indica*** **plants community**, the total number of species recorded is 55 (Table 8) with a mean number of 15.15 ± 5.14 per plot, ranged

Table 8. Characteristics of plant communities.

Characteristics	Plant communities #					Average
	Group1	Group2	Group3	Group4	Group5	
Area (ha)	1.1	1.8	1.5	1.3	1.5	1.44 ± 0.26
Number of Species (Richness)	60	58	57	55	49	55.8 ± 4.20
Canopy Cover (%)	91	74	95	99	99	91.6 ± 10.38
Total Yield (Kg/ha)	1450	1120	1640	880	1080	1234 ± 300
Potential use of biomass (%)	48.33	37.33	54.67	29.33	36	41.1 ± 10.18
The daily requirement (Kg/DM per Day)	8.06	6.22	9.11	4.89	6	6.85 ± 1.69
The length of the grazing season (Day)	180	180	180	180	180	180 ± 0.00
Grazing Capacity (AU per Month/ha)	0.43	0.33	0.49	0.26	0.32	0.36 ± 0.09
Rangeland Value or Pasture Value	40.65	43.44	44.11	24.8	39.02	38.4 ± 7.88
Shannon diversity index (H′)	3.31	3.75	3.33	3.5	3.34	3.44 ± 0.18
Evenness	0.56	0.64	0.57	0.6	0.59	0.59 ± 0.03

Group1: Schoenefeldia gracilis – Brachiaria ramosa community
Group2: Brachiaria xantholeuca – Mitracarpus villosus community
Group3: Zornia glochidiata – Solenostemon rotundifolius community
Group4: Schizachyrium exile – Walteria indica community
Group5: Commelina forskoalei – Englerastrum gracillium community

from 3 to 21 species. The Shannon diversity index (H′) of the community is 3.50 bits and the evenness is 0.60. The life forms spectrum of this group was dominated by Therophytes at 84% followed by Geophytes at 7%, Chamephytes at 5% and Hydrophytes at 4% of the total number of species. Chorotype spectrum is dominated by paleotropical 29% followed by Pantropical 22% of species. The annual phytomass productivity of the herbaceous ranged from 520 kg.DM/ha, to 2270 kg.DM/ha with an average of 880 ± 360 kg.DM/ha (Table 8).

In ***Commelina forskoalei–Englerastrum gracillium*** **plants community**, the total number of species recorded is 49 (Table 8), with a mean number of 14.2 ± 5.46 per plot, ranged from 3 to 22 species. The Shannon diversity index (H′) of the community is 3.34 bits and the evenness is 0.59. The life forms spectrum of this group was dominated by Therophytes with 80% followed by Chamephytes with 8%, Hydrophytes and Geophytes with 6% each. Chorotype spectrum is dominated by Pantropical and Paleotropical 24% for each followed by Afro-tropical 16% of species, sudano-zambezian 14%.

The annual phytomass productivity of the herbaceous ranged from 510 kg.DM/ha, to 2410 kg.DM/ha with an average of 1080 ± 480 kg.DM/ha (Table 8).

Discussion

The most represented plant families in Falmey rangeland are the Poaceae, followed by the Fabaceae, following Garba (1984), Ali (2005), Morou (2010). However, Poacea and Fabaceae are the main dominant families of the flora of Niger. This domination by Poaceae herbaceous annual plants, mainly grasses, is characteristic of the Sahelian zone. This predominance has been highlighted by many authors as characteristic of Sahelian pastures (Saadou, 1990; Akpo and Grouzis, 2000; Hiernaux and Houérou, 2006; Morou, 2010; Sanon et al., 2015; Soumana, 2011; Yameogo et al., 2013). In addition, Soumana et al. (2012) found that Poaceae (grass) species had great potential forage value.

The predominance of therophytes reflects the dry environment to which the study area belongs. The predominance of therophytes in Sahalian rangelands has been observed by Soumana (2011), Alassan et al. (2019) and Ali et al. (2017). Our results corroborate those obtained by these authors and will be linked to the similarity of ecological conditions which are the Sahalian environment. This therophytization is a characteristic of arid zones, a strategy of adaptation to conditions unfavorable, a form of resistance to severe climatic conditions and a sign of degradation advanced on the vegetation (Soumana, 2011).

In highly anthropized savannas, Mbayngone et al. (2008) recorded an abundance of species with a wide geographic distribution and linked it to grazing. They pointed out that the abundance of a wide distribution of species is an indicator of disturbance.

Following Agglomerative Hierarchical Cluster and Detrended Correspondence Analysis (DCA), five herbage communities were discriminated. According to the multi-response permutation procedure (MRPP), these herbages had significantly different plant species composition and occurred in different places in the rangelands. The biodiversity estimates with Richness, Shannon index and Pielou Equitability respectively ranged from 49 to 60; 3.31 to 3.75 bits for Shanon index and from 0.56 to 0.64 for equitability index indicating that all the herbage communities have high phytodiversity. High richness had been recorded in *Schoenefeldia gracilis–Brachiaria ramosa* herbage community and the lower *Commelina forskoalei-Englerastrum gracillium* herbage Community. The high Shannon index has been recorded with *Brachiaria xantholeuca–Mitracarpus villosus* pasture community and the lower with *Schoenefeldia gracilis–Brachiaria ramosa* herbage community; when the highly *Brachiaria xantholeuca–Mitracarpus villosus* Community and the lower recorded with *Schoenefeldia gracilis–Brachiaria ramosa* herbage community. These are in accordance with Idrissa et al. (2016), Soumana (2011), who had also identified different Richness, Shannon index and Pielou Equitability in different plant communities. In Idrissa et al. (2016), Richness has ranged between 29 and 83; Shannon index ranged between 2.4 and 4 bits and Pielou equitability between 0.4 and 0.6. The herbage communities had significant differences of produced phytomass with a mean of 1230 ± 300 kg.DM/ha ranged between 880 ± 360 kg.DM/ha to 1640 ± 510 kg.DM/ha (Table 8), in accordance with Soumana (2011) and Idrissa et al. (2016). In the present study, the high value of phytomass has been recorded by the *Zornia glochidiata–Solenostemon rotundifolius* community and the low biomass value was recorded by the *Schizachyrium exile–Walteria indica* community. Changes in phytomass are correlated with changes in carrying capacity. The community of *Zornia glochidiata–Solenostemon rotundifolius* which had the highest value of biomass, had also the highest value of carrying capacity (0.49 AU/ha/year), and the community of *Schizachyrium exile–Walteria indica* observed the lowest biomass value, has recorded also the lowest carrying capacity (0.26 AU/ha/year). Carrying capacity is associated with producing biomass. A community with high production of biomass had a high value of carrying capacity and a community with low biomass also had low carrying capacity. Although Richness, Shannon index, Pielou equitability, phytomass, and carrying capacity vary with plant communities. Pastoral values also changed with the plants' community. It ranged between 24.80% to 44.11% in the Falmey herbages community and indicating the lower quality of the pasture of Falmey rangelands. The highest pastoral value has been recorded in *Zornia glochidiata–Solenostemon rotundifolius* and the lowest pastoral value in *Schizachyrium exile* (Hochst.) *Pilger–Walteria indica* Community. These lower values of pastoral have been to high relative abundance with no palatable species, very low and low quality forage species. Very high and high-quality forage species are less represented compared to the other species. This variation in the forage quality of species among herbage communities has also been observed by (Soumana, 2011; Idrissa et al., 2016).

Compared to the present study, Soumana (2011), Idrissa et al. (2016) observed a high quantity and quality of forage species. However, Falmey rangelands had different

herbage communities with different Richness, Shannon index, Pielou equitability, phytomass, carrying capacity and pastoral value.
These could be linked to the difference in plant composition and ecological condition, which have been revealed by the multi-response permutation procedure (MRPP). Thus, the rangelands of Falmey are heterogeneous with different plant communities, species composition, locations, productivities, diversity and pastoral values. Several environmental factors drive spatial heterogeneity in plant community composition, which can in turn create functional heterogeneity (Fuhlendorf et al., 2017). It remains to be determined the main environmental factors that structure and drive the heterogeneity of the Falmey rangelands vegetation.

Conclusions

Therefore, the result indicates that changes in phytomass were correlated with changes in carrying capacity. The highest value of biomass also had the highest carrying capacity. Although Richness and diversity were expressed by the Shannon index, equitable distribution of species within the community was expressed by the Pielou equitability index and pastoral value change with the plant community. In total, the pastoral value of Falmey's four rangelands ranged from 24.80% to 44.11% indicating the lower quality of the pasture of Falmey four rangelands. This low pastoral value results from an abundance of species of non-palatable and low-quality forage. This information is a key for the manager for suitable management of rangeland.

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Authors contributions
Authors have contributed equally in preparing and writing the manuscript.

Availability of data and materials
The data that support the findings of this study are available from the corresponding author, upon reasonable request.

Conflict of interests
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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