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Specific diversity of *Vachellia tortilis subsp. raddiana* formations in Kilakam and N'Guel kolo in the Diffa region, Niger

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ABSTRACT

Objective: The objective of the study was to analyse the ecological and floristic indicators of natural formations with *Vachellia tortilis* subsp. *raddiana*.

Methodology and Results: The present study was conducted in the departments of Maine-Soroa and Goudoumaria located in the Diffa region, in the extreme south-east of Niger Phytosociological data were collected using the Braun-Blanquet sigmatiste method and the Daget and Poissonet quadrat point method. In total, 80 plots were delimited. The data collected are related to the coverage of plant species and environmental variables. The spectra of biological and phytogeographical types were calculated. Hierarchical Ascending Classification (HAC), Canonical Detrended Analysis (CDA) and Canonical Correspondence Analysis (CCA) were used to determine the plant groupings and their ecological and floristic characteristics. The results revealed a total species richness of 72 plant species divided into 34 families and 70 genera. The most represented families are Poaceae (18.06%), Fabaceae- Mimosoideae, and Convolvulaceae (8.33% each). Therophytes are the most represented biological type (50%). Paleotropical species is the dominant phytogeographic type (37.5%). The ascending hierarchical classification (CHA) and the Canonical Correspondence Analysis (CCA) allowed to discriminate three (3) plant groupings with *V. tortilis*. These are the *Vachellia tortilis* and *Dactyloctenium aegyptium* group (G1) and the *Vachellia tortilis* and *Cenchrus biflorus* group (G2) observed on the dune flats and slopes and the *Vachellia tortilis* and *Schoenefeldia gracilis* group (G3) in the lowlands. The analysis of structural parameters showed that the population of *V. tortilis* is characterized by an average density of 102.5±22.10 plants/ha with individuals having an average diameter of 14.68±8.22 cm, an average height of 5.24±1.49 m and an average cover of 25.58±16.47 m².

Conclusion and application of results: This study constitutes a reference state that can serve as a basis for sustainable management of the ecosystems in these areas, whose main uses are essentially pastoral.

Key words: *Vachellia tortilis*, Biological types, Phytogeographical types, Floristic diversity, Niger.

INTRODUCTION

In the Sahel and particularly in Niger, woody species play a predominant role in the socio-economic and cultural life of the populations. They are part of the bio-geochemical cycle of production systems by contributing biomass and/or necromass, creating a favourable microclimate for crops and protecting soils against water and wind erosion (Moussa *et al*., 2015). In addition, woody plants constitute important inputs of human and animal food especially during difficult periods of the year in the Sahel (Moussa *et al.,* 2015). Like the rest of the country, the Diffa region is currently facing a sharp deterioration in its production potential, due to the combined effect of increased land pressure, irregular and unfavourable climatic conditions, and production methods that remain traditional. This situation pushes rural populations to draw even more on the only remaining available capital (soil, pastures, forests), beyond the capacity to maintain and renew (CUD, 2014). Highly constraining climatic conditions combined with anthropogenic threat lead to fragility of the region's ecosystems. This leads to the vegetation cover being subjected today to accelerated degradation due to drought, erosion, silting, overgrazing, deforestation of anthropic origin favouring the setting in motion of sandy substrates thus making it difficult to reclaim the spaces lost by the vegetation cover. This vegetation cover is characterized by hardy species like *Vachellia tortilis*. *Vachellia tortilis is the* most represented species in the Saharan-Sahelian zones because of its particular ecology well adapted to the arid zone. The species spreads in Saharan, Sahelian to Sudano-Sahelian zones. It prefers sandy soils, but can also be found in scree, lateritic scree and the edges of temporary pools (Arbonnier 2004). Its range extends from Senegal to Cameroon to Somalia. It is found throughout tropical Africa, North Africa, the Middle East and Arabia. The species is quite common and gregarious, sometimes in pure stands (Arbonnier, 2004). *Vachellia tortilis* is used in human food, traditional pharmacopoeia, livestock feed, energy wood and timber (Grouzis and Le Floc'h 2003). It plays an important role in improving the microclimatic factors of its ecosystem (Abdallah *et al.,* 2008), which ensures an increase in the diversity and production of the herbaceous stratum (Abdallah *et al.,* 2008). The positive impact of the species is mainly due to the improvement of soil water and nutrient availability (Bowie *et al.,* 2004; Abdallah *et al.,* 2008; Abdallah *et al.,* 2012; Fterich *et al.,* 2012). In Niger, natural pastures form the basis and more often than not, the entire feed resource for ruminants (Karim 2013). Under the effect of anthropic pressure, many species have disappeared, others are threatened with extinction and the natural landscape is transformed into parks where woody plants, crops and/or animals cohabit (Mahamane *et al.,* 1997, Lawarnou *et al*., 2005). This new dynamic requires the updating of knowledge on vegetation, particularly woody vegetation in agroforestry parks, in order to understand the structure, floristic richness and regeneration capacity of woody stands to facilitate the management of these resources for the benefit of the populations (Sâadou *et al.*, 1997). The study of the flora and vegetation of the rangelands in relation to environmental variables makes it possible to predict the response of communities to changes in their environment through the development of scientific instruments for sustainable management (Abdourahamane 2016, Alhassane 2019). This study aims to evaluate the floristic potential of the *Vachellia tortilis* vegetation in the departments of Mainé Soroa and Goudoumaria in Niger.

MATERIAL AND METHODS

Study area: The study is conducted in two departments of the Diffa region (Figure 1). These are the N'Guel Kolo site, located between 13°25'12" N and 11°22'12" E, and the Kilakam site, located between 13°33'36" N and 11°44'24" E. The sites are unique in that they contain natural formations of *Vachellia tortilis*. The particularity of the sites lies in the presence of natural formations of *Vachellia tortilis*. The N'Guel kolo site is located in the Maïné Soroa department, which is situated between 13°05' and 14°30' North latitude and 10°35' and 12°30' East longitude. The relief is characterized by plains and sand dunes, oasis basins and lowlands (Harouna 2006 and Kaou *et al.*, 2017). The main types of soil encountered include the soils of the plains and dune plateaus (Kaou *et al.*, 2017). The climate of the area is of the Saharan-Sahelian type marked by a long dry season (9 to 10 months), followed by a rainy season with short and violent rainfall mainly during the months of July and August (Bodart *et al.*, 2010 and Kaou *et al.*, 2017). The cumulative annual rainfall is 384.3 ±72.6 mm over the last 15 years with temperatures showing two minima of 12 and 23°C and two maxima of 38 and 41°C (Toudjani *et al.*, 2004; Kaou *et al.*, 2017). The vegetation is essentially steppe (tree, shrub and herbaceous) characterized by a strong presence of *Vachellia tortilis*, *Leptadenia pyrotechnica* and *Calotropis procera*. Depending on the latitude, atypical forest formations are observed, formed by phreatophyllous stands of the Arecaceae family. The agroforestry parks, the lowlands and the riparian formations of the Komadougou are essentially composed of *Senegallia senegal*, *Vachellia tortilis*, *Faidherbia albida*, *Salvadora persica*, *Tamarindus indica*, *Commiphora africana*. The main economic activities remain agriculture and livestock. The impact of climatic hazards on rudimentary production systems leads to chronic food insecurity. This situation constitutes one of the main factors of extreme vulnerability of rural populations. As for the Kilakam site, it is located in the Goudoumaria department. It is located between 13°42' North latitude and 11°11'2 East longitude. The climate is Sahelo-Sudanese with a short rainy season from June to September and a long dry season from October to May. The maximum temperature varies between 42°C and 45°C in April-May with a minimum of 19°C in December-January, which can drop to 10°C or even 5°C at night during these months. Rainfall varies from 0 mm to 119.2 mm between the driest month (January) and the wettest month (August) where rainfall is the highest of the year. The relief is made up of semi-arid plateaus dotted with hills. The area is characterized by a vast sandy plateau composed of sharp dunes. This plateau, whose altitude varies between 300 and 400 m, is interspersed with elongated, open or semi-open depressions called lowlands. The woody flora is characterized in the lowlands and on the plateau by tree species such as *Vachellia tortilis*, *Balanites aegyptiaca*, *Commiphora africana*, *Ziziphus mauritiania*, *Acacia nilotica*, *Boscia senegalensis*, *Guiera senegalensis*, *Leptadenia pyrotechnica* and *Calotropis procera* with pure or mixed stands of *Senegalia senegal*. This vegetation is confronted with overexploitation for domestic and livestock uses. In addition to this, there are the effects of water erosion and the aridity of the climate in some places. The main economic activity of the populations, livestock breeding, is confronted with an insufficiency of grazing areas and passage corridors because of the strong occupation of the land by agriculture.

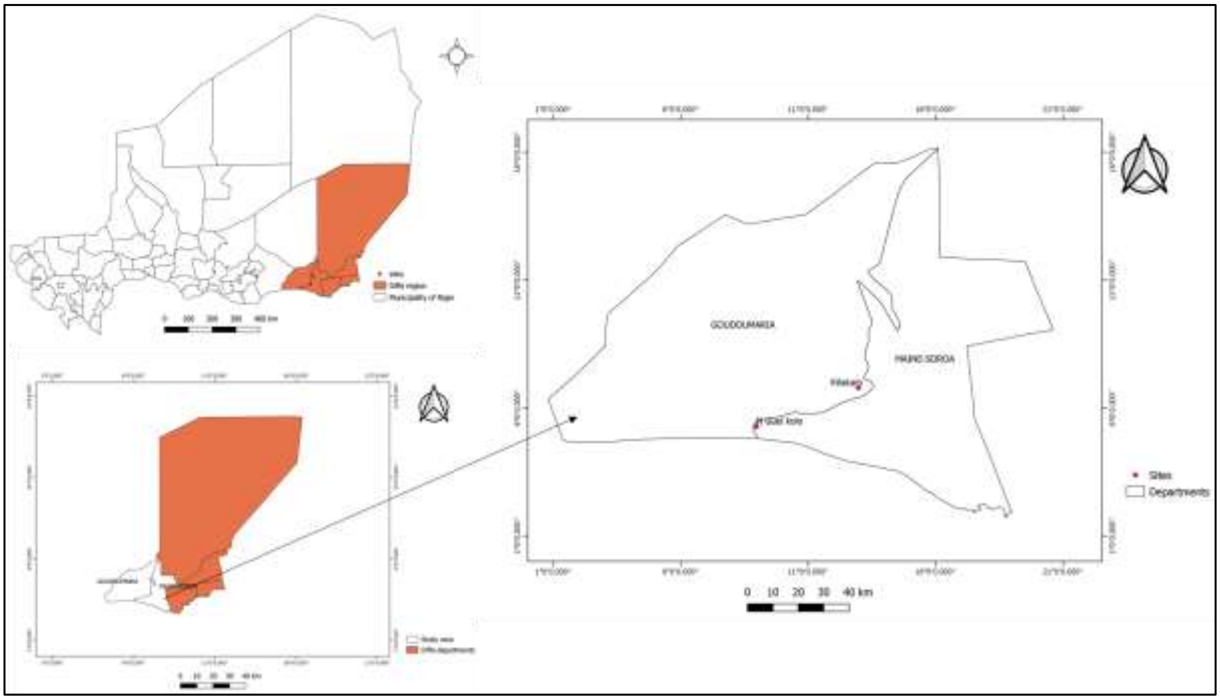


Figure 1: Location of the study area

Sampling and data collection: Sampling was focused on four (4) radial transects at each site. The size of the sampling units varied according to land use type. On each transect, plots of 2500 m² (50 m x 50 m) for agroforestry systems and 1000 m² (20 m x 50 m) for natural formations were delimited with an equidistance of 300 m. In each plot, all *V. tortilis plants* with a diameter greater than or equal to 5 cm were measured. A total of 80 plots were surveyed. For data collection, two methods were applied. These are the quadrat point method of Daget and Poissonnet and the abundance-dominance method of Braun Blanquet (Mahamane 2005, Morou 2010, Soumana 2011, Karim 2013 and Abdourahamane 2016).

√ The quadrant point method consists of counting species using a graduated string of 50 observation points. The observation points are placed regularly (every 20 cm) along a 10 m string stretched over the grass cover. In each plot, the string is stretched 5 times, i.e. 250 observation points per plot. The reading of each point is done with a metal rod. The sum of the observation points corresponds to the number of observations of each species on the same observation line. This method gives the frequency of species but does not give an exhaustive list of all species found in the sampling unit.

√ The Braun Blanquet method provides a comprehensive list of all species present in the plot. This method uses the species abundance-dominance score. Abundance expresses the number of individuals that form the population of the species present in the survey. Dominance represents the cover of all the individuals of a given species, i.e. the vertical projection of their vegetative apparatus on the ground. The abundance-dominance coefficients assigned to species are:

+: Species present as a single individual (covering less than 1%), i.e., an average cover (MR)
of .5%;
1: Species present as sparse individuals occupying less than 5% of the area, or 3% MR;
2: Species present as abundant individuals, covering 5-25% of the area, i.e., 15% MR; 3:

Species with 25-50% recovery, or 37.5% MR;
3 Species: Species with 50-75% recovery, or 62.5% MR;
5: Species with 75-100% recovery, or 87.5% MR.

Data analysis and processing

Biological types: Biological types or biological forms designate the adaptive behaviour of the species to the environment. It provides information on the plant formation, its origin and its transformations. The classification used is that of Raunkiaer (1934) used by several authors Mahamane (2005), Moro (2010), Soumana (2011), Karim (2013), Abdourahamane (2016), Rabiou (2016) and Alhassane (2019). These are, for the woody state, Phanerophytes (Ph): higher plants whose renovation buds are located at more than 50 cm from the ground. Nanophanerophytes (np): from 50 cm to 2 m in height; Microphanerophytes (McPh): from 2 to 8 m in height;

For the herbaceous stratum, the types used are: Chamephytes (Ch): Woody or suffrutescent perennial species, whose renovation buds are located at a maximum of 50 cm from the ground; Gr: Rhizomatous geophytes; Hydrophytes (Hy): Aquatic plants whose persistent buds are located at the bottom of the water; Hemicryptophytes (H): Perennial plants whose renovation buds are outcropping on the soil surface; Therophytes (Th): These are annual plants that form their spores or seeds during a single life period; LTh: Therophyte lilies; LCH: Chamephyte lilies.

Phytogeographic types: The types used are those of the world chorology of White (1983) and Saadou (1990). These are: African (A): These are species found only in Africa; Paleotropical (Pal): These are species common to Africa, tropical Asia and some islands of the Indian Ocean; Pantropical (Pan): These are species found in all tropical regions of Africa, Asia and America; Cosmopolitan (Cos): These are species that are widely distributed on the surface of the earth; Afro-Malagasy (AM): They are common to Africa, Madagascar, Comoros, Mascarene Islands and Seychelles; Afroneotropical (AN): They are common to Africa and tropical America.

Identification of plant groups: For the identification of the different plant groups, a matrix consisting of 80 records and 32 species was submitted to a multidimensional positioning (MNDS) with the PCORD version 5 software. The resulting plant groups were subjected to an Ascending Hierarchical Classification (AHC). Indicator values for each plant community species were calculated based on Indicator Species Analysis (ISA) of the same software. All the species with a probability lower than 0.05 is classified among the indicator species of the grouping.

To investigate the relationship between plant groupings and environmental parameters, a Canonical Correspondence Analysis (CCA) was performed with Canoco 4.5 software. Direct gradient analysis tested the effect of each environmental variable on species distribution using the Monte Carlo permutation test.

Floristic diversity: To measure diversity, several parameters must be calculated. These are:

Alpha diversity (α): It is composed of parameters such as species richness, Shannon index (H') and Piélou equitability (E).

Species richness (S): It is defined as the number of species that a community contains; Shannon index (H') calculated by the following formula: $\mathbf{H' = -\Sigma P_i * Log_2 P_i}$

$p_i = n_i / N$: Relative proportion of the average cover of species i in the community;

n_i : average recovery of species i and N : total recovery of all species;

H'= 0 if all individuals in the stand belong to a single species, H' is also minimal if in a stand each species is represented by a single individual, except for one species that is represented by all other individuals in the stand. The index is maximal when all individuals are equally distributed over all

species (Frontier, 1983; Karim, 2013).
The Piélou equitability (E) calculated by the following formula: $\mathbf{E} = \frac{H'}{Hmax} = \frac{H'}{\log_2 S}$
With S: Total number of species

The Piélou equitability index can vary from 0 to 1 (0 < E < 1). It is maximal when species have identical abundances in the stand and minimal when a single species dominates the entire stand.

RESULTS

Specific diversity of the study area: The analysis of floristic characteristics shows that the study area has 72 species divided into 34 families (Figure 2) and 70 genera (Table 1). The most represented families are Poaceae (13 species or 18.06%), Fabaceae-Mimosoideae and Convolvulaceae (6 species or 8.33%) and Capparaceae and Euphorbiaceae (5 species or 6.94%). The other remaining families group together species that are very little represented (2 to 3 species).

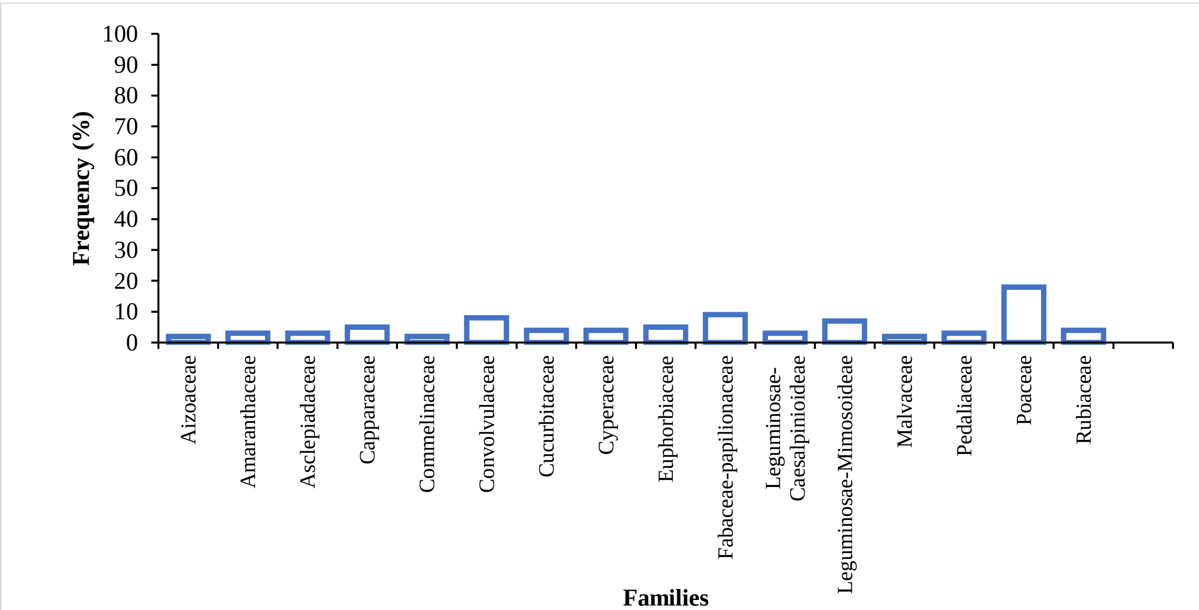


Figure 2: Representation of the families in the study area

Table 1: Botanical families

Families	Global			
	Genres	**Frequency (%) 55(%)**	**Species**	**Frequency (%)**
Acanthaceae	13	18.57	13	18.06
Aizoaceae	6	8.57	6	8.33
Amaranthaceae	6	8.57	6	8.33
Asclepiadaceae	5	7.14	5	6.94
Balanitaceae	5	7.14	5	6.94
Borraginaceae	2	2.86	4	5.56
Capparaceae	4	5.71	4	5.56
Caryophyllaceae	3	4.29	3	4.17
Convolvulaceae	3	4.29	3	4.17
Cucurbitaceae	3	4.29	3	4.17
Cyperaceae	2	2.86	2	2.78
Euphorbiaceae	2	2.86	2	2.78

Fabaceae- Faboideae	1	1.43	1	1.39
Fabaceae-papilionaceae	1	1.43	1	1.39
Lamiaceae	1	1.43	1	1.39
Leguminosae-Caesalpinioideae	1	1.43	1	1.39
Leguminosae-Mimosoideae	1	1.43	1	1.39
Malvaceae	1	1.43	1	1.39
Molluginaceae	1	1.43	1	1.39
Poaceae	1	1.43	1	1.39
Polygalaceae	1	1.43	1	1.39
Rhamnaceae	1	1.43	1	1.39
Rubiaceae	1	1.43	1	1.39
Scrophulariaceae	1	1.43	1	1.39
Sterculariaceae	1	1.43	1	1.39
Tiliaceae	1	1.43	1	1.39
Tribulaceae	1	1.43	1	1.39
Verbenaceae	1	1.43	1	1.39
Total	70	100	72	100

Biological types: The overall analysis of biological types (Table 1) shows a dominance of Therophytes (Th) in all the surveys with 50% of raw spectrum and 67.83% of weighted spectrum. They are followed by Microphanerophytes with 19.44% of raw spectrum and 25.2% of weighted spectrum. Rhizomatous Geophytes (Gr) and Chaméphytes Lianes (LCH) are less represented in terms of raw and weighted spectrum with 1.39% raw spectrum and 0.98% and 0.08% weighted spectrum respectively.

Phytogeographic types: The overall analysis of phytogeographic types (Table 2) shows a dominance of Paleotropical species with 37.5% of raw spectrum and 47.02% of weighted spectrum. They are followed by African species with 34.72% of the gross spectrum and 33.88% of the weighted spectrum. The Afro-Malagasy, Afroneotropical and Neotropical species are very poorly represented with respectively 2.78%, 1.39% and 1.39% of raw spectra and respectively 0.11%, 1.01% and 0.11% of weighted spectra.

Table 2: Biological types

Biological types	Raw spectra								Weighted spectra							
	G1		G2		G3		Global		G1		G2		G3		Global	
	NE	F (%)	NE	F (%)	NE	F (%)	NE	F (%)	R (m²)	F (%)	R (m²)	F (%)	R (m²)	F (%)	R	F (%)
CH	3	4.29	0	0	3	7.69	3	4.17	0.12	0.60	0	0	0.14	0.53	0.11	0.50
Gr	1	1.43	0	0	0	0	1	1.39	0.00	0.00	0	0	0	0.00	0.22	0.98
H	3	4.29	1	4.17	1	2.56	3	4.17	0.07	0.34	0.08	0	0.07	0.27	0.07	0.31
Hy	2	2.86	1	4.17	1	2.56	2	2.78	0.01	0.04	0.67	2	0.25	0.93	0.34	1.54
LCH	1	1.43	0	0	0	0	1	1.39	0.03	0.13	0	0	0	0.00	0.02	0.08
McPh	17	24.29	6	25.00	7	17.95	18	25.00	7.53	38.77	0.58	2	0.71	2.66	5.88	26.35
Th	43	61.43	16	66.67	27	69.23	44	61.11	11.67	60.11	26.17	95	25.71	95.59	15.67	70.26
Total	**70**	**100**	**24**	**100**	**39**	**100**	**72**	**100**	**19.4083**	**100**	**27.5**	**100**	**26.893**	**100**	**22.306**	**100**

Legend: CH: Chamephytes; Gr: Rhizomatous geophytes; LCH**:** Chamephytes; **McPh:** Microphanerophytes; **Th:** Therophytes; **Ph:** Phanerophytes; **Hy:** Hydrophytes; **H:** Hemicryptophytes; **NE:** Number of species; **R:** Cover; **F:** Frequency.

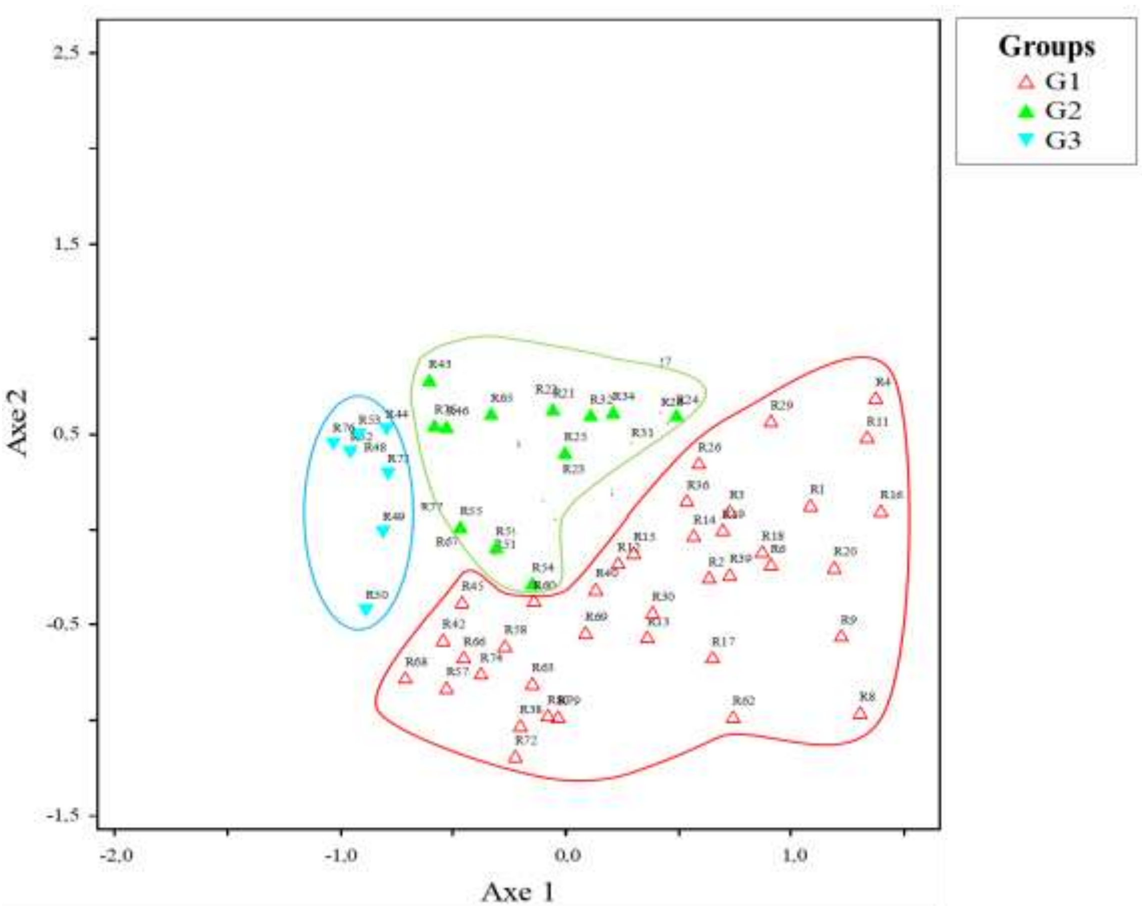
Table 3: Phytogeographic types

Phytogeographic types	Raw spectra								Weighted spectra							
	G1		G2		G3		Global		G1		G2		G3		Global	
	NE	F (%)	NE	F (%)	NE	F (%)	NE	F (%)	R (m²)	F (%)	R (m²)	F (%)	R (m²)	F (%)	R (m²)	F (%)
A	25	35.71	8	33.33	11	28.21	25	34.72	9.20	44.41	9.20	5.76	3.07	11.42	7.56	33.88
AM	2	2.86	0	0.00	1	2.56	2	2.78	0.03	0.12	0.03	0	0.04	0.13	0.03	0.11
AN	1	1.43	1	4.17	1	2.56	1	1.39	0.21	1.01	0.21	1.82	0.18	0.66	0.23	1.01
N	1	1.43	1	4.17	0	0.00	1	1.39	0.03	0.12	0.03	0.30	0	0	0.03	0.11
Pal	25	35.71	10	41.67	17	43.59	27	37.50	6.79	32.78	6.79	78.48	21.57	80.21	10.49	47.02
Pan	16	22.86	4	16.67	9	23.08	16	22.22	4.47	21.56	4.47	13.64	2.04	7.57	3.99	17.88
Total	70	100	24	100	39	100	72	100	20.72	100	20.72	100	26.89	100	22.31	100

Legend: A: African; AM: Afro-Malagasy; AN: Afroneotropical; N: Neotropical; Paleotropical; Pan: Pantropical; NE: Number of species; R: Coverage; F: Frequency.

Identification of plant groups: Dimensional Positioning Analysis (DPA), Ascending Hierarchical Classification (AHC) and Canonical Correspondence Analysis (CCA) allowed us to discriminate three (3) plant groupings (Figure 3, 4 and 5) to *Vachellia tortilis*. These are:

Grouping with *Vachellia tortilis* and *Dactyloctenium aegyptium*: These are plant groupings of dune flats of the courses. The pedological substratum is of sandy type with a strong infiltration of rainwater. These groups were constituted from 60 surveys and 72 species. In their vertical structures, these groups are composed of a herbaceous stratum dominated by *Dactyloctenium aegyptium* (L.) Willd. and the woody stratum is composed of Vachellia tortilis subsp. raddiana. The characteristic species from Indicator Species Analysis (ISA) are *Vachellia tortilis* subsp. *raddiana*, *Dactyloctenium aegyptium* (L.) Willd., *Chloris pilosa* Schum., *Boscia senegalensis* (Pers.) Lam. Ex Poir, *Ipomoea pubescens* Lam, *Euphorbia hirta* L., *Maerua crassifolia* Forsk, *Amaranthus spinosus* L.. Plant groups with *Vachellia tortilis* and *Cenchrus biflorus*: They develop on pastoral rangelands characterized by a sandy textured soil. These groups were constituted from 7 surveys and 72 species. These communities present two strata, a herbaceous stratum composed essentially of *Cenchrus biflorus* Roxb. The woody component is formed *Vachellia tortilis* subsp. *raddiana* on the 72 species recorded. However, the Indicator Species Analysis (ISA) has highlighted as characteristic species *Vachellia tortilis* subsp. *raddiana*, *Cenchrus biflorus* Roxb., *Chloris pieurii* Kunth. *Digitaria horizontalis* Willd., *Zornia glochidiata* Reichb. Ex DC, *Cenchrus prieurii* (Kunth.) Maire, *Alysicarpus ovalifolius* (Schum. et Thonn.) J. Léonard, *Spermacoce stachydea* DC, *Bulbostylis barbata* (Rottb.) C. B.Cl. Plant groups with *Vachellia tortilis* and *Schoenefeldia gracilis*: They are located in the lowlands, with a clay soil texture. These groups described from 13 surveys and 72 species also present a herbaceous state essentially composed of *Schoenefeldia gracilis* Kunth; and a woody stratum composed of *Vachellia tortilis* subsp. *raddiana*. The Indicator Species Analysis (ISA) revealed as characteristic species *Vachellia tortilis* subsp. *raddiana*, *Schoenefeldia gracilis* Kunth., *Pennisetum pedicellatum* Trin., *Gisekia pharnacioides* L., *Maerua angolensis* DC. ,



Legend: G1: Grouping with *Vachellia tortilis and Dactyloctenium aegyptium*; **G2:** Grouping with *Vachellia tortilis* and *Cenchrus biflorus*; **G3:** Grouping with *Vachellia tortilis* and *Schoenefeldia gracilis*

Figure 3: Distribution of surveys by multidimensional positioning (NMDS)

Diversity analysis: The analysis of the diversity indices shows that the overall species richness S is 72 species with a Shannon diversity index of 3.13 and a Piélou Equitability 0.51. The analysis also shows a similarity between the three clusters identified with a species richness of 71 species each, a high Shannon diversity index that varies between 3.23 and 3.29 and a Piélou Equitability index between 0.52 and 0.54 (Table 4).

Table 4: Floristic characteristics of plant groups

Groupements	S	H'	E
G1	71	3,24	0,53
G2	71	3,29	0,54
G3	71	3,23	0,52
Global	72	3,13	0,51

Legend: G1: Grouping with *Vachellia tortilis and Dactyloctenium aegyptium*; **G2:** Grouping with *Vachellia tortilis* and *Cenchrus biflorus*; **G3:** Grouping with Vachellia *tortilis* and *Schoenefeldia gracilis*

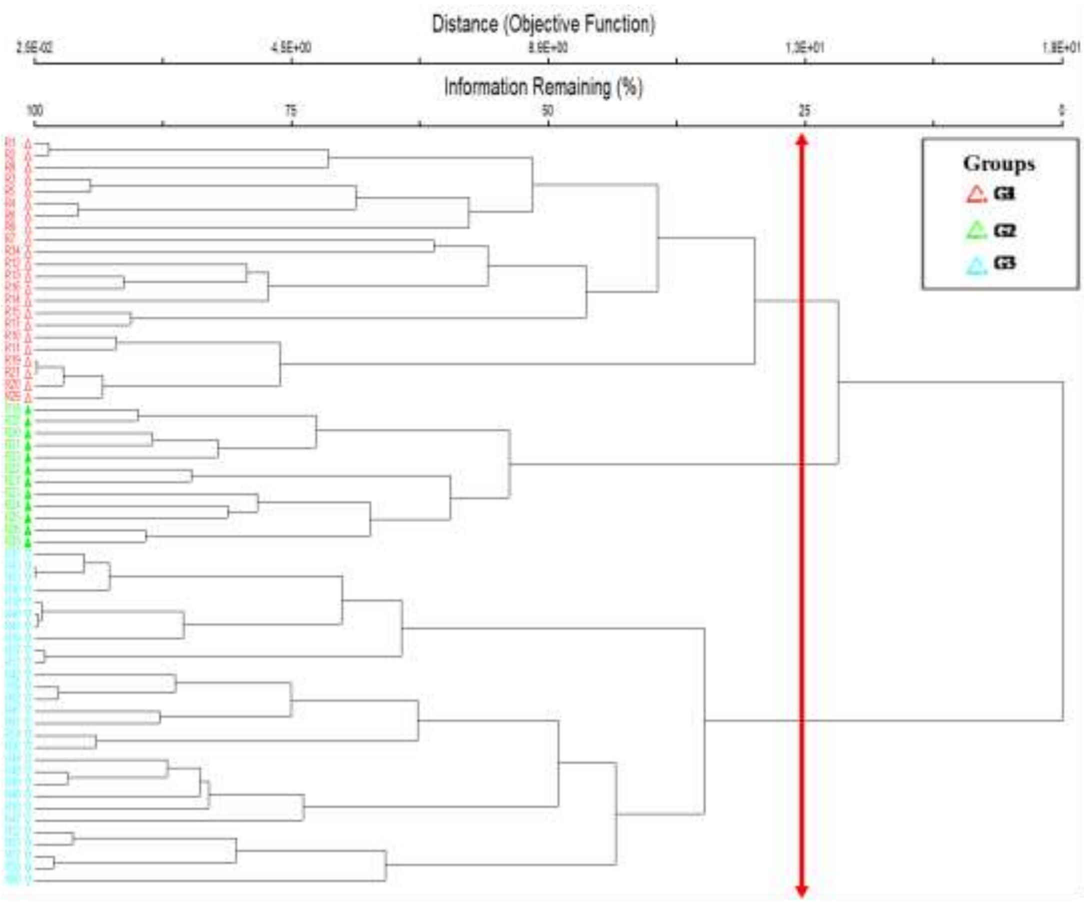
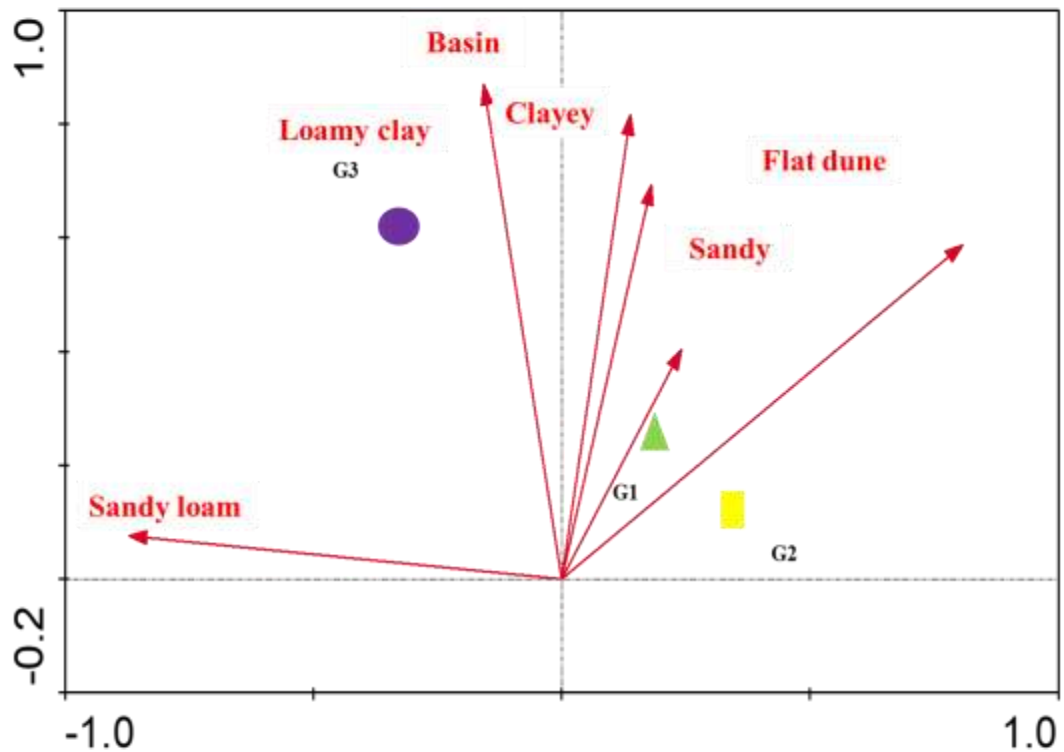


Figure 4: Ascending Hierarchical Classification (AHC)

Dendrometric characteristics of *Vachellia tortilis* population: From the overall analysis in Table 5, it appears that *V. tortilis* populations have an average density of 102.5±22.10 stems/ha with an average diameter of 14.68±8.22 cm. These formations are characterized by an average height of 5.24±1.49 m. The results of the comparison test show a significant difference between the groupings for all parameters ($P < 0.05$).



Legend: G1: Grouping with *Vachellia tortilis and Dactyloctenium aegyptium*; **G2:** Grouping with *Vachellia tortilis* and *Cenchrus biflorus*; **G3:** Grouping with Vachellia *tortilis* and *Schoenefeldia gracilis*

Figure 5: Distribution of environmental variables and the different groupings (Direct gradient analysis) CCA

Table 5: Dendrometric parameters of *V. tortilis* populations by grouping

Dendrometric parameters	G1	G2	G3	Global	Probabilistes
Average density (stems/ha)	22.50±4.79[c]	27.5±8.34[b]	34.50±5.01[a]	102.5±22.10	*0.001*
Average diameter (cm)	18.94±5.89[a]	15.24±9.45[b]	14.48±8.28[c]	14.68±8.22	*0.014*
Average height (m)	6.08±0.90[a]	5.27±1.46[b]	5.24±1.50[b]	5.24±1.49	*0.05*
Coverage (m^2)	28.42±6.89[a]	25.75±16.44[b]	25.44±16.79[b]	25.58±16.47	*0.05*

Legend: G1: Grouping with *Vachellia tortilis and Dactyloctenium aegyptium*; **G2:** Grouping with *Vachellia tortilis* and *Cenchrus biflorus*; **G3:** Grouping with Vachellia *tortilis* and *Schoenefeldia gracilis*

DISCUSSION

The analysis of floristic characteristics identified 72 species, including 13 woody species and 59 herbaceous species divided into 6 and 22 families respectively. This floristic richness of the area is lower than that obtained by other works carried out in the same bioclimate in Niger (Moussa 2010, Soumana 2011 and Alhassane *et al.*, 2017). The flora recorded in the different rangelands is dominated by three (3) families. These are the Poaceae family (18.06%), Fabaceae-Mimosoideae and Convolvulaceae (8.33%

each). The results obtained for Poaceae corroborate to those found by Moussa (2010) (19.18%), Soumana (2011) (19.44%), Alhassane *et al.*, (2017) (22.4%) in the same bioclimate type. According to Moussa (2010), the high frequency of the Poaceae family reflects a good quality of these rangelands because they are the species most palatable to livestock. The dominance of the herbaceous layer by annual plants, mainly grasses (Moussa 2010, Soumana 2011, Morou 2010) is characteristic of the Sahelian zone (Hiernaux and Le Houérou 2006). The analysis of the spectra of biological type shows the dominance of Therophytes (50%) followed by Microphanerophytes (19.44%). This dominance of Therophytes corroborates the results observed in similar bioclimates by Moussa (2010) (75%); Soumana (2011) (55.56%) and Alhassane *et al.*, (2017) (64.1%). Indeed, this predominance of Therophytes is explained by their adaptation to arid and semi-arid environments. They complete their cycle during the rainy season and spend the dry season as seeds in the soil, thus less affected by the harsh environmental conditions (Morou 2010). According to Moussa (2010), the decrease in phanerophytes characterizes the progressive degradation of these ecosystems. According to Alhassane *et al.*, (2017), Theophytes are the most dominant life form followed by Phanerophytes by far. According to Daget (1980), therophytization is a characteristic of arid zones and expresses an adaptation strategy towards unfavourable conditions and a form of resistance to climatic rigors. The phytogeographic distribution of species in the study area shows a dominance of Paleotropical species (37.5%) followed by African species (34.72%). This value of the spectrum of Paleotropical species is higher than that obtained by Soumana (2011). The results obtained corroborate that author who observed a frequency of 30.95% for Paleotropical species and 22.2% for Pantropical. Similar frequencies were observed by Alhassane *et al.*, (2017). Phytogeographic types are good indicators of the dynamism or stability of plant communities. However, the high proportion of broadly distributed species is an indication of disturbance and indicates that the flora is losing its specificity (Toko and Sinsin 2008). The Shannon index shows that the diversity for all the groupings is low (H'= 3.13 bits). Indeed, at the scale of the groups, this diversity is more or less homogeneous for all the groups (G1, G2 and G3) with respectively 3.24 bits, 3.29 bits and 3.23 bits. This homogeneity observed between these groups would be due to the low disturbance (anthropic pressure and overgrazing) of the area, which presents uniform climatic conditions on all the groups but varied edaphic conditions. The distribution of the surveys in the multidimensional positioning and the ascending hierarchical classification (CHA) allowed us to discriminate three (3) plant groups. This distribution of plant groupings shows that *V. tortilis* is much more associated with two (2) families. These are the Poaceae and Fabaceae-papilionaceae families. Indeed, the groups with *V. tortilis* and *Dactyloctenium aegyptium* (G1) and with *V. tortilis* and *Cenchrus biflorus* (G2) are observed on sandy textured soils and dune flats. The *Vachellia tortilis and Schoenefeldia gracilis* group (G3) is observed in lowlands characterized by sandy-silty, silty-clay and clayey textured soils. As for the distribution of *V. tortilis*, it is observed on all land use units and on soils of all textures, showing that the species is well adapted to these areas under the harshest pedoclimatic conditions. These observations corroborate those made by Arbonnier (2004). Overall analysis of *V. tortilis* formations in the study area reveals an average density of 102.5±22.10 feet/ha. This value is similar to that found by Bio *et al.*, (2021). However, it is higher than that found by Rabiou *et al.*, (2019) in the refugee camps in the Diffa region, and Abdou Habou *et al.*, (2020) in the Gouré plant formations (35.6 ± 15.8). This observed difference would be due to sample size and anthropogenic pressure. *V. tortilis* is a multipurpose species. It is used as service wood, energy wood, in traditional pharmacopoeia and as livestock feed (Bio *et al.,* 2021). The average diameter of the observed plants (14.68±8.22 cm) is smaller than that found by Abdou *et al.,* (2020) (20.6 ± 8.1 cm). This can be explained by the high heterogeneity in the sample. Indeed, the low average diameter observed is a consequence of the predominance of young individuals in the population of the species (Bio *et al.*, 2021). A dominance of large diameter individuals observed could be related to climatic factors combined with anthropogenic factors that constitute the main obstacles to regeneration (Rabiou 2016). According to Jaouadi *et al.*, (2012), the lack of large-diameter individuals is the consequence of a former disturbance such as the cutting of firewood and service wood. In the study area, the low frequency of large-diameter individuals shows low anthropogenic pressure with the influx of refugees and displaced populations (Bio *et al.*, 2021).

CONCLUSION AND APPLICATION OF RESULTS

The present study has provided a better understanding of the floristic composition and structural characteristics of the vegetation groups in the southern part of the department of Maine-Soroa and the northern part of the department of Goudoumaria in southeast Niger. The vegetation of the zones is composed of 72 plant species (13 woody species and 59 herbaceous species) divided into 34 families and 70 genera. In terms of abundance and dominance, species such as *Vachellia tortilis* subsp. *raddiana* (Savi.) Brenan, *Cenchrus biflorus* Roxb., *Alysicarpus ovalifolius* (Schum. et Thonn.) J. Léonard., *Schoenefeldia gracilis Kunth. and Pennisetum pedicellatum* Trin. are the most represented. Therophytes are the most represented biological type in the area. In terms of phytogeographic type, Paleotropical species are the most dominant. The value of the Shannon diversity index proves the existence of favourable conditions for these species. The three (3) identified groupings are respectively located on distinct geomorphological units. These results can help communities to sustainably exploit these natural resources. The results of this study constitute both a database and a tool for decision-makers and populations to properly orient their actions in development programs and sustainable management of these ecosystems.

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