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Spatio-Temporal Variability in Plant Diversity in the Pastures of the Okouessé Ranch (Boundji, Republic of Congo)

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Abstract | **Original Research Article**

In the Congolese Basin, the savannahs serve as grazing lands for N'dama cattle. Overgrazing can lead to a decline in plant diversity and herbaceous production, which would indicate that the pastures are in a state of degradation. The aim of this study is to analyse changes in plant diversity in the pastures of the Okouéssé ranch. The plant inventory was carried out using the aligned quadrat method. Plant diversity was assessed by calculating biological diversity indices. Three types of pasture were identified *Trachypogon spicatus* (L.f.) Kuntze pasture, *Ctenium newtonii* Hack. Pasture and *Elionorus hensii* K. Schum. pasture. Plant biodiversity in the pastures increased slightly in 2024 (2.38 ± 0.13) compared with 2023 (2.14 ± 0.11). The flora of these pastures is poorly diversified and the distribution of individuals within species is uneven (0.65 ± 0.01 to 0.67 ± 0.05). Grazing appears to alter the floristic composition of the pastures. The presence of *Ctenium newtonii* Hack. And *Elionorus hensii* K., Schum. Indicates a threat of degradation to the forage potential of the pastures studied. The results of this study could serve as a basis for further work on the sustainable management of pastures in the study area and elsewhere in the Congo and the intertropical zone.

Keywords: Biodiversity indices, herbaceous layer, pastures, ranch, Okouessé.

INTRODUCTION

Savannahs are natural ecosystems in which a continuous herbaceous layer coexists with a more or less discontinuous woody layer; they are commonly found in tropical regions (Hetier et Lopez, 2005). They are rich in forage potential, providing the bulk of cattle feed (Yoka, 2009; Akouango et Mopoundza, 2014; Amboua, 2021).

Savannahs cover more than 20% of the world's land area, 40% of tropical land, and are home to at least 20% of the world's population (Beerling & Osborne, 2006). Rural communities living in savannah regions use them primarily for agriculture and livestock farming. In addition to their economic importance, savannahs provide a vital habitat for a significant proportion of animal and plant biodiversity (Kouamé, 2019).

In tropical regions, savannahs are extensively used for cattle, sheep and goat farming, and efforts to improve production should be based on rational and sustainable pasture management (Rippstein, 1985; Yoka *et al*., 2011; Bokatola *et al.,* 2016 ; Amboua *et al*., 2019). They have significant potential for agriculture and livestock farming (Sinsin, 1993; Rippstein *et al*., 1996; Diamouangana, 2002; Rakotoarimanana, 2002; Yoka *et al*., 2012).

Extensive pastoral production accounts for 10% of total global meat production and supports around 200 million pastoralist households. Livestock farming is an agricultural activity of economic, social and cultural significance (FAO, 2012). It helps to secure livelihoods in rural areas in tropical countries (Laouali *et al*., 2014), but also contributes to the growth of urban populations by supplying meat at competitive prices (Catley *et al*., 2013).

The Congolese savannahs provide animals with grass, which is the primary and indispensable source of feed for both large and small ruminants. This leads to the final products on the market (milk, meat, leather, etc.). They are used for agricultural and pastoral activities. These savannahs constitute genuine pastures grazed by

N'dama cattle (Yoka *et al*., 2011). This form of land use leads to a reduction in plant diversity and herbaceous production, which are characteristic of degraded pastures (Yoka *et al.,* 2011; Amboua *et al*., 2019). It is with this in mind that the present study was conducted. The overall aim of this study is to assess the herbaceous floristic diversity of the pastures at the Okouéssé ranch.

1. MATERIAL AND METHODS

1.1. Study environment

The study was conducted in the Boundji area, in the south-western part of the Congolese Basin, in the north of the Republic of Congo. It is situated between 0° and 2° South latitude and between 15° and 16° East longitude. The site selected is the Okouéssé ranch, situated approximately 30 km from the town of Boundji, which is managed by the Boundji Cattle Technical Support Centre (CATB). The climate is of the sub-equatorial type (Samba-Kimbata, 1991). The reference weather station is Makoua (Geographical coordinates : altitude 379 m ; latitude 00° 1'S; longitude 15° 35'E).

Annual minimum temperatures range from 19.5°C to 21.9°C, whilst maximum temperatures vary between 29.9°C and 31.9°C over the course of a year. The average annual temperature in the study area is 25.5°C (Samba-Kimbata, 1991; Yoka *et al*., 2011; Amboua, 2021). The average temperature hovers around 25°C. Relative humidity is in the range of 75–90%. The average annual rainfall in the study area is 1,657 mm (Yoka, 2009; Amboua, 2021). April and October are the wettest months of the year in the Congolese Basin (Yoka *et al*., 2011). The highest rainfall is recorded in October. Ecologically speaking, there is no dry season in the study area; rainfall is almost continuous, accompanied by a three-month lull (from June to August) known as the 'dry season' (Yoka, 2009).

The Congolese Basin comprises two geological formations, namely the Batéké sands and alluvial deposits (ORSTOM, 1969; Bouka-Biona et Sounga, 2001). The soils found there are mainly highly desaturated, depleted ferrallitic soils, represented by the clay-sandy series formed on sandy or slightly clayey materials, which are low in bases and highly permeable, and hydromorphic soils covering large areas, particularly in the centre (De Boissezon *et al*., 1969).
The Congolese Basin is dominated by two vegetation types: forests and savannahs (IUCN, 1990).

There are four types of savannah in the Congolese Basin (IUCN, 1990 and Yoka, 2009): *Hyparrhenia diplandra* (Hack) Stapf savannah, *Trychypogon spicatus* (L.f.) Kuntze savannah, *Andropogon schirensis* Hochst savannah, and *Loudetia simplex* (Nees) C.E Hubbard savannah.

As is the case throughout the Congolese Basin, the forests in the Boundji area comprise several types (IUCN, 1990): Dense lowland rainforest, Open lowland rainforest, Evergreen lowland forest, Evergreen flooded and swamp forest, Deciduous mesophilic forest of Central Congo, Flooded forest, and Raphiales in flooded areas in pure or near-pure stands of *Raphia* sp.

1.2. Methods

- **Experimental setup**

Four experimental plots, each measuring 50 m × 50 m (i.e. 2,500 m²), are marked out in each type of pasture. Each plot is subdivided into four subplots measuring 25 m x 25 m, within which measurements are taken. Consequently, an area of 1 ha (i.e. 4 x 2,500 m²) was sampled.

- **Flora invotory**

The floristic inventory provides the floristic composition of the study area. It was carried out using the linear analysis method or the aligned quadrat method (Daget et Poissonet, 1971), over two consecutive periods, 2023 and 2024. This method has been widely used for the assessment of pastures in the Congolese Basin, as evidenced by the work of Yoka (2009); Bokatola (2016); and Amboua *et al.,* (2019). Observations were made along lines marked by two stakes between which a 10-metre tape measure was stretched. Measurements were taken at regular intervals of 10 cm using a metal rod with a tapered tip, which was driven into the ground at a right angle (Boudet, 1977). At each observation point, contact with a species occurs either via the leaves, the stem or the inflorescences, but the species is recorded only once per reading point (Boudet, 1991).

- **Processing of floristic analysis data**

Measurement accuracy

The number of rows of aligned quadrat points is determined (with a measurement accuracy of 5%) by the calculated confidence interval of the cumulative count, row by row, of the dominant species relative to the total count of all species. The confidence interval is calculated using the formula below (Diamouangana, 2002):

$$Ic = \pm 2\sqrt{\frac{n(N-n)}{N3}} \quad \text{X } 100$$

I_C: confidence interval; n: number of sightings (cumulative total, line by line) of the dominant species; N: total number of all recorded attendances.

The effect of random variation can be considered negligible when the precision reaches 5% (Daget et Poissonnet, 1971).

A line of 200 points, selected as the most representative of each plot, was used to determine the plant species composition of the identified pasture.

Specific Frequencies and contributions

The specific frequencies and specific contributions are calculated using the following formulas (Diamoungana, 2002):

Fsi = ni/N x 100, with, Fsi: specific frequencie; N: number of sampling units; ni: the number of units in which species i is present.

Csi = Fsi/∑Fsi = 100 x ni/∑ni, with, Csi: specific contribution; ni: number of sampling units in which species i was found; ∑ni: number of specific observations made.

Key species are those with a specific contribution of more than 5% (Apani, 1990), and the dominant species is therefore the one with the highest specific contribution. A species is classified as a producer when its specific contribution reaches 1% (Diamouangana, 2002).

Biological diversity indices

Floristic diversity is a concept that reflects the species richness of a given community, such as the number of families, genera and species, as well as the distribution of species within the community, known as evenness or equitability (Duquet, 1993). It can be expressed using several diversity indices.

The diversity and regularity indices are assessed and defined as follows (Barbault, 1997):

Maximum diversity : Hmax = Log_2S, with, Hmax : Maximum diversity ; S= total population of the species ; Shannon-Weaver diversity index : H' = -∑CsixLog2Csi, avec 0<Csi<1.

H' : Shannon-Weaver diversity index ; Csi : specific contribution.

The Shannon-Wever index generally ranges between 0 and 5. According to Djego *et al.,*(2012), plant diversity can be considered low when H' is less than 3 ; it is moderate when H' is between 3 and 4 ; and it is high when H' is greater than 4.

Pielou équity or regularity index (Frontier and Pichod-Viale, 1991) expresses the distribution of species within a given stand. It is given by the following formula :

$$E = \frac{H'}{Hmax}$$

With, E : Pielou equity index ; H' : Shannon-Weaver diversity index ; Hmax : Maximum diversity.

The equity value ranges from 0 to 1 (Legendre et Legendre, 1984). It is 1 when all species have the same abundance and tends towards 0 when almost the entire population is concentrated in a single species.

Statistical analysis of the data

The data were analysed using R software, version i386 4.1.0, as suggested by Matoumouene (2022). The t-test or Student's t-test and the one-factor Wilcoxon test are used following the normality test, which is the Shapiro-Wilk test at a 5% (0.05) significance level. This test is used to verify normality within the categories of a variable. The t-test or Student's t-test is used when the normality test (N) is greater than the 5% threshold (0.05), and the one-factor Wilcoxon test is used when the normality test (N) is less than the 5% threshold (0.05).

2. RESULTS

2.1. Herbaceous plant composition of the plots sampled in 2023

Tables 1, 2, 3 and 4 present data on the floristic composition of the pastures in 2023. In plot 1 (Table 1), the main herbaceous species are *Trachypogon spicatus* (L.f.) Kuntze (43.22%), *Ctenium newtonii* Hack. (29.66%), *Elionorus hensii* K. Schum. (9.32%) and *Indigofera capitata* Kotschy (5.08%). The other species identified are less common, with a specific contribution of less than 5%. The most dominant botanical family is the Poaceae (63.63%), followed by the Cyperaceae (27.27%). The eleven (11) plant species recorded are divided into 10 genera and 3 families. The Fabaceae are the least well represented (9.09%) in this plot. Plot 1 is therefore defined within the pasture by *Trachypogon spicatus* (L.f.) Kuntze.

The main herbaceous species in plot 2 (Table 2) are : *Ctenium newtonii* Hack. (34.18%), *Elionorus hensii* K. Schum. (29.27%), *Trachypogon spicatus* (L.f.) Kuntze (22.86%) and *Sporobolus congolensis* Franch. (6.41%). *Ctenium newtonii* Hack. is the most dominant herbaceous plant in this pasture. The Poaceae constitute the most representative botanical family in this pasture (70%). The Apocynaceae (10%), Cyperaceae (10%) and Fabaceae (10%) are the least represented.

The flora of this plot comprises 10 species across 9 genera and 4 families. This plot forms part of the pasture where *Ctenium newtonii* Hack grows.

In plot 3 (Table 3), species such as *Ctenium newtonii* Hack. (32.20%), *Elionorus hensii* K. Schum. (31.52%), *Trachypogon spicatus* (L.f.) Kuntze (18.98%) and *Bulbostylis laniceps* C.B. Clarke ex T. Durand & Schinz. (10.16%) are the main species. *Ctenium newtonii* Hack. and *Elionorus hensii* K. Schum. are the two most dominant herbaceous species in this plot. The Poaceae constitute the most abundant botanical family in terms of the number of plant species (70%), followed by the Cyperaceae (20%). The Fabaceae family is the least well represented. The flora of this plot comprises 10 species across 9 genera and 3 families. This plot was demarcated within the pasture at *Elionorus hensii* K. Schum.

In plot 4 (Table 4), the main herbaceous species are *Ctenium newtonii* Hack. (48.26%), *Trachypogon spicatus* (L.f.) Kuntze (27.77%), *Elionorus hensii* K. Schum. (17.01%), and *Bulbostylis laniceps* C.B. Clarke ex T. Durand & Schinz. (5.55%). The most abundant plant species in this plot is *Ctenium newtonii* Hack., followed by *Trachypogon spicatus* (L.f.) Kuntze (27.77%). The other herbaceous species, whose specific contribution is less than 5%, are the least abundant. The most abundant botanical family is the Poaceae (57.14%), followed by the Fabaceae (28.57%). The Cyperaceae are less common (14.28%). This plot was demarcated within the pasture at *Ctenium newtonii* Hack. It contains seven species across seven genera and three families.

From a statistical perspective, the differences between specific contributions (CSi), cumulative specific contributions (CSc) and the rankings of species for each plot sampled in 2023 are highly significant (***).

Table 1: Families, specific contributions, cumulative specific contributions and ranks of herbaceous plants, plot 1 in 2023

Species	Families	CSi (%)	CSC (%)	Ranks (%)
Trachypogon spicatus (L.f.) Kuntze	Poaceae	43.22c	43.22d	9.09d
Ctenium newtonii Hack.	Poaceae	29.66d	72.88c	18.18d
Elionorus hensii K. Schum.	Poaceae	9.32e	82.20c	27.27cd
Indigofera capitata Kotschy.	Fabacea	5.08e	87.29a	36.36c
Bulbostylis laniceps C.B. Clark	Cyperaceae	2.97b	90.25a	45.45c
Hyparrhenia diplandra Stapf.	Poaceae	2.97b	93.22a	54.54a
Angropogon Schirensis Hochst. Ex A. Rich.	Poaceae	1.69a	94.91a	63.63a
Sporobolus congolensis Franch.	Poaceae	1.69a	96.60ab	72.72a
Cyperus sp	Cyperaceae	0.85a	98.30b	81.81b
Cyperus pectinatus Vahl.	Cyperaceae	0.85a	99.15b	90.90b
Bracharia comata Hochst. ex. A. Ric	Poaceae	0.85a	100.00b	100.00b
P-value		***	***	***

Legend : CSi : Specific contribution of the identified species ; CSc : cumulative specific contributions.

Table 2: Families, specific contributions, cumulative specific contributions and ranks of herbaceous plants, plot 2 in 2023

Species	Families	CSi (%)	CSc (%)	Ranks (%)
Ctenium newtonii Hack.	Poaceae	34.18b	34.18b	10c
Elionerus hensii K. Schum.	Poaceae	29.27c	63.46c	20d
Trachypogon spicatus (L.f.) Kuntze	Poaceae	22.86c	86.32d	30d
Sporobolus congoensis Franch.	Poaceae	6.41a	92.73ad	40a
Brachiaria comata Hochst. ex. A. Rich.	Poaceae	3.41a	96.15a	50a
Bulbolstilis laniceps C.B. Clarke ex T. Durand & Schinz.	Cyperaceae	2.13a	98.29a	70b
Hyparrhenia diplanda Stapf.	Poaceae	1.06d	99.35a	70b
Elionurus brazzae Kranch.	Poaceae	0.21d	99.57a	80b
Eriosema psoraleoides (Lam.) G. Don.	Fabaceae	0.21d	99.78a	90e
Landelphia comptoloba (K. Schum.) Pichon	Apocynaceae	0.21d	100a	100e
P-value		***	***	***

Legend : CSi : Specific contribution of the identified species; CSc : cumulative specific contributions.

Table 3: Families, specific contributions, cumulative specific contributions and ranks of herbaceous plants, plot 3 in 2023

Species	Families	CSi (%)	CSc (%)	Ranks (%)
Ctenium newtonii Hack.	Poaceae	32.20c	32.20b	10d
Elionurus hensii K. Schum.	Poaceae	31.52c	63.72c	20cd
Trachypogon spicatus (L.f.) Kuntze	Poaceae	18.98e	82.71d	30c
Bulbostilis laniceps C.B. Clarke ex T. Durand & Schinz.	Cyperaceae	10.16b	92.88ad	40c
Sporobolus congoensis Franch.	Poaceae	3.38d	96.27a	50ac
Andropogon shirensis Hochst. Ex A. Rich.	Poaceae	1.69a	97.96	60a
Elionurus brazzae Kranch.	Poaceae	0.67a	98.64a	70a
Eriosema psoraleoides (Lam.) G. Don.	Fabaceae	0.67a	99.32a	80ab
Brachiaria comata Hochst. ex. A. Rich.	Poaceae	0.33a	99.66a	90b
Cyperus pectinatus Vahl.	Cyperaceae	0.33a	100a	100b
P-value		***	***	***

Legend : CSi : Specific contribution of the identified species ; CSc : cumulative specific contributions.

Table 4: Families, specific contributions, cumulative specific contributions and ranks of herbaceous plants, plot 4 in 2023

Species	Families	CSi (%)	CSc (%)	Ranks (%)
Ctenium newtonii Hack.	Poaceae	48.26b	48.26b	14.28b
Trachypogon spicatus (L.f.) Kuntze	Poaceae	27.77^{e}	76.04c	28.57ab
Elionurus hensii K. Schum.	Poaceae	17.01c	93.05a	42.85a
Bulbolstilis laniceps C.B. Clarke ex T. Durand & Schinz.	Cyperaceae	5.55a	98.61a	57.14a
Sporobolus congoensis Franch.	Poaceae	0.69d	99.30a	71.42d
Indigofera capitata Kotschy.	Fabaceae	0.34d	99.65a	85.71d
Eriosema psoraleoides (Lam.) G. Don.	Fabaceae	0.34d	100a	100c
P-value		***	***	***

Legend : CSi : Specific contribution of the identified species; CSc : cumulative specific contributions.

2.2. Herbaceous plant composition of the plots sampled in 2024

Data-t-on the herbaceous plant composition of the plots sampled in 2024 are presented in Tables 5, 6, 7 and 8. These vary from one plot to another.

In plot 1 (Table 5), the main herbaceous species are *Trachypogon spicatus* (L.f.) Kuntze (39.29%), *Ctenium newtonii* Hack. (20.06%) and *Elionorus hensii* K. Schum. (20.06%). The most dominant herbaceous plant is *Trachypogon spicatus* (L.f.) Kuntze, followed by *Ctenium newtonii* Hack. and *Elionorus hensii* K. Schum. The other plant species are the least abundant. The most dominant botanical family is Poaceae (42.85%), followed by Cyperaceae (28.57%) and Fabaceae (21.42%). The least well-represented family is the Commelinaceae (7.14%). These 14 species are divided into 11 genera, 14 species and 4 botanical families. This plot was demarcated within the pasture at *Trachypogon spicatus* (L.f.) Kuntze.

In plot 2 (Table 6), three main herbaceous species were identified: *Ctenium newtonii* Hack. (42.24%), *Trachypogon spicatus* (L.f.) Kuntze (27.58%), *Elionorus hensii* K. Schum. (14.08%) and *Sporobolus congoensis* Franch. (7.75%). *Ctenium newtonii* Hack. is the most dominant herbaceous plant, followed by *Trachypogon spicatus* (L.f.) Kuntze. The Poaceae are the most dominant family (50%), followed by the Fabaceae (16.66%) and the Cyperaceae (16.66%). The least well-represented botanical families are the Asteraceae (8.33%) and the Commelinaceae (8.33%). Twelve (12) plant species, comprising 11 genera and 5 families, were recorded. Plot 2 was demarcated within the *Ctenium newtonii* Hack. Pasture.

The main species in plot 3 (Table 7) are *Trachypogon spicatus* (L.f.) Kuntze (27.44%), *Elionorus hensii* K. Schum. (22.18%), *Andropogon shirensis* Hochst. ex A. Rich. (17.66%), *Ctenium newtonii* Hack. (16.16%) and *Urochloa comata* (Hochst. ex A. Rich.) Sosef (6.01%). The dominant species is *Trachypogon spicatus* (L.f.) Kuntze, followed by *Elionorus hensii* K. Schum. The botanical family is the Poaceae (77.77%). The Cyperaceae (11.11%) and Fabaceae (11.11%) are less common. Nine (09) plant species, divided into 08 genera and 03 botanical families, were identified. Plot 3 was delineated in a pasture of *Trachypogon spicatus* (L.f.) Kuntze.

Herbaceous plants such as *Ctenium newtonii* Hack. (35.47%), *Trachypogon spicatus* (L.f.) Kuntze (34.86%), *Elionorus hensii* K. Schum. (17.12%) and *Sporobolus congoensis* Franch. (8.25%) are the main species in plot 4 (Table 8). Two dominant herbaceous species have been identified : *Ctenium newtonii* Hack. and *Trachypogon spicatus* (L.f.) Kuntze. The most common botanical family is the Poaceae (63.63%), followed by the Fabaceae (18.18%). The least abundant botanical families are the Cyperaceae (9.09%) and Commelinaceae (9.09%). Eleven (11) species, comprising 10 genera and 4 families, were recorded. Plot 4 was delineated within a pasture of *Ctenium newtonii* Hack.

From a statistical perspective, the differences between specific contributions (CSi), cumulative specific contributions (CSc) and the rankings of species for each plot sampled in 2024 are highly significant (***).

Table 5: Families, specific contributions, cumulative specific contributions and ranks of herbaceous plants, plot 1 in 2024

Species	Families	CSi (%)	CSc (%)	Ranks (%)
Trachypogon spicatus (L.f) Kuntze	Poaceae	38.29d	38.29d	7.14b
Ctenium newtonii Hack.	Poaceae	20.06b	58.35c	14.28b
Elionorus hensii K. Schum	Poaceae	20.06b	78.41b	21.42c
Elionurus brazzae Kranch.	Poaceae	4.25c	82.67ab	28.57c
Cyperus rotundus L.	Cyperaceae	3.34c	86.01ab	35.71c
Sporobolus congoensis Franch.	Poaceae	3.34c	89.36ab	42.85ac
Cyperus pectinatus Vahl.	Cyperaceae	3.03c	92.40a	50ac
Cyanotis lanata Benth.	Commelinaceae	2.12c	94.52a	57.14ac

Hyparrhenia diplandra (Hack.) Stapf.	Poaceae	1.51a	96.04a	64.28a
Bulbostylis laniceps C.B. Clarke ex T. Durand & Schinz.	Cyperaceae	0.91a	96.96a	71.42a
Indigofera capitata Kortschy	Fabaceae	0.91a	97.87a	78.57a
Cyperus rotundus L.	Cyperaceae	0.91a	98.78a	85.71d
Desmodium sp.	Fabaceae	0.60a	99.39a	92.85d
Eriosema psoraleoides (Lam.) G. Don	Fabaceae	0.60a	100a	100d
P-value		***	***	***

Legend : CSi : Specific contribution of the identified species ; CSc : cumulative specific contributions.

Table 6: Families, specific contributions, cumulative specific contributions and ranks of herbaceous plants, plot 2 in 2024

Species	Families	CSi (%)	CSc (%)	Ranks (%)
Ctenium newtonii Hack.	Poaceae	42.24c	42.24b	8.33c
Trachypogon spicatus (L.f) Kuntze	Poaceae	27.58e	69.82c	16.66c
Elionorus hensii K. Schum	Poaceae	14.08de	83.90ac	25.00e
Sporobolus congoensis Franch.	Poaceae	7.75d	91.66a	33.33e
Elionurus brazzae Kranch.	Poaceae	2.87b	94.54a	41.66b
Bulbostylis laniceps C.B. Clarke ex T. Durand & Schinz.	Cyperaceae	2.29b	96.83a	50.00b
Bulbostylis hispidula (Vahl) R.W. Haines	Cyperaceae	0.86a	97.70a	58.33b
Vernonia smithiana Less.	Asteraceae	0.86a	98.56a	66.66a
Brachiaria comata Hocht. ex A. Rich.	Fabaceae	0.57a	99.13a	75.00a
Eriosema psoraleoides (Lam.) G. Don	Fabaceae	0.28a	99.42a	83.33ad
Hyparrhenia diplandra (Hack.) Stapf.	Poaceae	0.28a	99.71a	91/66d
Cyanotis lanata Benth.	Commelinaceae	0.28a	100.00a	100.00d
P-value		***	***	***

Legend : CSi : Specific contribution of the identified species ; CSc : cumulative specific contributions.

Table 7: Families, specific contributions, cumulative specific contributions and ranks of herbaceous plants, plot 3 in 2024

Species	Families	CSi (%)	CSc (%)	Ranks (%)
Trachypogon spicatus (L.f) Kuntze	Poaceae	27.44e	27.44d	11.11^{e}
Elionerus hensii K. Schum	Poaceae	22.18e	49.62ad	22.22a
Andropogon schirensis Hochst. Ex A. Rich.	Poaceae	17.66a	67.29a	33.33ab
Ctenium newtonii Harck.	Poaceae	16.16a	83.45b	44.44ab
Brachiaria comata Hocht. ex A. Rich.	Fabacea	6.02b	89.47b	55.55b
Elionurus brazzae Kranch.	Poaceae	4.51bc	93.98c	66.66d
Sporobolus congoensis Franch.	Poaceae	4.13bc	98.12c	77.77d
Bulbostylis laniceps C.B. Clarke ex T. Durand & Schinz.	Cyperaceae	1.12c	99.24c	88.88c
Eriosema psoraleoides (Lam.) G. Don.	Fabacea	0.75c	100.00c	100.00c
P-value		***	***	***

L Legend : CSi : Specific contribution of the identified species ; CSc : cumulative specific contributions.

Table 8: Families, specific contributions, cumulative specific contributions and ranks of herbaceous plants, plot 4 in 2024

Species	Families	Fsi (%)	FSc (%)	Ranks (%)
Ctenium newtonii Harck.	Poaceae	35.47b	35.47b	9.09c
Trachypogon spicatus (L.f) Kuntze	Poaceae	34.86b	70.33d	18.18cd
Elionerus hensii K. Schum	Poaceae	17.13c	87.46c	27.27d
Sporobolus congoensis Franch.	Poaceae	8.25d	95.71a	36.36a
Andropogon schirensis Hochst. Ex A. Rich.	Poaceae	0.91a	96.63a	45.45a
Bulbostylis laniceps C.B. Clarke ex T. Durand & Schinz.	Cyperaceae	0.61a	97.24a	54.54a
Cyanotis lanata Benth.	Commelinaceae	0.61a	97.85a	63.63ab
Desmodium sp	Fabaceae	0.61a	98.47a	72.72b
Brachiaria comata Hocht. ex A. Rich.	Poaceae	0.61a	99.08a	81.81b
Eriosema psoraleoides (Lam.) G. Don	Fabaceae	0.61a	99.69a	90.90a
Elionurus brazzae Kranch.	Poaceae	0.30a	100.00a	100.00e
P-value		***	***	***

Legend : CSi : Specific contribution of the identified species ; CSc : cumulative specific contributions.

2.3. Plant diversity

Data on plant diversity in the plots sampled in 2023 and 2024 are presented in Tables 9 and 10. These vary from one plot to another and from one year to the next. The species richness of the plots studied in 2023 ranges from 7 to 12 species ; the maximum diversity from 2.8 to 3.58; the Shannon index from 1.79 to 2.31; and the Pielou equity index from 0.63 to 0.68.

The biodiversity index values for the four plots sampled in 2023 show statistically significant differences (**). Overall, they indicate that the flora of the surveyed pastures is less diverse and that the distribution of individuals within species is uneven.

In 2024, plant species richness increased in plot 1 (14 species), plot 2 (12 species) and plot 4 (11 species). It decreased slightly in plot 3 (9 species). Plant diversity increased in all plots during that year. Apart from the evenness index, which shows statistically different values, the other diversity indices show statistically highly significant values (***). Overall, despite the increase in Shannon index values, the flora of the sampled plots remains less diverse. Within this flora, the distribution of individuals across species is uneven, with the exception of plot 3.

Figure 9: Diversity indice for the plots sampled in 2023

Plots	Species richness (S)	Maximum diversity (Hmax)	Shannon index (H')	Pielou Equity index (E)
Parcelle 1	12a	3.58a	2.31a	0.64ab
Parcelle 2	10ab	3.32ab	2.20ab	0.66ab
Parcelle 3	10ab	3.32ab	2.26ab	0.68b
Parcelle 4	7b	2.8b	1.79b	0.63a
P-value	**	**	**	**

Table 10: Diversity indices for plots sampled in 2024

Plots	Species richness (S)	Maximum diversity (Hmax)	Shannon index (H')	Pielou Equity index (E)
Parcelle 1	14a	3.8a	2.61a	0.68a
Parcelle 2	12ab	3.58b	2.22b	0.61a
Parcelle 3	9b	3.16c	2.62a	0.82b
Parcelle 4	11ab	3.45b	2.1c	0.6a
P-value	***	***	***	**

3. DISCUSSION

In the pastures studied at the Okouéssé ranch, the Poaceae family is the most represented in terms of species diversity. This could be explained by the conditions of the study area, which are more favourable to grasses. Camara (2009) states that savannahs are ecosystems dominated by grasses, which explains their high prevalence. Grasses regrow rapidly after being grazed by animals or following a fire; this explains their high prevalence.

Three types of grassland have been identified : *Trachypogon spicatus* (L.f.) Kuntze grassland, *Ctenium newtonii* Hack. Grassland and *Elionorus hensii* K. Schum. Grassland. Yoka *et al.,* (2011) state that the original savannahs in the Boundji area were *Trachypogon spicatus* savannahs and *Loudetia simplex* savannahs. The finding is that these savannahs are transforming into *Ctenium newtonii* Hack. Pasture and *Elionorus hensii* K. Schum. Pasture. This change is thought to be due to the grazing of N'dama cattle, which causes the most palatable plant species to disappear and leads to the emergence of those that are less palatable or not palatable at all. The floristic composition of the pastures is influenced by grazing, which is reflected in the presence of species such as *Ctenium newtonii* Hack. and *Elionorus hensii* K. Schum. These results confirm the findings of Amboua *et al.,* (2019) from the Essimbi ranch.

The data from this study reveal that in 2023, plot 1 had the highest species richness (12 species) and the highest Shannon index (2.31), followed by plot 3 (10 species, Shannon index of 2.26) and plot 2 (10 species, Shannon index of 2.2). Plot 4 has the lowest species richness (7 species) and the lowest species diversity (Shannon index of 1.79). In 2024, Plot 1 retained its position as having the highest species richness (14 species) and the greatest increase in biodiversity (Shannon index of 2.61), followed by Plot 2 (12 species, Shannon index of 2.22). Plot 4 has seen an increase in species richness that is close to that of plot 2 and exceeds that of plot 3. This plot shows a slight decrease in species richness (9 species), but the Shannon index and Pielou equity index have increased from 2.26 to 2.62 and from 0.68 to 0.82 respectively. This shows that, despite the fact that the distribution of individuals within the species on this plot is even, the plant diversity remains less diverse. In plot 4, the number of species increased significantly (from 7 to 11) ; this led to a rise in the Shannon index from 1.79 to 2.1, indicating a substantial improvement in biodiversity. This could be explained by the reduction in grazing pressure and the rainfall in the area.

The results of this study differ from those of Amboua *et al.,* (2019) at the Essimbi ranch, which showed Shannon index values ranging from 1.08 to 1.28 in scrubby pastures and from 0.81 to 1.43 in non-scrubby

pastures. Bokatola (2016) reports a species richness ranging from 9 to 15 species; Shannon index ranging from 1.49 to 2.56 and Pielou equity index ranging from 0.44 to 0.67 in grazed savannah. Tambika (2014) found that the values for the Shannon diversity index and Pielou equity index ranged from 1.75 to 3 and from 0.45 to 0.75 respectively. The values presented (Shannon index) by these three authors, who worked in the same area, are lower than those we found in the pastures in 2023 and, in particular, in 2024. The difference in these results could be explained by differences in stocking rates, the type of pasture, and the growth stages during which the assessment of floristic diversity was carried out.

CONCLUSION

The study identified three types of pasture: *Trachypogon spicatus* (L.f.) Kuntze pasture, *Ctenium newtonii* Hack. Pasture, and *Elionorus hensii* K. Schum. Pasture. There is a gradual change in the plant biodiversity of the sampled pastures from one year to the next. Despite this, the flora of these pastures is less diverse and the distribution of individuals within species is not even across all plots. *Ctenium newtonii* Hack. and *Elionorus hensii* K. Schum., which are dominant in the pastures of the area, indicate a risk of deterioration in the forage potential of these pastures. The results of this study show that grazed vegetation is not static but evolves over time, depending on the method of pasture management. They could serve as a basis for further work on the sustainable management of pastures in the study area and elsewhere in the Congo and the intertropical zone.

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