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ORIGINAL ARTICLE

PHYTODIVERSITY, PRODUCTIVITY AND CARRYING CAPACITY OF HERBAGES PLANTS COMMUNITIES INVADED BY *SIDA CORDIFOLIA* L.

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ABSTRACT

Rangelands are vast natural ecosystems composed of grasslands, shrubs, woody vegetation, and arid lands that support both wild and domestic grazing animals. They are vital for livestock production, wildlife conservation, and ecosystem services. However, livelihoods dependent on extensive livestock keeping are increasingly threatened by invasive species. These species disrupt grazing practices, reduce forage yield and quality, increase management costs, slow animal growth, lower meat, milk, wool, and hide quality, and may even poison livestock.

In Niger Republic, *Sida cordifolia* (Malvaceae) poses a major threat to rangeland biodiversity and productivity. Its spread reduces the presence of key forage grasses such as *Andropogon gayanus*, *Pennisetum pedicellatum*, *Alysicarpus ovalifolius*, and *Diheteropogon hagerupii*. To assess the impact, 126 phytosociological plots were established using the Braun-Blanquet method, with vegetation characterized by the Point-Intercept Method. Biomass productivity was measured in five subplots (1 m²) for each plot. The study recorded 114 herbaceous species across 25 families and 74 genera. Poaceae dominated (31 species, 27.43%), followed by Fabaceae (14 species, 12.39%) and Malvaceae (10 species, 9%). Fodder production ranged from 424.83 to 730.98 kg/ha. However, *Sida cordifolia* contributed disproportionately high biomass (246.97–392.6 kg/ha, 40.4–70.2% of total), reducing the productivity of palatable forage species. Consequently, carrying capacity and pastoral value were significantly lower compared to other studies.

The findings highlight that *Sida cordifolia* invasion decreases biomass productivity, pastoral value, and availability of nutritious forage species. Sustainable management requires introducing high-quality fodder species through reseeding and involving breeders in rangeland management to restore productivity and ensure livestock development in Niger Republic.

Keywords: *Sida cordifolia* L., Invasive plant, Phytosociology, herbaceous biomass, species diversity, Rangeland management.

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INTRODUCTION

Rangelands are wide land area, with naturally occurring vegetation, comprising of grasslands, bushes, woody vegetation and even arid lands in different combination which support the wild and domestic grazing animals (Liniger & Mekdaschi, 2019). They are primarily utilized for extensive livestock grazing and browsing, and contribute significantly to the provision of multiple ecosystem services including biodiversity conservation, climate regulation, and soil stabilization. Globally, rangelands cover approximately 25% of the Earth's terrestrial surface and support the livelihoods of over 500 million people, particularly in arid and semi-arid regions (Robinson *et al.,* 2021).

In Niger and across the Sahel, rangelands form the backbone of pastoral and agropastoral economies. However, these ecosystems face increasing degradation due to both natural and anthropogenic pressures. Rangeland degradation is commonly reflected in a decline in vegetation cover, reduced biodiversity, diminished biomass productivity, increased soil erosion, and a drop in livestock productivity (Zerga, 2015; Nianogo *et al*., 2020). One of the most pressing threats to rangeland integrity is the invasion of aggressive plant species. Invasive species, whether exotic or native, can outcompete palatable forage species, disrupt ecological balances, and severely limit the pastoral value of rangelands (Maxime *et al*., 2014).

In Niger, *Sida cordifolia* has emerged as a highly invasive herbaceous species, altering the composition, structure, and functioning of herbaceous plant communities, thereby threatening forage availability and biodiversity. Such invasions can adversely affect animal nutrition, grazing management, and pastoral production, leading to both economic and ecological consequences (CNEDD, 2014). *The invasion of rangelands in Niger by Sida* cordifolia threatens herbaceous plant diversity, reduces forage productivity, and undermines rangeland carrying capacity, yet its ecological impacts remain poorly quantified.

This study aims to assess the phytodiversity, productivity, and carrying capacity of herbaceous communities in rangelands invaded by *Sida cordifolia* with a view to better control its expansion for the sustainable management of rangelands in Niger. Specific objectives include: (i) determining species composition and diversity, (ii) classifying plant communities using multivariate analyses, and (iii) characterizing these communities in terms of ecological spectra, biomass productivity, carrying capacity, and pastoral value. It was hypothesized that *Sida cordifolia* invasion reduces palatable species diversity, alters community structure, and lowers biomass productivity and carrying capacity.

METHODOLOGY

Study Area

The study was carried out in the Department of Falmey Dosso Region. The Department of Falmey covers an area of1,172 km^2 and is located in the extreme South-West of Niger Republic, 100 km from Dosso and 155 km from Niamey (capital of the country) (Sitou *et al.,* 2019). The Department of Falmey is located between Latitudes 12°35'38" and 12°50'00 North, Longitudes 2°35 and 3°00 East in the western part of the Dosso Region (Figure 1). The climate of the Department of Falmey is tropical arid with an annual average rainfall of between 600 and 800 millimeters (Sitou *et al.,* 2019). The climate is characterised by two alternating seasons: a rainy season which spans from May to September and a dry season which occurs

from October to April (PDC, 2014). Temperature varies considerably throughout the year, depending on the season. Maximum temperatures are recorded during the months of March and April, while minimum temperatures during the months of December and February (PDC, 2014). Among the different types of soils in the study area include: the sandy soils of dallol, Valley soils, Hydromorphic soils, Lateritic soils and soils of the "Zigui" and "Fakara" plateau. The herbaceous stratum is dominated by *Andropogon gayanus*, *Cenchrus biflorus*, *Eragrostis tremula*, *Cassia mimosoides*, *Tripogon minimus*, and *Diheteropogon hagerupii (*PDC, 2014). There is significant degradation of pastoral areas due to occupation by crops, the proliferation of unpalatable plant species, gullying and non-development of these pastoral areas (Maarouhi & Fataw, 2022).

A reconnaissance survey was conducted in Falmey at the beginning of August 2022 to identify the rangelands invaded by *Sida cordifolia* (Plate 1 & 2). It was possible to identify the rangelands of the study area as well as that invaded by *Sida cordifolia*. The information was collected from the environment Director of Falmey Department and his team through an interview. For this purpose, the following rangelands were chosen for data collection: the rangeland of Kara in the village of Bellande; the rangeland of Toungan gambou in the village of Garbou; the rangeland of Karel Koissi in the village of Koissi, the rangeland of Binguel bodi in the village of Djonkoto, the rangelands of Natangou and Galala in the village of Sour –Sour all of them invaded by *Sida cordifolia.*

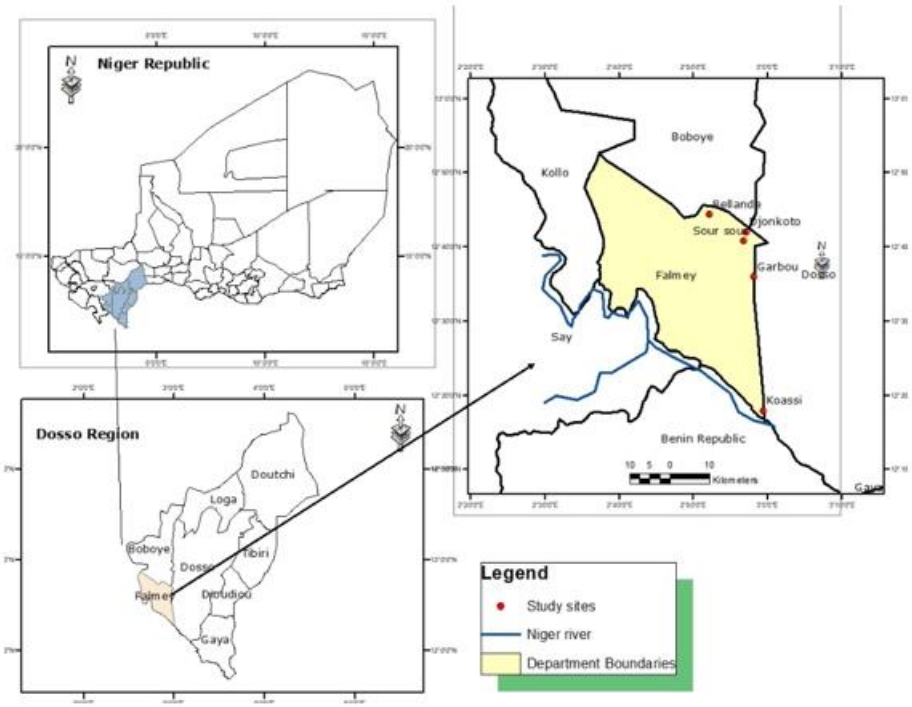

Figure 1. Location of the study area

Plate 1: A part of the rangeland of Toungan Gambou completely invaded by *Sida cordifolia*

Plate 2: Animals looking for forage in a part of the rangeland of Kara partially invaded by *Sida cordifolia*

Floristic Inventory

The floristic survey was carried out from August to September 2022. During this period, the Sahelian herbs cover was at its maximal development stage, with grasses and forbs easily identifiable (Soumana, 2011). This inventory was conducted using the quadrats points method aligned (Daget & Poissonet 1971). It consists of identifying the presence of the species in the vertical dots arranged regularly, every 20 cm along a double tape measure (20 m) stretched over a grass mat. A tapered metal rod embodying the line of sight is positioned at each point, and the species in contact with the rod are enumerated. By convention, each species is recorded

only once per line of sight for a total number of contact points of 100 in each line. At each reading point, the contact of a species took place either through leaves or culms, and other organs, but the species were noted only once per reading point.

Biomass Productivity

Within each plot of 1000 m² for aligned point method, five sub plots of 1m x 1m ($1m^2$), one in each corner of the main plot and the fifth one in the middle, were established. All the above ground forage samples were harvested using cutter (Fenetahun *et al.,* 2020), subdivided into categories of *Sida cordifolia,* grasses, legume and others and collected in paper bags (Plate 3). The samples were dried under the sun for several days and were finally weighed to determine the dry matter content of the biomass. This phytomass obtained was used to calculate the carrying capacity of the invade rangelands.

Life Form or Biological type

The biological types used are those defined by Raunkiaer (1934): Phanerophytes (Ph), Chamephytes (Ch), Geophytes (Ge), Hemicryptophytes (H) Therophytes (Th), and Hydrophytes (Hy).

Phytogeographical Type

The phytogeographical types used in this study are those described by White (1983): Widely Distributed Species including: Cosmopolitan species (Cos), Pantropical species (Pan), Palaeotropical species (Pal), Afro-American species (AA). African multi-regional species including: Afro- Malagasy species (AM), Pluriregional species (PA); Floral Endemism species: Afro- Tropical species (AT), Sudano-Zambezian species (SZ) and Sudanian species (S).

Plate 3: Harvesting and categorization of phytomass

Data Analysis

Discrimination of herbage plant communities - The matrix of data analysed consist of 116 plots and 113 herbaceous species. This has been subjected to multivariate analysis to identify the herbage plant communities. With the Euclidean distance option selected in the software PC-ORD ver. 5, Then, Hierarchical Ascendant Classification was complemented by Detrended Correspondence Analysis (DCA) (McCune *et al.,* 2002), an indirect gradient analysis was

implemented to detect the level of change in species composition along the two first ordination axis. To test for differences between the pre-defined plant communities in terms of plant species composition, multi-response permutation procedure (MRPP) with the Sørensen distance measure have been used because its less inclined to exaggeration based on outliers and zero values for cover estimates. Multi-Response Permutation Procedures (MRPP) is a nonparametric test used to compare the similarity of variables within groups relative to other groups. MRPP generates three key statistics: T statistic which measures the separation between groups, a more negative T value indicates greater separation. A statistic which represents the chance-corrected within-group agreement. A value of 1 indicated perfect agreement, while 0 suggests no agreement beyond random expectation. In community ecology, A values are generally less than 0.1. P-value: This determines the statistical significance of the test.

Indicator species analysis - Indicator species analysis was conducted using PC-ORD 5 to identify the characteristics species of each plant community. This analysis allows to combine both the relative frequency and abundance to calculate the indicator value (IV) of each species whose significance is tested by the Monte Carlo test. The Indicator Value was computed using the following formula:

$$IV_{kj} = RA_{kj} \times RF_{kj} \times 100 \quad \text{..... equation 1}$$

Where:

IV= is Indicator Value, RA= is the relative abundance of a given species j in a given site type k and RF= is the proportional frequency of species j in site type k (i.e., the proportion of plots in each site type with species j).

Values of IV ranged from 0 to 100. All species with a probability of less than 0.05 were retained as characteristic species of a plant community. The plant communities were named each time by *Sida cordifolia* and another most characteristic species of the herbaceous stratum or the ligneous stratum, but the ruderal species were avoided in this nomenclature.

Pastoral Value - The relative value of species called Specific Index (SI) quality reflects their zootechnical interest. It was established from a rating scale of 0 to 5 (Daget & Poissonet, 1971). The ISQ used in this study was advanced by Soumana (2011) in which species are classified by indices as follows: species with ISQ equal to 5 represent Very High-Quality Forage (VHQF); species with 4 ISQ indicates High-Quality Forage (HQF), ISQ = 3 means species with quality forage; 2 ISQ means species with Low-Quality Forage (LQF); ISQ = 1 means species with Very Low-Quality Forage (VLQF) and 0 means No Palatable species (NP) (Aboh, 2008; Soumana, 2011 and Kiema *et al*., 2014).The specific contribution (CSi) species that determines their involvement in land cover is one that is directly measured on pastures. The Pastoral Value was calculated by Daget & Poissonet (1971) formula which was:

$$PV = 0.2 \sum_{i=1}^{n} (\mathrm{CSi} * \mathrm{ISi}) \quad \text{..... equation 2}$$

In which 0.2 is a coefficient enabling to express VP in %, the Pastoral Value ranged from 0 to 100.

Carrying Capacity (CC) - Carrying capacity was estimated based on 40% allowable grazing material (Abdullah *et al.,* 2017). It is calculated based on the productivity of the pasture and

the food requirements of the Tropical Livestock Unit (TLU). The products of pasture considered include the usable biomass and the daily consumption rate of the Tropical Livestock Unit (6.25 kg Dry matter/day).

CC (TLU/ha /year) = productivity [kg DM/ ha]) ×U/(6.25 × period of use [180 days]) ……. equation 4

In which productivity is the annual average phytomass of the pasture. U is the coefficient of potential use of biomass and one third is retained during the maturation phase of the grasses. 180 days (6 months) is maintained period of use in this study.

RESULTS

Taxonomic diversity

The floristic investigations in the rangelands invaded by *Sida cordifolia* have identified 113 species of herbaceous plants belonging to 25 families and 74 genera. The most dominant family in terms of species number was Poaceae with 31 species (27.43%), followed by Fabaceae (14 species, 12.39%), Malvaceae (10 species, 8.84%), Amaranthaceae (9 species, 7.96%), Convolvulaceae (6 species, 5.30 %), Rubiaceae (5 species, 4.42%), Cyperaceae (4 species, 3.54%), Amaryllidaceae, Apocynaceae, Curcubitaceae, and Molluginaceae with 3 species (2.65% each). Acanthaceae, Commelinaceae, Euphorbiaceae, Lamiaceae, Asteraceae and Pedaliaceae 2 species with 1.77% each one. The remaining families Zygophyllaceae, Boraginaceae, Colchicaceae, Nyctaginaceae, Capparidaceae and Limeaceae have one species each with 0.88 (Figure 2).

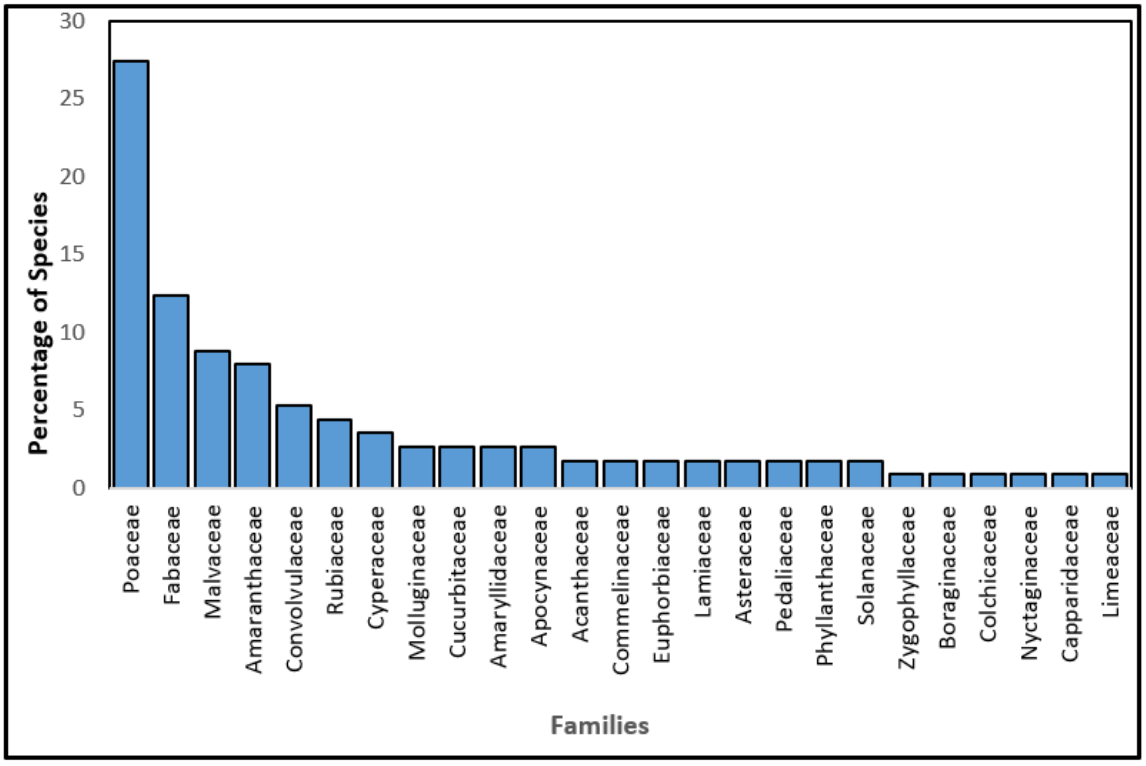

Figure 2: Distribution of Species Families of Herbages Plant Communities

Life Forms or Biological Spectrum

Figure 25 shows life forms spectrum of the herbaceous species. It indicates the interface of plants and their environmental conditions. The assessment of life form spectrum indicates that the dominant life forms were Therophytes, which constitute 76% of the studied flora. The other life forms are less represented: Phanerophytes with 8%, Chamaephytes with 7% and Geophytes with 5% of the total flora (Figure 3).

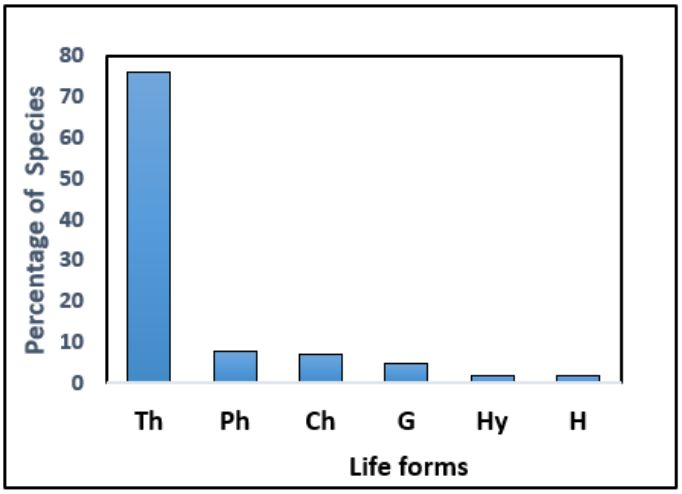

Figure 3: Life Forms Spectrum of the Herbaceous Species (Th: Therophyte, Ph: Phanerophyte, Ch: Chamaephyte, G: Geophyte, Hy: Hydrophyte, H: Hemicryptophyte)

Phytogeographical Spectrum

Figure 26 shows phytogeographical spectrum of the herbaceous species the total flora was composed mostly of pantropical elements (36%), followed by paleotropical elements (26%), Sudano-zambezian (12%), Afro-tropical and Pluri-regional African (7%) each, Cosmopolian (5%) and Soudanian (4%). The other elements were represented by only one or two species (Figure 4).

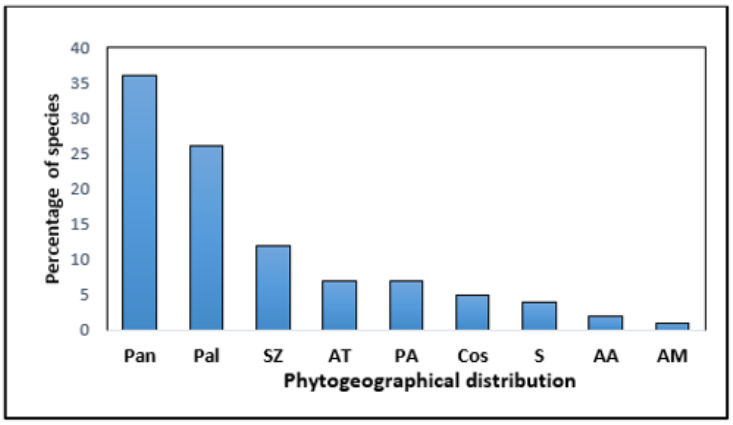

Figure 4: Phytogeographical spectrum of the species herbages

Typology of Herbage Plants Communities

The floristic data analyzed correspond to a raw matrix of 116 plots and 114 herbaceous plant species. This matrix was subjected to Hierarchical Correspondence Analysis (HCA). The

dendrogram (Figure 5) resulting of this analysis showed a partition of the 116 plots and 114 herbaceous plants into 5 herbage plant communities according to their similarity formed by axes 1 and 2. The detrended correspondence analysis revealed ecological patterns in species distribution across these five plant communities (Figure 6).

The Multi-Response Permutation Procedure (MRPP) indicates that there are significant differences between these plant communities (A = 0.20; p = 0.00; T = -43.88) (Table 1). In this study, the value of expected delta is 0.66 and that of the observed delta is 0.53 with a difference of 0.13. This difference between the expected and observed delta values confirms the strong variation in species composition between communities. The high chance-corrected within-group agreement (A = 0.20) and T statistic test show (T= -43.88) that the five plants communities were distributed in different regions of the species space and relate to the spatial heterogeneity of the herbages plants communities.

Table 1: Summary of Multi-Response Permutation Procedure (MRPP) statistics of the plant communities

Test statistic: T	-43.88
Observed delta	0.53
Expected delta	0.66
Variance of delta	0.99
Skewness of delta	-0.68
A	0.20
P	0.00

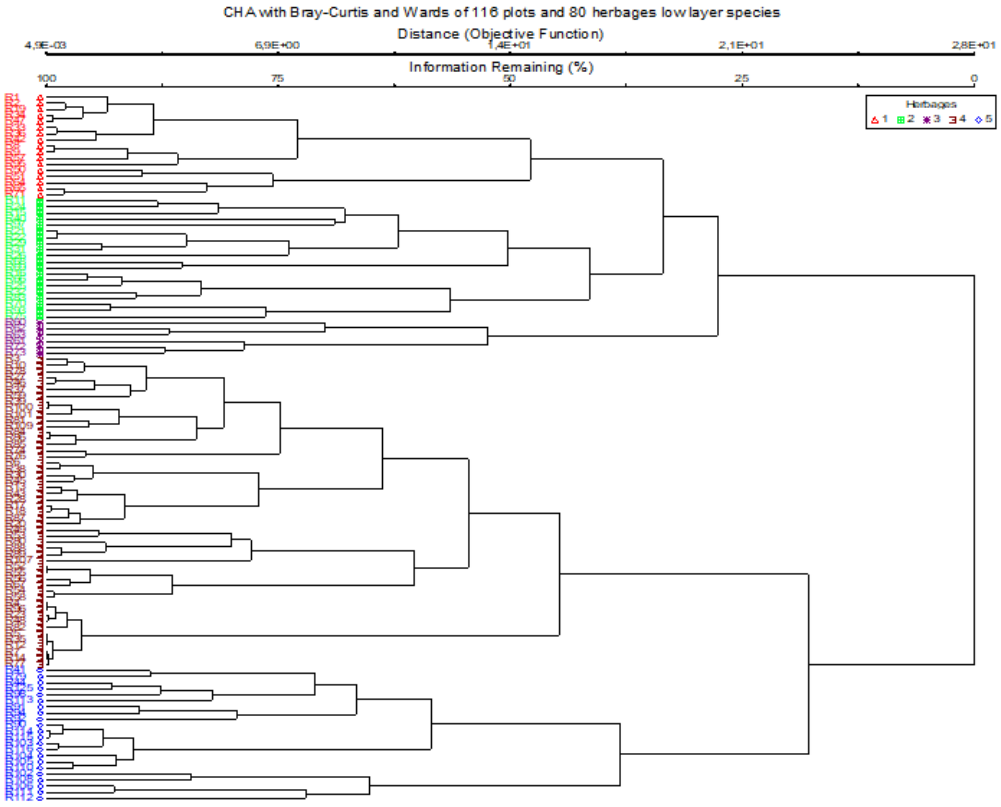

Figure 5: Dendrogram of herbage plant communities

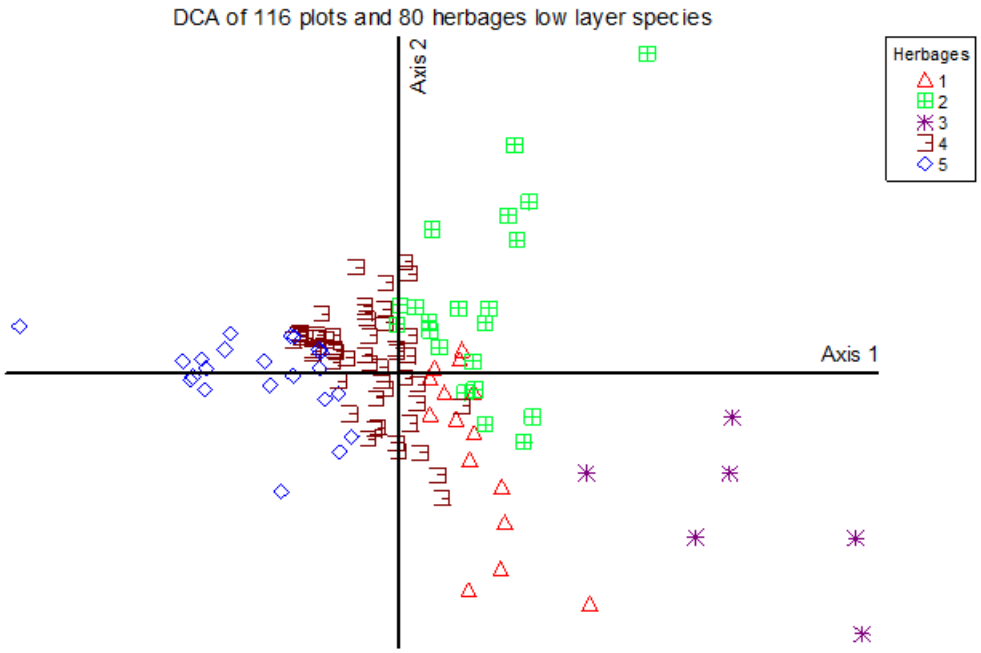

Figure 6: Ordination of Releves by Detrented Correspondence Analysis (DCA)

Sida cordifolia and *Zornia glochidiata* Herbage Plant Community (G1) Diversity

This community was represented by 17 plots and a total of 76 species recorded (Table 8). It is characterized by *Sida cordifolia* and *Zornia glochidiata (*56.5 IV) which has the greatest Indicator Value (IV). Others characteristic species of this community are *Tripogon minimus* (35.3 IV) and *Triumfetta pentandra (*15.9 IV) (Table 7).

In terms of frequency, *Sida cordifolia* and *Zornia glochidiata* are the most frequent species in this community. These two species are in codominance and occupy first place (94.11%) in the community. They are followed by *Aristida longiflora, Waltheria indica* and *Tripogon minimus* with 70.58% each (Table 7). However, in terms of average recovery, *Sida cordifolia* (17%) occupies third place after *Zornia glochidiata* (31.5%) and *Tripogon minimus* (20.5%) (Table 2).This community was characterized by a very low Shannon index, H = 0.25 bits and Pielou evenness E= 0.04 (Table 8) which indicated that this community has low diversity and few number of species with a significant cover due to the invasion of *Sida cordifolia*.

In the assessment of life form spectrum of herbage in rangelands invaded by *Sida cordifolia*, the dominant life forms are therophytes 60 species and constitutes 79% of the herbage, followed by chamaephytes with 5 species (7%), geophytes and phanerophytes with 4 species each (5%). The other life forms have one or two species (Figure 7)

The herbage of this community is composed mostly of Pantropical (28 species, 36.84%) and Paleotropical (18 species, 23.68 %). They are followed by Sudano Zambezian (8 species, 10.52%) and Pluriregional (6 species 7.89%), Africa Tropical and Sudanese (5 species, 6.57% each) and Cosmopolitan (3 species, 3.94 %) (Figure 8)

Productivity, Pastoral Value and Carrying Capacity

The production of fodder within the same herbage plant community varies depending on the category of fodder. The dry matter production of *Sida cordifolia* is the highest and constitutes 53.70% with 392.6 (Kg/ha) of the other categories. It is followed by grasses 18.31% with 133.9

(Kg/ha) of the total, others fodder species 15.40% with 112.6 (Kg/ha) and legumes 12.56% with 91.88 (Kg/ha). The total production of this community is 730.98 (kg/ha) (Figure 9). Therefore, the carrying capacity 0.21TLU/ha/year (Table 2) was lower than those reported by these authors. The pastoral value 43 of this community is relatively low, in spite of the high proportion of grasses and leguminous species. The production of *Sida cordifolia* 53.70% of the total is remarkable, but unfortunately the plant is not palatable. This confirms its high capacity to occupy the environment. Such occupation of the environment, as already indicated, is always to the detriment of the diversity of forage species, on the one hand, but also of their productivity, on the other.

Table 2: Species Relative Abundance (SRA), Specific Index of Quality (IS), Pastoral Value (PV) and Carrying Capacity (CC) of *Sida cordifolia* and *Zornia glochidiata* community

				CC (TLU/ha/year			0.21
B S	LF	SRA	Families	Species	SR A	IS	VP
PA	Th	VHQF	Fabaceae	*Zornia glochidiata*	7.05	5	7.05
Pal	H	HQF	Poaceae	*Eragrostis tenella*	2.2	4	1.76
Pan	Th	VHQF	Fabaceae	*Desmodium hirtum*	3.08	5	3.08
Pan	Ch	NP	Malvaceae	*Waltheria indica*	5.29	0	0
Pal	Th	LQF	Poaceae	*Tripogon minimus*	5.29	2	2.11
Pan	Gr	VLQF	Cyperaceae	*Cyperus rotundus*	3.08	1	0.62
AT	Th	NP	Rubiaceae	*Mitracarpus scaber*	2.64	0	0
Pal	Th	LQF	Malvaceae	*Corchorus fascicularis*	0.88	2	0.35
S	Th	NP	Cyperaceae	*Fimbristylis hispidula*	1.76	0	0
Pan	CH	NP	Malvaceae	*Sida cordifolia*	7.05	0	0
PA	Th	NP	Asteraceae	*Acanthospermum hispidium*	0.44	0	0
SZ	Th	NP	Amaranthaceae	*Alternanthera nodiflora*	0.44	0	0
Pal	Th	QF	Poaceae	*Brachiaria lata*	0.44	3	0.26
Pan	CH	HQF	Poaceae	*Aristida longiflora*	5.29	4	4.23
Pal	Hy	VHQF	Poaceae	*Echinochloa colona*	2.64	5	2.64
PA	Th	VLQF	Rubiaceae	*Spermacoce filifolia*	2.2	1	0.44
SZ	Th	VLQF	Rubiaceae	*Spermacoce radiata*	0.88	1	0.18
S	Th	VHQF	Poaceae	*Diheteropogon hagerrupii*	0.44	5	0.44
Pal	Th	LQF	Commelinaceae	*Commelina benghalensis*	0.88	2	0.35
Pal	Th	QF	Phyllanthaceae	*Phyllanthus pentandrus*	0.44	3	0.26
Pan	Th	VLQF	Molluginaceae	*Mollugo nudicaulis*	0.44	1	0.09
SZ	Th	QF	Poaceae	*Brachiaria xantholeuca*	1.76	3	1.06
S	Th	VLQF	Euphorbiaceaee	*Euphorbia aegyptiaca*	0.44	1	0.09
Pan	Th	VHQF	Poaceae	*Digitaria horizontalis*	0.88	5	0.88
Pan	Th	LQF	Poaceae	*Aristida mutabilis*	0.44	2	0.18
Pan	Th	HQF	Poaceae	*Pennisetum pedicellatum*	0.88	4	0.7
S	LTh	QF	Convolvulacea e	*Ipomoea vagans*	0.44	3	0.26
Pan	G	VLQF	Cyperaceae	*Cyperus difformis*	1.32	1	0.26
Pan	Th	HQF	Poaceae	*Digitaria nuda*	0.44	4	0.35
Pal	Th	QF	Tiliaceae	*Corchorus tridens*	1.32	3	0.79
PA	LTh	NP	Cucurbitaceae	*Citrullus lanatus*	0.88	0	0

SZ	Th	VLQF	Rubiaceae	*Spermacoce scabra*	2.2	1	0.44
Pan	Th	VHQF	Fabaceae	*Alysicarpus ovalifolius*	1.76	5	1.76
Pan	Th	QF	Poaceae	*Eragrostis tremula*	2.2	3	1.32
Pal	Th	VHQF	Poaceae	*Dactyloctenium aegyptium*	0.88	5	0.88
Pal	Th	NP	Fabaceae	*Cassia mimosoides*	2.64	0	0
AT	Th	QF	Fabaceae	*Brachiarria distitichophylla*	0.44	3	0.26
Pal	Th	QF	Lamiaceae	*Leucas martinicensis*	0.44	3	0.26
Pal	Th	QF	Fabaceae	*Indigofera diphylla*	0.44	3	0.26
Pan	G	NP	Amaryllidaceae	*Allium tricoccum*	0.44	0	0
Pan	Th	NP	Malvaceae	*Sida Urens*	0.44	0	0
Pal	Th	HQF	Poaceae	*Brachiaria mutica*	1.32	4	1.06
SZ	Th	QF	Fabaceae	*Tephrosia linearis*	0.44	3	0.26
Pan	Th	VLQF	Lamiaceae	*Hyptis suaveolens*	0.44	1	0.09
AM	Th	NP	Fabaceae	*Sesbania pachycarpa*	0.44	0	0
Pal	Th	QF	Tiliaceae	*Corchorus olitorius*	1.32	3	0.79
PA	NnPh	NP	Fabaceae	*Indigofera tinctoria*	1.32	0	0
Pan	Nnph	LQF	Fabaceae	*Cassia Tora*	1.76	2	0.7
AT	Th	NP	Malvaceae	*Triumfetta pentandra*	1.32	0	0
Pan	Th	VLQF	Amaranthaceae.	*Achyranthes aspera*	1.32	1	0.26
Pal	Th	QF	Commelinaceae	*Commelina forskalaei*	1.32	3	0.79
PA	Th	QF	Pedaliaceae	*Ceratotheca sesamoides*	0.88	3	0.53
SZ	Th	HQF	Poaceae	*Panicum laectum*	0.88	4	0.7
Pan	Th	HQF	Poaceae	*Panicum maximum*	0.44	4	0.35
SZ	Th	QF	Poaceae	*Oryza barthii*	0.44	3	0.26
Pan	Th	VLQF	Zygophyllaceae	*Tribulus terrestris*	1.32	1	0.26
AT	Th	QF	Poaceae	*Aristida Stipoides*	0.44	3	0.26
Pan	Th	QF	Poaceae	*Digitaria exilis*	0.44	3	0.26
Pal	Th	HQF	Poaceae	*Brachiaria ramosa*	0.44	4	0.35
S	H	HQF	Poaceae	*Andropogon gayanus*	0.88	3	0.53
Pan	Th	QF	Poaceae	*Aristida adscensionis*	0.88	3	0.53
Pan	Th	NP	Convolvulaceae	*Evolvulus alsinoides*	0.44	0	0
Pan	LCH	NP	Convolvulaceae	*Ipomoea asarifolia*	0.44	0	0
AT	Th	NP	Acanthaceae	*Monechma ciliatum*	0.44	0	0
Pal	Th	NP	Fabaceae	*Indigofera colutea*	0.44	0	0
Cos	Th	VLQF	Amaranthaceae	*Amaranthus graecizans*	0.44	1	0.09
AA	LTh	QF	Convolvulaceae	*Jacquemontia tamnifolia*	0.44	3	0.26
SZ	Ch	NP	Fabaceae	*Cassia italica*	0.44	0	0
AA	LTh	QF	Convolvulaceae	*Digitaria ciliaris*	0.88	3	0.53
Pan	Th	NP	Asteraceae	*Vernonia cinerea*	0.44	0	0
Pan	Th	NP	Phyllanthaceae	*Phyllanthus amarus*	0.44	0	0
Pal	NnPh	NP	Apocynaceae	*Pergularia tomentosa*	0.44	0	0
Cos	Th	VLQF	Amaranthaceae	*Amaranthus spinosus*	0.88	1	0.18
Pan	Gr	NP	Amaryllidaceae	*Crinum ornatum*	0.88	0	0
Cos	NnPh	NP	Solanaceae	*Datura innoxia*	0.88	0	0

Pan	Th	QF	Malvaceae	*Hibiscus sabdariffa*	0.44	3	0.26
							43

***Sida cordifolia* and *Echinochloa colona* herbage plant community (G2) diversity**

The community *of Sida cordifolia* and *Echinochloa colona* was diverse and large community, with 102 species recorded from 51 plots (Table 8). This community was characterized by *Echinochloa colona*, *Aristida longiflora Desmodium hirtum, Alysicarpus ovalifolius, Commelina forskalaei* and *Brachiaria xantholeuca* with 55.9, 42.6, 40.4, 26.8, 24.4, and 24.2 of species Indicator Value respectively (Table 7). On the 51 plots, *Sida cordifolia* was the most frequent species in this community; it was present on all the 51 plots in the community, with 100% in terms of frequency. It was followed by *Waltheria indica* 68.63%, *Tripogon minimus* 66.67%, *Zornia glochidiata* 64.71% and *Cyperus rotundus* 47% and *Mitracarpus scaber* 41% (Table7). Regarding the average coverage, *Sida cordifolia* 54% represents the most abundant species. The Shannon diversity index and evenness indices of this community were 0.24 bits and 0.04 (Table 8) respectively which were very low and indicated significant low species diversity and dominance of one or few species in the community.

The largest life form of this community are therophytes (80 species) which constitutes 79% of herbage, followed by the chamephytes (7 species, 7%) geophytes and Phanerophytes in codominance with 5 species, 5% each, Hemicryptophytes and Hydrophytes with 2 species each (Figure 7).

The most representative type with regard to the phytogeographical distribution are Pantropical 35 species which constitute 34, 65% of the herbage, followed by Paleotropical (24 species, 23.76%), Sudano Zambezian (14 species, 13.86%), Pluri-regional (8 species, 7. 92%), Africa Tropical (7 species 6.93%), and Cosmopolitan and Sudanese (5 species, 4.94 % each). The other types are represented only one or two species (Figure 8)

Productivity, Pastoral Value and Carrying Capacity

Figure 7 presents the dry biomass of fodder categories. The analysis of this figure shows that the biomass was mainly dominated by *Sida cordifolia* 70.26% (482 kg/ha) of the total productivity of the group. It was followed by grasses 12.97% (88.99kg/ha), others species 8.52% (58.49kg/ha) and legumes (8.23% (56.52kg/ha), with an overall dry biomass production of 686 kg/ha/year (Figure 9). The annual carrying capacity is low 0.20 TLU/ha/year, and the pastoral value 47 is relatively low (Table 3).

Table 3: Specific Frequency (SF), Species Relative Abundance (SRA), Specific Index of Quality (IS) and Pastoral Value (VP) and Carrying Capacity (CC) of *Sida Cordifolia* and *Echinochloa Colona* herbage plant community

				CC (TLU/ha/year)			0.20
P S	L F	IS	Families	Species	SRA	IS	VP
PA	Th	VHQF	Fabaceae	*Zornia glochidiata Rchb.*	4.34	5	4.3
Pal	H	HQF	Poaceae	*Eragrostis tenella*	0.92	4	0.7

Pan	Th	VHQF	Fabaceae	*Desmodium hirtum*	2.11	5	2.1
Pan	Ch	NP	Malvaceae	*Waltheria indica*	4.61	0	0
Pal	Th	LQF	Poaceae	*Tripogon minimus*	4.47	4	3.6
Pan	Gr	VLQF	Cyperaceae	*Cyperus rotundus*	3.16	1	0.6
AT	Th	NP	Rubiaceae	*Mitracarpus scaber*	2.76	0	0
Pal	Th	LQF	Malvaceae	*Corchorus fascicularis*	0.53	2	0.2
S	Th	NP	Cyperaceae	*Fimbristylis hispidula*	3.03	0	0
Pan	CH	NP	Malvaceae	*Sida cordifolia*	6.71	0	0
PA	Th	NP	Asteraceae	*Acanthospermum hispidium*	0.26	0	0
SZ	Th	NP	Amaranthaceae	*Alternanthera nodiflora*	0.66	0	0
Pan	CH	HQF	Poaceae	*Aristida longiflora*	4.08	4	3.3
Pal	Hy	VHQF	Poaceae	*Echinochloa colona*	2.76	5	2.8
PA	Th	VLQF	Rubiaceae	*Spermacoce filifolia*	0.66	1	0.1
SZ	Th	VLQF	Rubiaceae	*Spermacoce radiata*	0.53	1	0.1
S	Th	VHQF	Poaceae	*Diheteropogon hagerrupii*	0.39	5	0.4
Pal	Th	LQF	Commelinaceae	*Commelina benghalensis*	1.84	2	0.7
Pal	Th	QF	Phyllanthaceae	*Phyllanthus pentandrus*	0.26	3	0.2
Pan	Th	VLQF	Molluginaceae	*Mollugo nudicaulis Lam.*	0.92	1	0.2
SZ	Th	QF	Poaceae	*Brachiaria xantholeuca*	1.58	3	0.9
S	Th	VLQF	Euphorbiaceaee	*Euphorbia aegyptiaca*	0.79	1	0.2
Pal	Th	QF	Poaceae	*Scoenefeldia gracilis*	0.66	3	0.4
Pan	Th	VHQF	Poaceae	*Digitaria horizontalis*	1.97	5	2
Pan	Th	LQF	Poaceae	*Aristida mutabilis*	0.66	2	0.3
Pan	Th	HQF	Poaceae	*Pennisetum pedicellatum*	1.71	4	1.4
S	LTh	QF	Convolvulaceae	*Ipomoea vagans*	0.92	3	0.6
Pan	G	VLQF	Cyperaceae	*Cyperus difformis*	0.39	1	0.1
AT	Th	LQF	Poaceae	*Digitaria gayana*	1.58	2	0.6
Pal	Th	QF	Tiliaceae	*Corchorus tridens*	3.03	3	1.8
PA	LTh	NP	Curcubitaceae	*Citrullus lanatus*	0.79	0	0
SZ	Th	VLQF	Rubiaceae	*Spermacoce scabra*	1.45	1	0.3
Pal	Th	VHQF	Poaceae	*Cenchrus biflorus*	1.32	5	1.3
Pan	Th	VHQF	Fabaceae	*Alysicarpus ovalifolius*	2.63	5	2.6
Pan	Th	QF	Poaceae	*Eragrostis tremula*	1.58	3	0.9
Pal	Th	VHQF	Poaceae	*Dactyloctenium aegyptium*	1.58	5	1.6
Pal	Th	NP	Fabaceae	*Cassia mimosoides*	2.76	0	0
AT	Th	QF	Fabaceae	*Brachiarria distitichophylla*	0.26	3	0.2
Pal	Th	QF	Lamiaceae	*Leucas martinicensis*	0.39	3	0.2
SZ	Th	VLQF	Rubiaceae	*Spermacoce stachydea*	1.18	1	0.2
Pal	Th	QF	Fabaceae	*Indigofera diphylla*	0.66	3	0.4
Pan	Th	VHQF	Poaceae	*Schizachyrium exile*	1.18	5	1.2
Pan	Th	NP	Malvaceae	*Sida Urens*	0.39	0	0
Pal	Th	HQF	Poaceae	*Brachiaria mutica*	1.58	4	1.3
SZ	Th	QF	Fabaceae	*Tephrosia linearis*	0.66	3	0.4
Pal	Th	VLQF	Molluginaceae	*Mollugo cerviana*	0.39	1	0.1
Pan	Th	VLQF	Lamiaceae	*Hyptis suaveolens*	0.26	1	0.1
AT	LTh	QF	Convolvulaceae	*Merremia pinnata*	0.53	3	0.3
AM	Th	QF	Fabaceae	*Sesbania pachycarpa*	0.26	3	0.2

Pal	Th	QF	Tiliaceae	*Corchorus olitorius*	0.79	3	0.5
PA	NnPh	NP	Fabaceae	*Indigofera tinctoria*	0.13	0	0
Pal	Th	QF	Poaceae	*Setaria pallide-fusca*	0.26	3	0.2
PA	Th	VLQF	Amaranthaceae	*Celosia trigyna*	0.39	1	0.1
Pan	Nnph	LQF	Fabaceae	*Cassia Tora*	0.66	2	0.3
AT	Th	NP	Malvaceae	*Triumfetta pentandra*	0.13	0	0
Pan	Th	VLQF	Amaranthaceae	*Achyranthes aspera*	1.05	1	0.2
Pal	Th	QF	Commelinaceae	*Commelina forskalaei*	1.32	3	0.8
PA	Th	QF	Pedaliaceae	*Ceratotheca sesamoides*	0.39	3	0.2
SZ	Th	HQF	Poaceae	*Panicum Laectum*	0.66	4	0.5
Pan	Th	HQF	Poaceae	*Panicum maximum*	0.26	4	0.2
Pan	Th	NP	Amaranthaceae.	*Gomphrena celosioides*	0.13	0	0
SZ	Th	QF	Poaceae	*Oryza barthii*	0.39	3	0.2
Pan	Th	NP	Malvaceae	*Sida alba*	0.26	0	0
Pan	Th	VLQF	Zygophyllaceae	*Tribulus terrestris*	0.13	1	0
Pan	Th	QF	Poaceae	*Digitaria exilis*	0.13	3	0.1
Pal	Th	HQF	Poaceae	*Brachiaria ramosa*	0.66	4	0.5
Pal	Th	NP	Acanthaceae	*Peristrophe bicalyculata*	0.13	0	0
S	H	HQF	Poaceae	*Andropogon gayanus*	0.53	3	0.3
Pan	Th	QF	Poaceae	*Aristida adscensionis*	1.58	3	0.9
Pan	Th	NP	Convolvulaceae	*Evolvulus alsinoides*	0.66	0	0
Pan	LCH	NP	Convolvulaceae	*Ipomoea asarifolia*	0.66	0	0
SZ	Th	QF	Fabaceae	*Indigofera astragalina*	0.92	3	0.6
AT	Th	NP	Acanthaceae	*Monechma ciliatum*	0.53	0	0
Pan	NnPh	NP	Euphorbiaceae	*Chrozophora brocchiana*	0.13	0	0
Pal	Th	NP	Fabaceae	*Indigofera colutea*	0.79	0	0
Cos	Th	VLQF	Amaranthaceae	*Amaranthus graecizans*	0.39	1	0.1
AA	LTh	QF	Convolvulaceae	*Jacquemontia tamnifolia*	1.05	3	0.6
Pan	Th	VHQF	Poaceae	*Cenchrus prieurii*	0.26	5	0.3
SZ	Ch	NP	Fabaceae	*Cassia italica*	0.66	0	0
AA	LTh	QF	Convolvulaceae	*Digitaria ciliaris*	1.32	3	0.8
Pan	LTh	LQF	Cucurbitaceae	*Cucumis melo*	0.26	2	0.1
Pan	Th	LQF	Amaranthaceae	*Pandiaka heudelotii*	0.39	2	0.2
SZ	Ch	VLQF	Fabaceae	*Tephrosia lupinifolia*	0	1	0
Th	G	NP	Liliaceae	*Gloriosa superba*	0.13	0	0
Pan	LCh	NP	Cucurbitaceae	*Citrillus colocynthis*	0.13	0	0
AT	G	LQF	Amaryllidaceae	*Pancratium trianthum*	0.13	2	0.1
Pan	Th	NP	Malvaceae	*Sida acuta*	0.26	0	0
AT	Th	VLQF	Aizoaceae	*Limeum viscosum*	0.39	1	0.1
Cos	Th	LQF	Solanaceae	*Physalis angulata*	0.13	2	0.1
SZ	Th	VLQF	Cyperaceae	*Killinga debilis*	0.13	1	0
SZ	Th	VLQF	Pedaliaceae	*Sesamum alatum*	0.13	1	0
Pan	Th	NP	Phyllanthaceae	*Phyllanthus amarus*	0.39	0	0
Pal	Hy	VHQF	Poaceae	*Echinochloa stagnina*	0.13	5	0.1
Pal	Th	QF	Malvaceae	*Corchorus olitorius*	0.13	3	0.1
SZ	Th	LQF	Fabaceae	*Crotalaria arenaria*	0.13	2	0.1
Cos	Th	HQF	Poaceae	*Eragrostis ciliaris*	0.13	4	0.1

Cos	Th	VLQF	Amaranthaceae	*Amaranthus spinosus*	0.26	1	0.1
Pan	Gr	NP	Amaryllidaceae	*Crinum ornatum*	0.39	0	0
PA	Th	LQF	Capparidaceae	*Cleome viscosa*	0.26	2	0.1
Cos	NnPh	NP	Solanaceae	*Datura innoxia*	0.13	0	0
Pan	Th	VLQF	Nyctaginaceae	*Boerhavia repens*	0.26	1	0.1
Pal	Ch	NP	Boraginaceae	*Heliotropium strigosum*	0.13	0	0
Total							47

***Sida cordifolia* and *Oryza barthii* Herbage Plant Community (G3) diversity**

This community was from 20 plots from where a total of 78 species were recorded (Table 8). The characteristic species of the community were *Oryza barthii, Aristida Stipoides, Panicum Laectum, Dactyloctenium aegyptium, Brachiaria xantholeuca, Digitaria nuda, Eragrostis tenella,* and *Digitaria exilis* with 81.9, 46.6, 45.0, 43.3, 37.9, 34.4, 34.3 and 18.8 of Indicator Value respectively (Table7).

Sida cordifolia is the most encountered species in this community with a frequency of 95%, followed by *Zornia glochidiata* 90%, *Echinochloa colona* 75% in terms of frequency. However, *Sida cordifolia* takes third place in terms of average coverage after *Brachiaria ramosa* 24%, *Desmodium hirtum* 21.65%, and *Aristida longiflora* 18.5% (Table 7). The Shannon diversity index and evenness indices of this community are 0.22 bits and 0.03 (Table 8) respectively which indicated a significant low species diversity and dominance of few species.

Therophytes (61 species, 78.20%) are the most represented with regard to life form of this community, followed by Chamephytes (6 species, 7.69%), Phanerophytes (5 species 6.41%) and Geophytes (3 species, 3.84%). Hemicryptophytes and Hydrophytes are represented respectively by one and two species (Figure 7).

In terms of phytogeographical distribution, the most dominant species are Pantropical 28 species 35.89%, followed by Paleotropical 18 species 23%, Sudano Zambezian 10 species 12.82% and Pluri regional 5 species 6% (Figure 8)

Productivity, Pastoral Value and Carrying Capacity

The overall productivity of this community is 718.66kg/ha/year. This productivity varies depending on the fodder categories. The highest value was evaluated at the level of *Sida cordifolia* at 392.6kg/ha (54.62%), followed by grasses 167.17kg/ha (23.26%), other forage species 84.85kg/ha and legumes 74.04 kg/ha (Figure 9).

The carrying capacity of this community is 0.21TLU/ha/year and the pastoral value is 50.60 (Table 4), this community is a good pasture. This could be due to the presence of species with good fodder quality, including *Oryza barthii, Aristida stipoides, Panicum laectum, Dactyloctenium aegyptium, Brachiaria xantholeuca, Digitaria nuda, Eragrostis tremula,* and *Digitaria exilis*

Table 4: Specific Frequency (SF), Species Relative Abundance (SRA), Specific Index of Quality (IS), Pastoral Value (PV) and Carrying Capacity (CC) in *Sida cordifolia* and *Oryza barthii* herbage plant community

		C C(TLU/ha/hea)			0.21
IS	Families	*Espèces*	RAS	IS	VP
VHQF	Fabaceae	*Zornia glochidiata*	5.279	5	5.28

HQF	Poaceae	*Eragrostis tenella*	0.88	4	0.7
VHQF	Fabaceae	*Desmodium hirtum*	3.812	5	3.81
NP	Malvaceae	*Waltheria indica*	3.226	0	0
LQF	Poaceae	*Tripogon minimus*	4.399	4	3.52
VLQF	Cyperaceae	*Cyperus rotundus L.*	3.226	1	0.65
NP	Rubiaceae	*Mitracarpus scaber*	2.346	0	0
NP	Cyperaceae	*Fimbristylis hispidula*	2.933	0	0
NP	Malvaceae	*Sida cordifolia*	5.572	0	0
NP	Asteraceae	*Acanthospermum hispidium*	0.293	0	0
NP	Amaranthaceae	*Alternanthera nodiflora*	1.466	0	0
VHQF	Poaceae	*Brachiaria lata*	0.293	5	0.29
HQF	Poaceae	*Aristida longiflora*	4.985	4	3.99
VHQF	Poaceae	*Echinochloa colona*	4.399	5	4.4
VLQF	Rubiaceae	*Spermacoce filifolia*	1.466	1	0.29
VLQF	Rubiaceae	*Spermacoce radiata*	0.293	1	0.06
LQF	Commelinaceae	*Commelina benghalensis*	1.466	2	0.59
VLQF	Molluginaceae	*Mollugo nudicaulis Lam.*	1.466	1	0.29
QF	Poaceae	*Brachiaria xantholeuca*	0.587	3	0.35
VLQF	Euphorbiaceaee	*Euphorbia aegyptiaca*	0.587	1	0.12
VHQF	Poaceae	*Digitaria horizontalis*	0.293	5	0.29
LQF	Poaceae	*Aristida stipoides*	1.173	2	0.47
HQF	Poaceae	*Pennisetum pedicellatum*	0.88	4	0.7
QF	Convolvulaceae	*Ipomoea vagans*	0.587	3	0.35
VLQF	Cyperaceae	*Cyperus difformis*	0.293	1	0.06
LQF	Poaceae	*Digitaria gayana*	1.173	2	0.47
QF	Tiliaceae	*Corchorus tridens*	1.76	3	1.06
NP	Curcubitaceae	*Citrullus lanatus*	0.88	0	0
VLQF	Rubiaceae	*Spermacoce scabra*	1.173	1	0.23
VHQF	Poaceae	*Cenchrus biflorus*	1.466	5	1.47
VHQF	Fabaceae	*Alysicarpus ovalifolius*	3.519	5	3.52
QF	Poaceae	*Eragrostis tremula*	2.053	3	1.23
VHQF	Poaceae	*Dactyloctenium aegyptium*	2.346	5	2.35
NP	Fabaceae	*Cassia mimosoides*	1.76	0	0
QF	Fabaceae	*Brachiarria distitichophylla*	0.293	3	0.18
QF	Lamiaceae	*Leucas martinicensis*	1.173	3	0.7
VLQF	Rubiaceae	*Spermacoce Stachydea*	1.173	1	0.23
QF	Fabaceae	*Indigofera diphylla*	1.466	3	0.88
HQF	Poaceae	*Brachiaria mutica*	1.173	4	0.94
QF	Fabaceae	*Tephrosia linearis*	0.293	3	0.18
VLQF	Molluginaceae	*Mollugo cerviana*	0.587	1	0.12
VLQF	Lamiaceae	*Hyptis suaveolens*	0.587	1	0.12
QF	Tiliaceae	*Corchorus olitorius*	0.587	3	0.35
NP	Fabaceae	*Indigofera tinctoria*	0.293	0	0
LQF	Fabaceae	*Cassia Tora*	0.293	2	0.12
VLQF	Amaranthaceae.	*Achyranthes aspera*	1.173	1	0.23
QF	Commelinaceae	*Commelina forskalaei*	2.933	3	1.76
QF	Pedaliaceae	*Ceratotheca sesamoides*	0.293	3	0.18

HQF	Poaceae	*Panicum Laectum*	0.293	4	0.23
NP	Malvaceae	*Sida alba*	0.293	0	0
LQF	Poaceae	*Aristida mutabilis*	0.293	2	0.12
QF	Poaceae	*Digitaria exilis*	0.293	3	0.18
HQF	Poaceae	*Brachiaria ramosa*	1.466	4	1.17
HQF	Poaceae	*Andropogon gayanus*	1.173	3	0.7
QF	Poaceae	*Aristida adscensionis*	1.466	3	0.88
NP	Convolvulaceae	*Evolvulus alsinoides*	1.76	0	0
QF	Fabaceae	*Indigofera astragalina*	1.466	3	0.88
NP	Acanthaceae	*Monechma ciliatum*	0.293	0	0
NP	Fabaceae	*Indigofera colutea*	0.293	0	0
VLQF	Amaranthaceae	*Amaranthus graecizans*	0.293	1	0.06
QF	Convolvulaceae	*Jacquemontia tamnifolia*	1.76	3	1.06
VHQF	Poaceae	*Cenchrus prieurii*	0.587	5	0.59
NP	Fabaceae	*Cassia italica*	0.293	0	0
QF	Convolvulaceae	*Digitaria ciliaris*	1.466	3	0.88
LQF	Cucurbitaceae	*Cucumis melo*	0.293	2	0.12
LQF	Amaranthaceae	*Pandiaka heudelotii*	0.587	2	0.23
VLQF	Fabaceae	*Tephrosia lupinifolia*	0.587	1	0.12
NP	Convolvulaceae	*Ipomoea asarifolia*	0.293	0	0
NP	Cucurbitaceae	*Citrillus colocynthis*	0.587	0	0
VLQF	Aizoaceae	*Limeum pterocarpum*	0.293	1	0.06
LQF	Solanaceae	*Physalis angulata*	0.293	2	0.12
NP	Phyllanthaceae	*Phyllanthus amarus*	0.587	0	0
NP	Malvaceae	*Sida ovata*	0.293	0	0
NP	Apocynaceae	*Pergularia tomentosa*	0.293	0	0
HQF	Poaceae	*Eragrostis ciliaris*	0.587	4	0.47
VLQF	Amaranthaceae	*Amaranthus spinosus*	0.587	1	0.12
NP	Amaryllidaceae	*Crinum ornatum*	0.293	0	0
LQF	Capparidaceae	*Cleome viscosa*	0.293	2	0.12
					50.6

Sida cordifolia **and** ***Schizachyrium exile*** **herbage plant community (G4)** ***d*****iversity**

The community constitutes 22 plots and 47 species (Table 8), and is less diverse in terms of the number of species, but largest than community 3 and 5 in terms of the number of plots. This community is characterized by *Sida cordifolia and Schizachyrium exile* with 48.8 and 17.6 of Indicator Value respectively (Table 7).

In terms of frequency, *Sida cordifolia* was the most frequent and abundant species and is present in 95.45% of the plots of this community with an average recovery of 24%. The Shannon diversity index and evenness indices of this community were 0.22 bits and 0.04 (Table 8) respectively. This indicated very low species diversity and uniform distributions among the species in this community. This low diversity in the plant community can be linked to the low average recovery of the invasive species (*Sida cordifolia*).

Therophytes are the largest life form of this community with 37 species and contributes to 78.72% of the total herbage flora. They are followed by Chamephytes with 4 species 8.51%

and Phanerophytes with 3 species 6.38%. In contrast, Geophytes and Hemicryptophytes are less represented (Figure 7).

With regards to geographical distribution, Pantropical (17 species, 36.17%) and Paleotropical (12 species, 25.53%) are the most dominant in this community. They are followed by Sudano Zambezian (6 species, 12.76%) and Pluri regional (5 species 10.63 %). Africa Tropical and Sudanese are codominant with 3 species each (Figure 8).

Productivity, Pastoral Value and Carrying Capacity

Within this community, *Sida cordifolia* has the highest dry biomass value 293kg/ha with (70%) of the total produced by the community. It was followed by other forage species with 85.85kg/ha (20.21%). The other categories have low productivity with 8.92% and 1.87% respectively for grasses and legumes (Figure 9). The community was characterized by the lowest carrying capacity of 0.13 TLU/ha/year in the study area and low value of pastoral value of 38 (Table 5). This was due to the higher value species relative abundance of *Sida cordifolia* 12 .7, *Cassia mimosoides* 10.9 and *Fimbristylis hispidula* 6.06 that are not palatable and the quality Index of each one which was nil (I S= 0). It could also be confirmed by the lowest dry biomass produced by other species, such as grasses, legumes and other fodder species with 30 % of the total production within the community.

Table 5: Specific Frequency (SF), Species Relative Abundance (SRA), Specific Index of Quality (IS) and Pastoral Value (PV) and Carrying Capacity (CC) of *Sida Cordifolia* and *Schizachyrium exile* Herbage Plant Community

				CC (TLU/ha/year)			0.13
P S	L F	IS	Families	species	RAS	IS	VP
PA	Th	VHQF	Fabaceae	*Zornia glochidiata*	2.42	5	2.4
Pan	Th	VHQF	Fabaceae	*Desmodium hirtum*	0.61	5	0.6
Pan	Ch	NP	Malvaceae	*Waltheria indica*	2.42	0	0
Pal	Th	HQF	Poaceae	*Tripogon minimus*	1.21	4	1
Pan	Gr	VLQF	Cyperaceae	*Cyperus rotundus.*	1.82	1	0.4
AT	Th	NP	Rubiaceae	*Mitracarpus scaber*	1.82	0	0
S	Th	NP	Cyperaceae	*Fimbristylis hispidula*	6.06	0	0
Pan	CH	NP	Malvaceae	*Sida cordifolia*	12.7	0	0
PA	Th	NP	Asteraceae	*Acanthospermum hispidium*	0.61	0	0
Pan	CH	LQF	Poaceae	*Aristida longiflora*	2.42	4	1.9
PA	Th	VLQF	Rubiaceae	*Spermacoce filifolia*	0.61	1	0.1
SZ	Th	VLQF	Rubiaceae	*Spermacoce radiata*	0.61	1	0.1
Pal	Th	LQF	Commelinaceae	*Commelina benghalensis*	2.42	2	1
Pal	Th	QF	Phyllanthaceae	*Phyllanthus pentandrus*	0.61	3	0.4
SZ	Th	QF	Poaceae	*Brachiaria xantholeuca*	1.82	3	1.1
Pan	Th	HQF	Poaceae	*Pennisetum pedicellatum*	0.61	4	0.5
S	LTh	QF	Convolvulaceae	*Ipomoea vagans*	0.61	3	0.4
Pan	G	VLQF	Cyperaceae	*Cyperus difformis*	1.21	1	0.2
AT	Th	LQF	Poaceae	*Digitaria gayana*	2.42	2	1
Pal	Th	QF	Tiliaceae	*Corchorus tridens*	0.61	3	0.4
PA	LTh	NP	Curcubitaceae	*Citrullus lanatus*	0.61	0	0
SZ	Th	VLQF	Rubiaceae	*Spermacoce scabra*	4.85	1	1
Pal	Th	VHQF	Poaceae	*Cenchrus biflorus*	7.88	5	7.9

Pan	Th	VHQF	Fabaceae	*Alysicarpus ovalifolius*	2.42	5	2.4
Pan	Th	QF	Poaceae	*Eragrostis tenella*	6.67	3	4
Pal	Th	VHQF	Poaceae	*Dactyloctenium aegyptium*	0.61	5	0.6
Pal	Th	NP	Fabaceae	*Cassia mimosoides*	10.9	0	0
Pal	Th	QF	Lamiaceae	*Leucas martinicensis*	1.21	3	0.7
SZ	Th	VLQF	Rubiaceae	*Spermacoce Stachydea*	0.61	1	0.1
Pal	Th	QF	Fabaceae	*Indigofera diphylla*	0.61	3	0.4
Pal	Th	HQF	Poaceae	*Brachiaria mutica*	1.82	4	1.5
Pan	Th	VLQF	Lamiaceae	*Hyptis suaveolens*	0.61	1	0.1
AT	LTh	QF	Convolvulaceae	*Merremia pinnata*	1.82	3	1.1
AM	Th	QF	Fabaceae	*Sesbania pachycarpa*	1.21	3	0.7
Pan	Nnph	LQF	Fabaceae	*Cassia Tora*	0.61	2	0.2
Pan	Th	VLQF	Amaranthaceae.	*Achyranthes aspera*	0.61	1	0.1
Pal	Th	QF	Commelinaceae	*Commelina forskalaei*	2.42	3	1.5
PA	Th	QF	Pedaliaceae	*Ceratotheca sesamoides*	1.21	3	0.7
SZ	Th	QF	Poaceae	*Oryza barthii*	0.61	3	0.4
S	H	QF	Poaceae	*Andropogon gayanus*	0.61	3	0.4
Pan	Th	QF	Poaceae	*Aristida adscensionis*	3.64	3	2.2
Pan	Th	NP	Convolvulaceae	*Evolvulus alsinoides*	0.61	0	0
Pan	LCH	NP	Convolvulaceae	*Ipomoea asarifolia*	1.21	0	0
SZ	Th	NP	Fabaceae	*Indigofera astragalina*	0.61	3	0.4
Pal	NnPh	NP	Amaranthaceae.	*Aerva javanica*	0.61	0	0
AT	Th	NP	Acanthaceae	*Monechma ciliatum*	1.21	0	0
Pan	NnPh	NP	Euphorbiaceae	*Chrozophora brocchiana*	0.61	0	0
Total							38

Sida cordifolia and *Cenchrus biflorus* herbage plant community (G5) diversity

The community was established from 6 plots and 55 species recorded (Table 8). This community is the smallest in terms of plot number and is characterized by presence of *Cenchrus biflorus, Cassia mimosoides, Eragrostis tremula* and *Sida alba*. *Sida cordifolia* (100%) was present in all records and was the most frequent. The Shannon diversity index and evenness indices of this community were 0.30 bits and 0.1 (Table 8) respectively which indicated significant low species diversity and dominance of few species. The diversity of this community was relatively low compared to others communities.

In terms of life form, the analysis of the Figure 11indicates that this community was widely dominated by Therophytes with 43 species (78%) of the total herbage. They were followed by Geophytes with 4 species (7.27%), Chamephytes and Phanerophytes in codominance with 3 species each (Figure 7).

The geographical distribution shows that Pantropical with 22 species (40%) was the most dominant of this community, followed by Paleotropical with 13 species (24%), Pluri-regional and Sudano Zambezian in codominance with 5 species (9%) each. There was also Africa Tropical and Sudanese in codominance with 3 species (5%) each, and Cosmopolitan 2 species (4%). The types are represented by only one species (Figure 8).

Productivity, Pastoral Value and Carrying Capacity

Sida cordifolia presents 40.41% (246.97 kg/ha) of the total dry biomass produced by this community. It was followed by grasses 32.38% (197.88 kg/ha), legumes 22.8% (139.35kg/ha) and other forage species 4.41% (27kg/ha) (Figure 9). This community has low value of carrying capacity 0.18TLU/ha/year and medium value of pastoral value 48.6 (Table 6). This can be explained by the high productivity of other species 60% of the total and the high species relative abundance of some fodder species, such as *Oryza barthii 5.26 Dactyloctenium aegyptium*, *Eragrostis tremula* and *Zornia glochidiata* 4.21 each, *Desmodium hirtum* and *Panicum laectum* 3.15 each.

Table 6: Species Relative Abundance (SRA), Specific Index of Quality (IS), Pastoral Value (PV) and of *Sida cordifolia* and *Cenchrus biflorus* herbage plant community

				CC (TLU/ha/year			0.18
P S	LF	IS	Families	Species	SRA	IS	VP
PA	Th	VHQF	Fabaceae	*Zornia glochidiata*	4.211	5	4.21
Pal	H	HQF	Poaceae	*Eragrostis tremula*	4.211	4	3.37
Pan	Th	VHQF	Fabaceae	*Desmodium hirtum*	3.158	5	3.16
Pan	Ch	NP	Malvaceae	*Waltheria indica*	2.105	0	0
Pal	Th	LQF	Poaceae	*Tripogon minimus*	2.105	4	1.68
Pan	Gr	VLQF	Cyperaceae	*Cyperus rotundus*	3.158	1	0.63
AT	Th	NP	Rubiaceae	*Mitracarpus scaber*	1.053	0	0
S	Th	NP	Cyperaceae	*Fimbristylis hispidula*	2.105	0	0
Pan	CH	NP	Malvaceae	*Sida cordifolia*	6.316	0	0
Pan	CH	LQF	Poaceae	*Aristida longiflora*	2.105	4	1.68
Pal	Hy	VHQF	Poaceae	*Echinochloa colona*	2.105	5	2.11
PA	Th	VLQF	Rubiaceae	*Spermacoce filifolia*	1.053	1	0.21
S	Th	VHQF	Poaceae	*Diheteropogon hagerrupii*	1.053	5	1.05
SZ	Th	QF	Poaceae	*Brachiaria xantholeuca*	3.158	3	1.89
Pan	Th	VHQF	Poaceae	*Digitaria horizontalis*	2.105	5	2.11
Pan	Th	LQF	Poaceae	*Aristida mutabilis*	1.053	2	0.42
Pan	Th	HQF	Poaceae	*Pennisetum pedicellatum*	1.053	4	0.84
S	LTh	QF	Convolvulaceae	*Ipomoea vagans*	1.053	3	0.63
Pan	G	VLQF	Cyperaceae	*Cyperus difformis*	1.053	1	0.21
AT	Th	LQF	Poaceae	*Cenchrus biflorus*	4.211	2	1.68
Pal	Th	QF	Tiliaceae	*Corchorus tridens*	2.105	3	1.26
PA	LTh	NP	Curcubitaceae	*Citrullus lanatus*	1.053	0	0
SZ	Th	VLQF	Rubiaceae	*Spermacoce scabra*	1.053	1	0.21
Pal	Th	VHQF	Poaceae	*Dactyloctenium aegyptium*	4.211	5	4.21
Pal	Th	NP	Fabaceae	*Cassia mimosoides*	1.053	0	0
Pal	Th	QF	Lamiaceae	*Leucas martinicensis*	1.053	3	0.63
Pan	G	NP	Amaryllidaceae	*Allium tricoccum*	1.053	0	0
Pan	Th	NP	Malvaceae	*Sida Urens*	1.053	0	0
Pal	Th	LQF	Poaceae	*Brachiaria mutica*	1.053	4	0.84
SZ	Th	QF	Fabaceae	*Tephrosia linearis*	1.053	3	0.63
Pal	Th	VLQF	Molluginaceae	*Mollugo cerviana*	1.053	1	0.21
AT	LTh	QF	Convolvulaceae	*Merremia pinnata*	1.053	3	0.63
AM	Th	QF	Fabaceae	*Sesbania pachycarpa*	1.053	3	0.63

Pal	Th	QF	Tiliaceae	*Corchorus olitorius*	1.053	3	0.63
PA	NnPh	NP	Fabaceae	*Indigofera tinctoria*	1.053	0	0
PRA	Th	VLQF	Amaranthaceae	*Celosia trigyna*	1.053	1	0.21
Pal	Th	QF	Commelinaceae	*Commelina forskalaei*	2.105	3	1.26
SZ	Th	LQF	Poaceae	*Panicum Laectum*	3.158	4	2.53
Pan	Th	NP	Amaranthaceae.	*Gomphrena celosioides*	1.053	0	0
SZ	Th	NP	Poaceae	*Oryza barthii*	5.263	3	3.16
Pan	Th	NP	Molluginaceae	*Trianthema portulacastrum*	1.053	0	0
Pan	Th	NP	Malvaceae	*Sida alba*	1.053	0	0
Pan	Th	VLQF	Zygophyllaceae	*Tribulus terrestris*	1.053	1	0.21
AT	Th	QF	Poaceae	*Aristida Stipoides*	3.158	3	1.89
Pan	Th	QF	Poaceae	*Digitaria exilis*	2.105	3	1.26
Pal	Th	NP	Acanthaceae	*Peristrophe bicalyculata*	1.053	0	0
Pan	Th	NP	Convolvulaceae	*Evolvulus alsinoides*	1.053	0	0
Pan	NnPh	NP	Euphorbiaceae	*Chrozophora brocchiana*	1.053	0	0
Pal	Th	NP	Fabaceae	*Indigofera colutea*	1.053	0	0
Cos	Th	VLQF	Amaranthaceae	*Amaranthus graecizans*	1.053	1	0.21
AA	LTh	QF	Convolvulaceae	*Jacquemontia tamnifolia*	1.053	3	0.63
Pan	Th	VHQF	Poaceae	*Cenchrus prieurii*	1.053	5	1.05
Pan	Th	LQF	Amaranthaceae	*Pandiaka heudelotii*	1.053	2	0.42
Pan	Gr	NP	Amaryllidaceae	*Crinum ornatum*	1.053	0	0
Cos	NnPh	NP	Solanaceae	*Datura innoxia*	1.053	0	0
							48.6

Table 7 presents the summary of characteristics species in the five herbage plants communities in the rangelands invaded by *Sida cordifolia*. It showed that the community G1 was characterized by *Sida cordifolia* and *Zornia glochidiata (*56.5 IV) which has the greatest Indicator Value (IV). Others characteristic species of this community are *Tripogon minimus (*35.3 IV), and *Triumfetta pentandra (*15.9 IV).

Plant community G2 was characterized by *Echinochloa colona*, *Aristida longiflora Desmodium hirtum, Alysicarpus ovalifolius, Commelina forskalaei* and *Brachiaria xantholeuca* with 55.9, 42.6, 40.4, 26.8, 24.4, and 24.2 of species Indicator Value respectively. The characteristic species of the herbage plant community G3 were *Oryza barthii, Aristida stipoides, Panicum laectum, Dactyloctenium aegyptium, Brachiaria xantholeuca, Digitaria nuda, Eragrostis tenella* and *Digitaria exilis* with 81.9, 46.6, 45.0, 43.3, 37.9, 34.4, 34.3 and 18.8 of Indicator Value respectively. The herbage plant community was characterized by *Sida cordifolia and Schizachyrium exile* with 48.8 and 17.6 of Indicator Value respectively. The G5 herbage community was characterized by presence of *Cenchrus biflorus, Cassia mimosoides, Eragrostis tremula* and *Sida alba*. (Table 7)

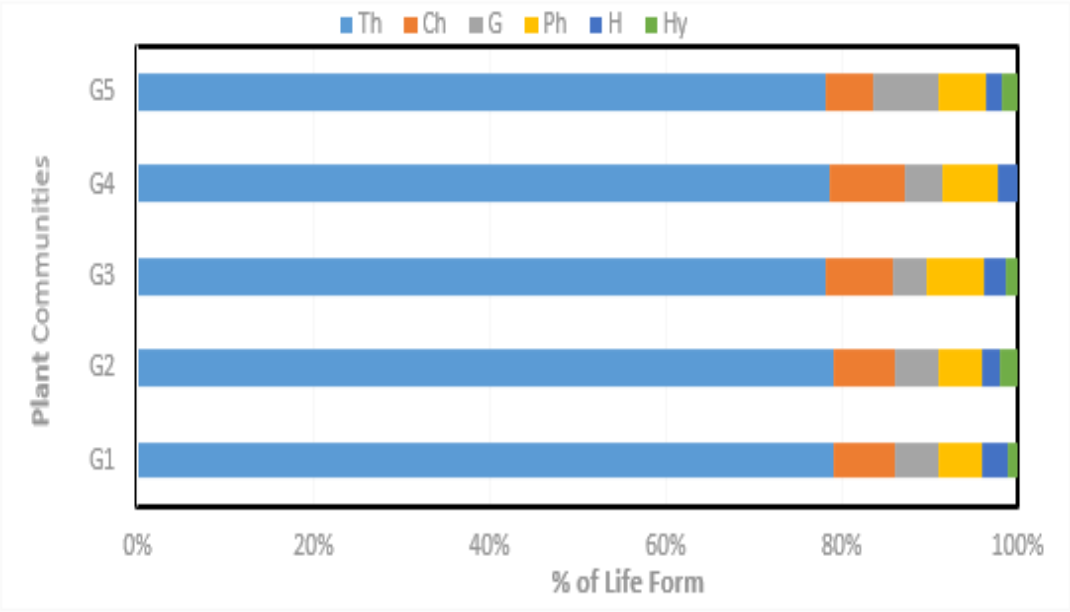

Figure 7: Life Form Spectrum of the Plant Communities Invaded by *Sida cordifolia* (Raunkiaer 1934) (Th: Therophytes; Ph: Phanerophytes; CH: Chamephytes; H: Hemicryptophytes; G: Geophytes; Hy: Hydrophytes)

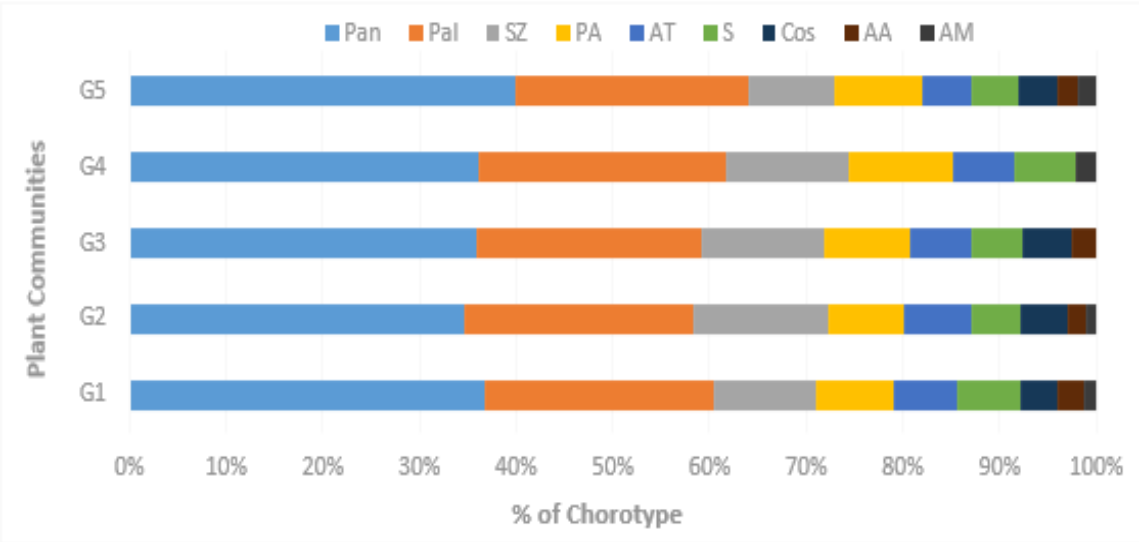

Figure 8: Chorotypes Spectrum of the Plant Communities Invaded by *Sida cordifolia* (White 1986). (AA: African-American; AM: Afro-malagasy; AT: Tropical Africa; Cos: Cosmopolitan; GC: Guinean-congolese; Pal: Paleotropical; Pan: Pantropical; PA: Pluri-regional; S: Sudanese; SZ: sudano-zambezians)

Table 7: Characteristics Species of Herbage Plant Communities in Rangelands Invaded by *Sida cordifolia*

Characteristics Species	R F (%)	I V (%)	P-Value
***Sida cordifolia* and *Zornia glochidiata* Herbage Plant Community (G1)**			
Zornia glochidiata	94	56.5	0.0002
Sida cordifolia	94	-	-
Tripogon minimus	71	35.3	0.0142
Triumfetta pentandra	18	15.9	0.0170
***Sida cordifolia* and *Echinochloa colona* Herbage Plant Community (G2)**			
Echinochloa colona	41	55.9	0.0014
Sida cordifolia	100	-	-
Aristida longiflora	61	42.6	0.0032
Desmodium hirtum	31	40.4	0.0076
Alysicarpus ovalifolius	39	26.8	0.0412
Commelina forskalaei	20	24.4	0.0490
Brachiaria xantholeuca	24	24.2	0.0382
***Sida cordifolia* and *Oryza barthii* Herbage Plant Community (G3)**			
Oryza barthii	17.7	81.9	0.0002
Sida cordifolia	95	-	-
Aristida Stipoides	20	46.6	0.0002
Panicum Laectum	5	45.0	0.0028
Dactyloctenium aegyptium	40	43.3	0.0008
Eragrostis tenella	35	49.7	0.0010
Digitaria exilis	5	18.8	0.0168
***Sida cordifolia* and *Schizachyrium exile* Herbage Plant Community (G4)**			
Sida cordifolia	95	48.8	0.0002
Schizachyrium exile	50	17.6	0.0408

Table 8: Diversity, Pielou evenness Indexes, and Average Recovery of herbage plant communities in rangelands invaded by *Sida cordifolia*

Plant Communities	G1	G2	G3	G4	G5
Number of Plots	17	51	20	22	6
Number of Species	76	102	78	47	55
Shannon index (H)	0.25	0.24	0.22	0,22	0.39
Pielou evenness	0.04	0.04	0.03	0.04	0.1
Average Recovery of *S. cordifolia* %	17	54	12.8	24	22.3

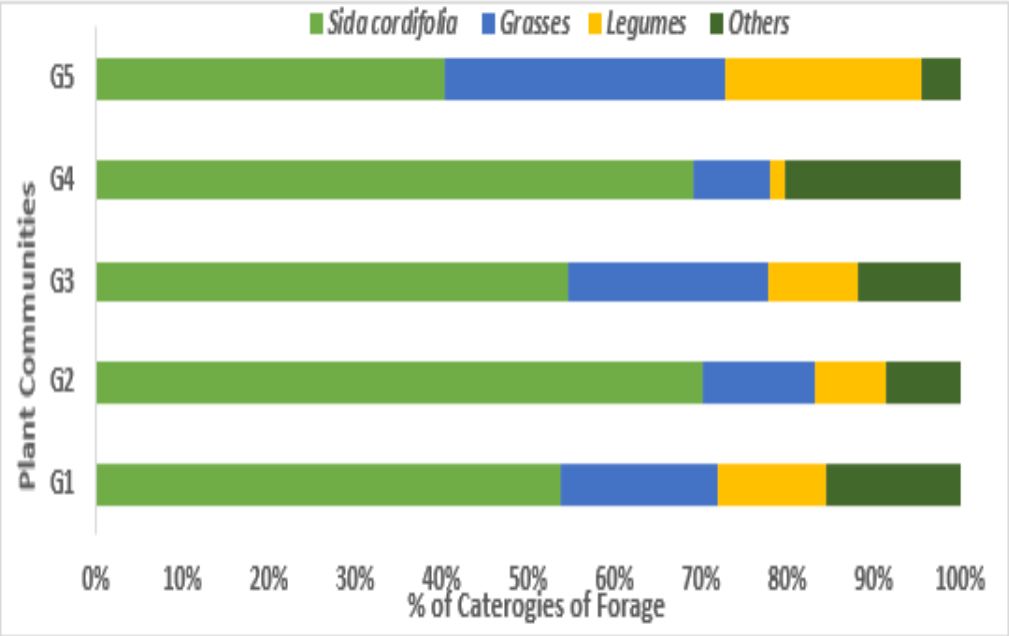

Figure 9: Dry Biomass of Forage Categories of Herbage Plant Communities in Rangelands Invaded by *Sida cordifolia*

G1= *Sida cordifolia* and *Zornia glochidiata* Herbage Plant Community
G2= *Sida cordifolia* and *Echinochloa colona* Herbage Plant Community
G3= *Sida cordifolia* and *Oryza barthii* Herbage Plant Community
G4= *Sida cordifolia* and *Schizachyrium exile* Herbage Plant Community
G5= Sida cordifolia and *Cenchrus biflorus* Herbage Plant Community

DISCUSSION

A total 113 herbaceous species belonging to 25 families and 74 genera were recorded in the rangelands invaded by *Sida cordifolia.* Barmo *et al. (*2020) reported 132 herbaceous species in the Baban Rafi (Maradi) although, the number of plots (126) is greater in this study than in that these authors (105 plots). This difference may be due to the invasion of *Sida cordifolia* therefore, shade created by the foliage of this species could be one of the major reasons for the reduction in the number of species. The Shannon diversity and evenness indexes of these rangelands were very low, the low value of the Shannon index indicated that the environment is unfavourable to floristic diversity and the low Evenness indicated unequal distribution of plant species and dominance of few species. The unequitable distribution of species has probably favoured the proliferation of *Sida cordifolia*. The invasive species pose a major threat to the diversity of these rangelands moreover, the other reason is that the pressure exerted on many plant species, mainly fodder plants in the study area.

The most dominant family were Poaceae with 31 species (27.43%), followed by Fabaceae (14 species, 12.39%), Malvaceae (10 species, 9%). These results were similar than that of Fada (2022) in the study area who reported that Poaceae was the most abundant family, followed by Fabaceae respectively 21.03% and 18.22% of the total plant species. This greatest species diversity of Poaceae family in the study area could be due to the production of a large number

of reproductive seeds and the many means of seed dispersion through grazing animals, fluvial water, and air (Saleem *et al.,* 2024). Poaceae taxa have a high tilling potential and a high regrowth rate after grazing if environmental conditions are favourable (Baudoin *et al.,* 2020) therefore, Poaceae species have adaptations that allows them to remain in existence and even have some positive effects from grazing stress and drought. This adaptation pertains to an ample network of shallow highly ramified roots allowing them to efficiently absorb moisture from the soil (Shaye *et al.,* 2020).

The abundance of Poaceae could indicate the low quality of fodder just after the period of maximum biomass. This predominance could be the cause of the fodder deficit during the dry season because some of them are short-cycle plants (Sarambé *et al.,* 2020), and this is also an adaptation that allows them to endure and getting benefit from the stress caused by grazing and drought.

The assessment of life form spectrum indicates that the most dominant life forms were Therophytes, 76%. The Therophytes' life form is usually associated with low precipitation and short vegetative growth seasons that are prevalent on distributed habitats, thus increases the percentage of therophytes (Haq *et al.*, 2021). Therefore, this predominance of Therophytes over other life forms could be response to hyper arid climate with insufficient rainfall and the nature of region of few available microhabitats that can support high percentage of perennials (Shaye *et al.,* 2020). The dominance of Therophytes indicated that the study area is under immense anthropogenic pressure and an accelerated rate of deforestation (Manan *et al.,* 2022). It also indicated that the vegetation has been slightly disturbed due to heavy grazing.

In all the herbage plant communities studied, species with wide distribution (51.68%) are more abundant than species with continental distribution (48.25). The strong dominance of these widely distributed species (Paleotropical, Pantropical) is an indication of ecosystem disturbance.

The production of fodder within the five herbage plants communities varied from 424.83 kg/ha to 730.98 kg/ha within the study area.This was lower than the one found by Aboh (2008) in Benin, which is 3637 kg /ha to 5622 kg/ha; Soumana (2011), which is 1.38 ± 0.62 t/ha; Mamoudou *et al*. (2020), which is 0.48±0.17t/ha ; Alhassane *et al. (*2017), and Idrissa *et al.* (2020), which is 3.4 tons MS/ha. This difference could be explained by the abundance of *Sida cordifolia* that is not or very poorly palatable for animals.

Therefore, the carrying capacity were lower than those reported by these authors. The low CC in this herbage community was linked to the low biomass productivity of forage species such as grasses and legumes and the high one to the invasive plant *Sida cordifolia.*

In terms of pastoral value, the five herbage plants communities could be classified in two categories according the pastoral value interval defined by Nicoara *et al.,* (2020). Communities G4, G1, G2 and G5 have medium quality and community G3 has good quality. The quality condition of G2, G1, G4 and G5 could be explained by both natural and anthropogenic factors. The anthropogenic factors included overgrazed, which can have irreversible effects on the quality of pasture such as reducing the quality of livestock products, plant species diversity,

increased dominance of no palatable species (*Sida cordifolia, Waltheria indica, Mitracarpus scaber, Cassia mimosoides, Triumfetta pentandra, Evolvulus alsinoides Fimbristylis hispidula Acanthospermum hispidium Alternanthera nodiflora).*

In Niger Republic, the livestock sector is currently facing several problems ranging from the decline of forage species to the degradation of pastures. One of the causes of this regression is the proliferation of invasive species, such as *Sida cordifolia*. The invasion of pastures by *Sida cordifolia* has been noted in previous studies [Alhassane *et al.* (2017); Alhassane *et al.* (2018) and Alhassane *et al*. (2020)]. This dominant species in the pastures have no fodder value and become invasive and lead to the degradation of these pastures. Therefore, *Sida cordifolia* reduces the productivity and fodder value of pastures. The development of this species is favored by its strong capacity for diffusion by the winds and the movement of animals and runoff water. The dominance of a plant species in a plant community may be caused by negative interactions, such as competition or allelopathic effects (Huerta-Martínez *et al*. 2004). Through its capacity to occupy the environment, *Sida cordifolia* stifles and neutralizes other species, reducing both their density and their diversity (Figure 10). The proliferation of *Sida cordifolia* and its high productivity from 246.97 to 392.6 kg of dry matter/ha (about 40.4 - 70.20% of the total) leads to a great reduction in the biomass of other forages species. Thus, the pastures invaded by *Sida cordifolia* have lowest pastures value (Alhassane *et al*. 2018). Such a situation is a major blow to livestock, which is essentially extensive in the study area and contributes significantly to the local and national economy.

In view of its rapid spread, its capacity of proliferation and the enormous loss of herbaceous fodder in the area, the continuity of the development and invasion of *Sida cordifolia* (Figure 10) in the pastures will have a negative impact on livestock.

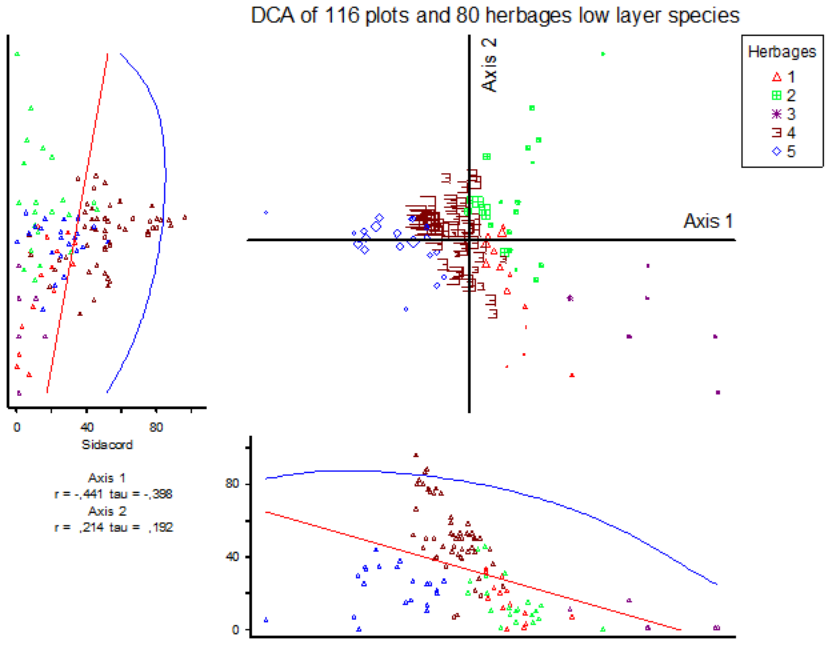

Figure 10: Overlay diagram showing the distribution of *Sida Cordifolia* on first and second axes

CONCLUSION

This study identified 113 species of herbaceous plants belonging to 25 families and 74 genera in the rangelands invaded by *Sida cordifolia*. The most dominant family in terms of species number was Poaceae followed by Fabaceae and Malvaceae but in terms of abundance *Sida cordifolia* was the most abundant species.

Hierarchical Ascendant Classification allowed to discriminate five (5) different groups of herbage plant communities. All the plant herbage plant communities are characterised by high dry matter production of *Sida cordifolia,* low pastoral value and low carrying capacity. These rangelands are beginning to deteriorate as a result of human pressures which can have irreversible effects on the quality of rangelands such as reducing plant species diversity, increased dominance of no palatable species (*Sida cordifolia, Waltheria indica L, Mitracarpus scaber, Cassia mimosoides, Triumfetta pentandra, Evolvulus alsinoides Fimbristylis hispidula Acanthospermum hispidium Alternanthera nodiflora)* and therefore, decreased the quality of livestock products. This is reflected in the low productivity and low carrying capacity of the Rangelands. The low pastoral value is explained by a low contribution from species with good pastoral value and a high contribution from *Sida cordifolia* with no pastoral value.

Since the invasion of *Sida cordifolia* reduces the diversity, introducing species with good fodder quality through seeding can help to improve both the productivity and the pastoral value of the rangelands.

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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