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Degradation of Edible Woody Species Consumed during Periods of Food Shortage and Their Preferences among the Local Population in the Sudano-Sahelian Zones of Niger, West Africa Sahel

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

In Niger, forest formations constitute a source and a potential reservoir of food products for the populations who use them especially during periods of low food availability. Very little research has been carried out on the woody food species of these formations which contribute enormously to the management of the food gap. This study aimed to fill this gap. It was carried out in two agro-ecological zones of Niger and has the overall objective of providing better knowledge on the ecology of the species as well as on the local perception of their conservation status in the southwest of Niger. The information was collected using a semi-structured questionnaire supplemented by interviews with key informants and preferential classification exercises of the species used. The results show that in total, 37 species are cited as food providers during the periods of food shortage by the local populations, including 26 woody food species in the Sudanian zone, 17 in the Sahelian zone and 11 species common to both zones. The most consumed organs are leaves (39.2% and 43.5%) and fruits (28.8% and 25.5%), respectively in the Sudanian zone and the Sahelian zone. Some collect them from vegetation relics such as savannahs and agrosystems, while others obtain supplies from local markets. Among the species recorded, the most preferred in the Sudanian zone are *Adansonia digitata, Vitellaria paradoxa, Tamarindus indica and Parkia biglobosa* and those preferred in the Sahelian zone are *Maerua crassifolia, Boscia senegalensis,* and *Balanites aegyptiaca.* However, threats have been reported for *Adansonia digitata, Vitellaria paradoxa, Maerua crassifolia, Boscia senegalensis* and *Balanites aegyptiaca* and the factors involved are uncontrolled exploitation, droughts, browsing of young shoots. The results of this study constitute a database to assess the availability and the evolutionary trend in terms of threat of the species widely used in the locality.

Keywords: Degradation; priority species; exploitation; food shortage; regeneration; wild edible species.

1. INTRODUCTION

Located in West Africa, Niger covers an area of 1,267,000 km² between 12° and 23° North latitude, 00°16' and 16° East longitude. The territory has a relatively flat relief, made up of low plateaus and plains, with some high plateaus reaching up to 2000 m in altitude in its northern part.

The climate is tropical arid in the southern band, and desert in the northern part of the country. The rainfall is characterized by a very high temporal and spatial variability and a tendency towards aridification perceptible through the sliding of the isohyets towards the south. Its economy is dominated by subsistence productions such as agriculture, livestock and fishing with a rural population of more than 80%, depending on more than 90% of natural resources for the satisfaction of its vital needs (Shirsat et al., 2024).

In recent decades, the country has been facing an acute food crisis, which has become recurrent due to the combined effects of human actions and fluctuating climatic factors, including recurrent droughts PANA (2006).

Low rainfall combined with poor soils lead to poor harvests that do not cover the food needs of rural households throughout the year (SP/CPSA, 2003; Janin, 2004). Added to this is a degradation of biodiversity on which the well-being of rural people depends. We are witnessing a situation of increasing impoverishment of natural productive capital and an intensification of desertification. Rural households frequently experience food deficits, especially at the beginning of the rainy season, extending until the new harvests. This period known as the "food lean season" (Millogo-Rasolodimby, 2001; Janin, 2004) forces rural populations to resort to the use of many wild plant species such as *Boscia senegalensis* almonds, *Maerua crassifolia* leaves, *Panicum laetum* (wild fonio) to cover their nutritional needs. The consumption of these plants, in addition to their nutritional importance, can help, due to their composition, to avoid problems of nutritional deficiencies. Given the importance of certain species for rural populations during lean times and to enable their sustainable exploitation, it is important to have scientific data on their status. The present study conducted in two agro-ecological zones through surveys aims to identify the woody lean season food plants

and their degrees of preference in food, and the local perception of the threats weighing on them.

2. MATERIALS AND METHODS

The study area: The study was conducted in four villages located in the rural communes of Tamou, Department of Say and Tondikiwindi, Department of Ouallam. These villages were chosen based on agro-ecological zones, the general physiognomy of the environments, their history and human activities.

The rural commune of Tamou is located in the total wildlife reserve of the National Park W of Niger, between latitudes 12°28' and 12°50' North and longitudes 2°06' and 2°24' East, in the Sudanian zone (Fig. 1).

Tamou Total Wildlife Reserve (RTFT) was created in 1962 by decree No. 62-188/MER of August 8, 1962. It covers an area of 140 000 haand is located at the northern limit of the Niger National Park W (PNWN), for which it serves as a buffer zone. In 1976, following the droughts of 1973, the Niger authorities downgraded the central part to a crop zone called " *Ayinoma* ".

In the area, rainfall varies in space and time, it is a semi-arid tropical climate of the Sahelian type in the North, where rainfall is around 400 to 600 mmand a humid tropical climate of the Sudanian type in the South where the rainfall regime is around 800 mm. The highest rainfall is recorded in the month of August. The average annual temperature is around 36.7°C. The maximum average monthly temperatures are in April with 42°Cand the minimum in December and February (20°C). The relative humidity is between 23% in April (the driest month) and 80.5% in August (the wettest month) (Amadou, 2005). Two types of soils are dominant in the area, these are the little evolved soils represented by the lithosols at the level of the cuirasses, the plateaus and the depressions (ponds and valleys) (Benoit, 1998) and the very deep tropical ferruginous soils, abundant in glacis. The Commune of Tamou has important natural resources both in the protected areas and in the banal zones including the agricultural

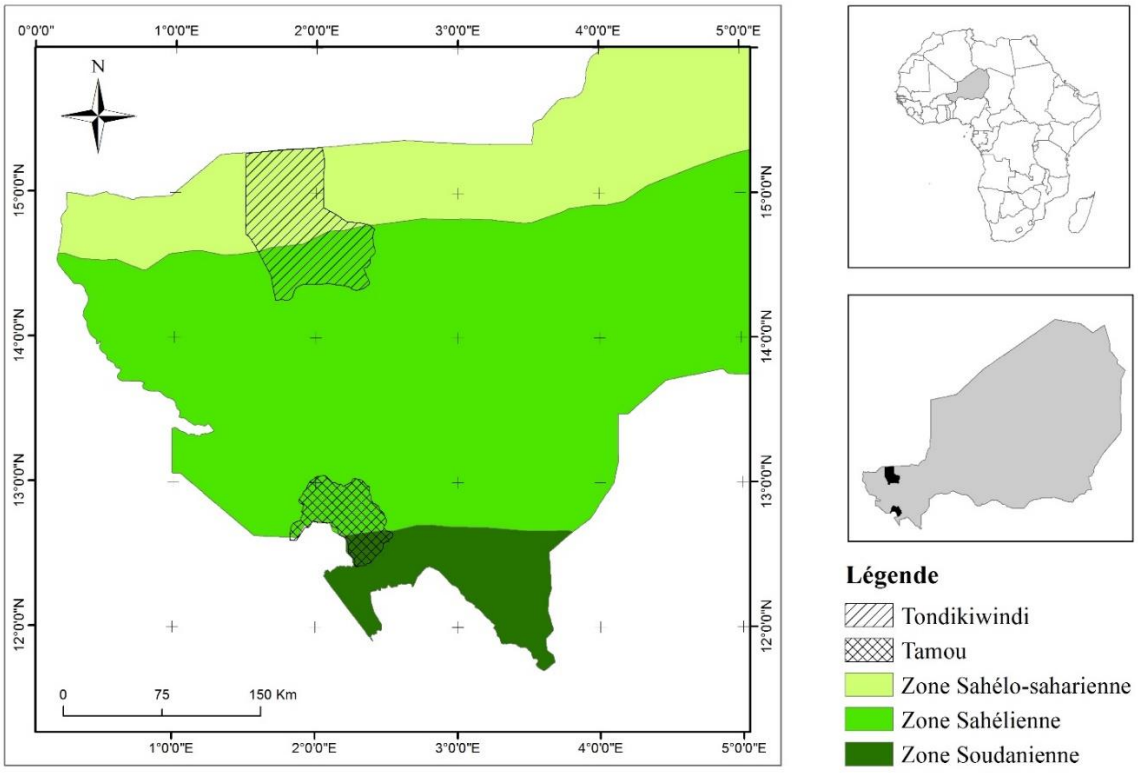

Fig. 1. Location map of the study area

lands. The flora is rich with 1068 species distributed between 340 genera and 73 families (Saadou, 1998). The vegetation is dominated by wooded savannas with *Terminalia avicenioides*, *Combretum glutinosum*, *Piliostigma reticulatum* and shrubs with *Ximenia americana*, *Boscia senegalensis*, *Cadaba farinosa*, from the forest galleries to *Anogeissus leiocarpus*, *Mitragyna inermis*, *Khaya sengalensis*, *Pterocarpus erinaceus*, along watercourses that degrade towards the North. Agroforestry parks are present on rainfed crop areas. They are the result, for the most part, either of improved clearing in fields far from homes (bush fields), or of assisted natural regeneration or plantations.

around the dwellings (house fields). The house fields are rich in woody species with edible organs or having fertilizing properties such as *Adansonia digitata, Hyphaene thebaica, Faidherbia albida*, etc. The agroforestry parks of the fields contain woody species such as Balanites *aegyptiaca, Piliostigma reticulatum, Sclerocarya birrea, Combretum nigricans, Combretum glutinosum*. The main socio-economic activity of the populations is subsistence agriculture. This agriculture, which is heavily dependent on rainfall, can no longer cover the needs of the populations. This situation forces the populations to resort to gathering, especially during periods of drought or food shortages when cereal reserves are almost non-existent.

Tondikiwindi site: The rural commune of Tondikiwindi is located between latitudes 15˚ 20 and 14˚ 16 North latitude and 1˚ 10 and 2˚ 25 East longitude, in the Sahelian zone (Fig. 1). The climate of the commune is tropical arid of the Sahelian type, with two distinct seasons, including a short rainy season (June-September) and a long dry season (October-May). Average temperatures vary from 18°C in January to 40°C in April. Average annual rainfall varies from 300 to 400 m, 350 mm, with maximum rainfall generally recorded during the month of August. The flora is also affected by climate change. Several species of trees and shrubs such as *Acacia nilotica, Acacia tortilis, Faidherbia albida, Balanites aegyptiaca, Guiera senegalensis, Combretum micranthum, Combretum nigricans)* and annual plants including *Cenchrus biflorus, Cassia tora*, etc. are of very low density. This vegetation is mainly impoverished by human overexploitation and runoff water, thus creating ravines or koris which reduce the land for habitation and cultivation. The Municipality of Tondikiwindi is one of the most deprived areas of Niger due not only to its isolation and poverty, but also to its extreme economic vulnerability and the almost permanent food insecurity that has been prevalent there for over 30 years. This is why the populations have developed a strategy of looking for available farmland, particularly in the canton of Tamou, department of Say, which has favorable agro-climatic conditions. Colonization movements in this canton date back to the early 1970s following the drought of 1973-74, but it was mainly during the 1980s that these migrations developed (Fig. 3). In 1982, the government of the time declassified part of the reserve to allow these immigrants to practice agriculture. This is why immigrants prefer to settle outside the host villages, in hamlets of ethnically homogeneous culture, which are called *Zarmagandey*. The people from Zarmaganda practice subsistence agriculture by reproducing the production systems as they practiced them in their areas of departure.

Methods: The surveys were conducted in four villages, namely the villages of Tondibiya and Tondikiwindi in the Tondikiwindi Commune, in the Sahelian zone; and those of Weilgorou and Senokonkogé, in the Tamou Commune, in the Sudanian zone (Table 1). As a prelude to the surveys, a field reconnaissance visit was carried out to present the subject of the survey to the populations and pre-test the questionnaires previously prepared. Since women are the collectors of the food parts of woody plants during the lean season, in each village, the surveys first involved 106 focus groups made up solely of women. The average number of women per focus group and per site is 5. After the focus group, a key respondent is isolated for other additional questions. Finally, resource persons well known in the villages for their knowledge of plants were interviewed. The information collected mainly concerned the woody species of welding, their states, the organs taken, the preferences, the threat factors, etc. With regard to the appreciation of the plants, a preferential classification was carried out to establish an order of preference between the plants. This classification consisted of assigning scores to the different plants (Belem *et al*., 2008). Each plant was assigned a score from 1 to 10 by local populations. The most important species was ranked first (1) and so on until the least important, which received a score of 10. As for the assessment of the threat, it consisted of giving points from 1 to 4 for all the woody bridging food plants to designate the level of

threat. Point 1 = plant not threatened, 2 = little threatened; 3 = threatened, 4 = very threatened.

Data analysis: The data collected on the field sheets were coded and then entered to create a database in Excel format. However, descriptive statistics were performed using Excel 2010 and SPSS 22.0 software. A median value of species cited by at least six key informants was calculated for all variables (food value, extinction, regeneration and threats). The responses obtained are then analyzed as quantitative variables based on the medians because the means do not represent the perceptions of the respondents. This method has been recommended by (Tukey, 1977), as the best way to analyze this type of data. A Principal Component Analysis was performed to test whether the preference of the species for its food value, the perception of its decline and its lack of regeneration increases the perception of the threat. The principal components were selected using Q^2 Stone- Gieser Statistics (PCA partial least Square method, NIPALS algorithm; Wold 1985). The number of components used in PCA informs about the complexity of the data and the cumulative percentage of autocorrelation (R^2X). The projection of the variables on the principal components (X- Wheights) provides information on the interdependencies between the analyzed variables. The Variance Importance in Projection (VIP, Esposito *et al.,* 2010) was used to assess the importance of independent variables to fit the model. VIP values greater than 0.8 are considered the most important to fit the model and to explain the variables studied. Statistica 10.0 was used for PCA.

3. RESULTS

Main woody food species indicated by populations: The survey allowed us to identify at the level of the Municipality of Tamou, 26 woody food species used during the lean period distributed between 23 genera and 17 families. The most represented families are: Capparaceae (3 species and 2 genera), Tiliaceae (3 species and 1 genus), Anacadiaceae (3 species and 2 genera), Caesalpinacea (3 species and 3 genera), followed by Bombacaceae (2 species and 2 genera). The most cited species in this area are: *Ziziphus mauritiana*, *Adansonia digitata*, and *Tamarindus indica.* with citation frequencies of 10.7%, 9.22% and 8.64% respectively. A Tondikiwindi, 17 edible woody food species were inventoried. These species belong to 13 genera and 10 botanical families, the most represented of which are: Capparaceae (4 species and 3 genera), Asclepiadaceae (3 species and 2 genera), Caesalpidaceae (2 species and 2 genera) and Tilliaceae (3 species and one genus) (Table 2). Among the species cited, 13 are common to both areas, the most commonly cited are *Balanites aegyptiaca, Boscia senegalensis, Sclerocarya birrea* and *Grewia bicolor* with citation frequencies of 12.8%, 10.98%, 9.76% and 9.17%.

3.1 Sources of Supply of Organs taken From Priority Species

The sources of supply of the organs of the lean food plants are diverse and vary according to the agro-ecological zones. In the Commune of Tamou, in the Sudanian zone, they come 54.83% from nature, followed by fields where these species are maintained by farmers. Plantations, markets and stocks are very little mentioned by the population. In the Commune of Tondikiwindi, they come 77.96% from nature, followed by markets. Plantations, fields and stocks are also very little mentioned at this level by the population **(**Fig. 2).

Main organs taken from the species: In general, the results of the interviews with local populations made it possible to identify the main parts frequently used to meet the food needs of the populations (Fig. 3). These are leaves, fruits, flowers, almonds, gum, etc. Leaves **are** used at 39.2% and 43.5% and fruits at 28.8% and 25.5% in the Sudanian and Sahelian zones. Flowers are those that are very little used.

Priority woody food species: The preference of woody species for welding varies according to the agro-ecological zones (Table 3). In the Commune of Tamou, in the Sudanian zone, the species most appreciated by the populations are *Adansonia digitata, Tamarindus indica, Parkia biglobosa and Vitellaria paradoxa.* with respectively the scores of 421, 382, 345 and 224. In Tondikiwindi, the most popular are *M. crassifolia*, *B. senegalensis*, *B. aegyptiaca* with scores of 371, 281, 235 and 199.

Food importance and threats to woody species: The food value and the nature of the threats depend on the woody food species and the agroecological zones. In the Sudanian zone, the most important species for food is *A. digitata* with a food value (va) of 10. It is followed by *Boscia senegalensis* which has a food value of 9. In the Sahelian zone, these are

Table 1. Characteristics of sites and number of respondents by type of survey

Agro Ecological Zones	**Sudanian**		**Sahelian**		**Total**
Region	**Tillaberi**				
Department	**Say**		**Ouallam**		
Commune	**Tamou**		**Tondikiwindi**		
Villages	**Senokonkoge**	**Weilgorou**	**Tondikiwindi**	**Tondibia**	
Location	02°22'33''	02°44'82''	02°02'10''	02º01'40''	
	12°42'33''	12°62'30''	14°18'00''	14°27'40''	
Ethnic Group	Zarma	Fulani	Zarma, Hausa	Zarma	
Number of Focus Groups	16	29	37	24	106
Number of key respondents	16	28	21	24	89

Table 2. List of woody food species indicated by populations according to the two zones

Scientific name	Surname	Sudanese zone		Sahelian Zone	
		Tamou		Tondikiwindi	
		Number of citations	Citation frequencies (%)	Number of citations	Citation frequencies (%)
Adansonia digitata L.	Bombacaceae	45	9.22	0	0
Annona senegalensis Pers.	Annonaceae	8	1.65	4	2.44
Balanites aegyptiaca (L.) Delile	Balanitaceae	38	7.82	21	12.8
Bombax costatum Pellegr. & Vuillet	Bombacaceae	3	0.62	0	0
Boscia senegalensis (Pers.) Lam. ex Poir .	Capparaceae	31	6.38	18	10.98
Cadaba farinosaForssk.	Capparaceae	8	1.65	9	5.49
Ceropegia aristolochioidesDecne.	Asclepiadaceae	**0**	0	2	1.22
Combretum nigricansLepr. ex Guill. & Perr.	Combretaceae	27	5.56	0	0
Detarium microcarpumGuill. & Perr.	Caesalpiniaceae	11	2.26	0	0
Diospyros mespiliformisHochst. ex A.DC.	Ebenaceae	22	4.53	0	0
Ficus platyphylla Delile	Moraceae	**1**	0.21	0	0
Grewia bicolorJuss .	Tiliaceae	7	1.44	15	9.15
Grewia flavescensJuss.	Tiliaceae	**1**	0.21	3	1.83
Grewia tenax (Forssk.) Flowers	Tiliaceae	**1**	0.21	0	0
Grewia villosaWilld.	Tiliaceae	**0**	0	1	0.61
Hyphaene thebaica (L.) Mart	Arecaceae	15	3.09	0	0
Lannea fruticosa (Hochst. ex A.Rich.) Engl.	Anacardiaceae	13	2.67	0	0
Lannea microcarpaEngl. & K.Krause	Anacardiaceae	30	6.17	0	0
Leptadenia arborea (Forssk.) Schweinf.	Asclepiadaceae	**0**	0	6	3.66
Leptadenia hastata (Pers.) Decne.	Asclepiadaceae	**1**	0.21	7	4.27
Maerua angolensis DC.	Capparaceae	0	0	9	5.49
Maerua crassifoliaForssk.	Capparaceae	20	4.12	20	12.2
Parkia biglobosa (Jacq.) R.Br. ex G.Don	Mimosaceae	30	6.17	0	0
Piliostigma reticulatum (DC.) Hochst.	Caesalpiniaceae	14	2.88	10	6.1
Sclerocarya birrea (A.Rich.) Hochst.	Anacardiaceae	29	5.97	16	9.76
Tamarindus indica L.	Caesalpiniaceae	42	8.64	0	0
Tapinanthus globiferus (A.Rich.) Tiegh.	Loranthaceae	0	0	7	4.27
Vitellaria paradoxaC.F.Gaertn.	Sapotaceae	27	5.56	0	0
Vitex donianaSweet	Verbenaceae	7	1.44	0	0
Ximenia americana L.	Olacaceae	3	0.62	0	0
Ziziphus mauritiana Lam.	Rhamnaceae	52	10.7	12	7.32
Total		**486**	**100**	**160**	**97.59**

Table 3. Citation scores and ranking of priority species by agro-ecological zone

Code	Botanical names	Botanical families	Local names (Zarma)	Consumed organs	Score	Rank
		Area Sudanese (Tamil)				
Ad	*Adansonia digitata* L.	Bombacaceae	Kogna	Leaves, fruits	421	1
You	*Tamarindus indica L.*	Caesalpiniaceae	Bossey	Fruits, leaves	382	2
Pb	*Parkia biglobosa (Jacq.) R.Br.*	Mimosaceae	Loutou	fruits	345	3
Vp	*Vitellaria paradoxa C.F.Gaertn .*	Sapotaceae	Boulanga	fruits	224	4
Zm	*Ziziphus mauritiana* Lam.	Rhamnaceae	Darey	fruits	191	5
Sb	*Sclerocarya birrea (A.Rich.) Hochst.*	Anacardiaceae	Diney	fruits	188	6
Lm	*Lannea macrocarpa Engl. & K.Krause*	Anacardiaceae	tamarza	fruits	171	7
Cn	*Combretum nigricans Lepr. ex Guill. & Perr.*	Combretaceae	Dely gna	eraser	159	8
Well	*Balanites aegyptiaca (L.) Delile*	Balanitaceae	garbey	Leaves, flowers, fruits	116	9
Dy	*Diospyros mespiliformis Hochst. ex A.DC.*	Ebenaceae	Tokey	fruits	112	10
		Area Sahelian (Tondikiwindi)				
Mc	*Maerua crassifolia* Forssk.	Capparaceae	hassou	leaves	371	1
Bs	*Boscia senegalensis (Pers.) Lam. ex Poir .*	Capparaceae	Anza	Seeds	281	2
Well	*Balanites aegyptiaca* (L.) *Delile*	Balanitaceae	garbey	Leaves, flowers, fruits	235	3
Zm	*Ziziphus mauritiana* Lam.	Rhamnaceae	Darey	Fruits	199	4
Sb	*Sclerocarya birrea (A.Rich.).*	Anacardiaceae	Diney	Fruits	162	5
Gb	*Grewia bicolor Juss.*	Tiliaceae	Sari,	Fruits	130	6
Pr	*Piliostigma reticulatum (DC.)*	Caesalpiniaceae	Kossey	Fruits	122	7
That	*Cadaba flour* Forssk.	Capparaceae	Bagey	Leaves	120	8

Table 4. Food value of woody plants and their threats

Species	N	Fv	Of	Reg.	Valley	Threats											
						Of	Fire	Past	Drink	Fl -Fr	Fe	Ecor	Tank	Wrong	Dry	Age	Ground
Ad	45	10	2	Sd	10	1	1	1	1	1	**4**	1	1	2	3	1	1
Well	57	7	2	Sh / Sd	7	1	1	1	3	1	1	1	1	1	1	1	1
Bs	43	9	2	Sh / Sd	9	2	1	1	1	**4**	1	1	1	1	3	1	1
Cf	17	8	2	Sh / Sd	8	1	1	1	1	1	**4**	1	1	3	**4**	1	2
Cn	27	7	3	Sd	7	2	1	1	2	1	1	1	1	1	1	1	1
Of	11	4	3	Sd	4	1	1	1	1	1	1	1	1	1	**4**	1	1
Dy	22	5	3	Sd	5	3	1	1	1	1	1	1	1	1	1	1	1
Gb	18	6	2	Sh / Sd	6	1	1	1	3	**4**	1	1	3	1	**4**	1	1
Ht	15	5	3	Sd	5	1	1	1	1	1	1	1	1	1	1	1	1
There	6	5	4	Sd	5	2	1	3	1	**4**	2	1	1	**4**	**4**	1	**4**
Lf	13	4	3	Sd	4	1	1	1	1	1	1	1	1	1	1	1	1
Lh	8	5	2	Sh	5	**4**	1	**4**	1	**4**	**4**	1	1	**4**	**4**	1	**4**
Lm	30	5	2	Sh	5	1	1	1	1	1	1	1	1	1	1	1	1
My	8	5	4	Sh	5	3	1	3	1	**4**	**4**	1	1	**4**	**4**	1	**4**
Mc	39	9	2	Sh	9	1	1	3	3	1	**4**	1	1	**4**	**4**	1	1
Pb	30	6	2	Sd	6	2	1	3	1	3	1	1	1	2	3	1	1
Pr	24	6	2	Sh / Sd	6	3	1	1	1	**4**	1	1	1	1	3	1	1
Sb	43	5	2	Sh / Sd	5	1	1	1	**4**	1	1	1	1	1	1	1	1
Tg	7	6	4	Sd	6	2	1	1	1	**4**	**4**	1	1	**4**	**4**	1	**4**
You	43	9	2	Sh	9	1	1	3	1	1	1	1	1	1	3	1	1
Vd	8	3	3	Sd	3	2	1	1	1	1	1	1	1	1	3	1	1
Vp	27	7	2	Sd	7	1	1	1	1	**4**	1	3	1	1	**4**	1	1
Zm	64	6	2	Sh / Sd	6	1	1	2	1	1	1	1	1	1	1	1	1

N= Key informants who mentioned the species; 1= not threatened; 2= not important; 3= somewhat threatened; 4= very important threat. From: clearing, Fire: bush fires, Pat: overgrazing, Wood: timber exploitation, Fl -Fr: flower and fruit picking, Fe: leaf picking, Ecor : bark stripping, Char: charcoal production, Mal: attacks by harmful insects and fungal diseases, Séch: droughts, Age: age of trees in fields, Soil: decline in soil fertility

Table 5. Partial Least Squares PCA analysis for priority species. Number of components (Comp.), Total correlation percentage (R2X), variance explained by the first component (R2X 1st component), cross-validation statistic (Q2 Stone-- Geiser) and maximum value of significant variation in projection (VIP). X- Weights columns show the variables most correlated with regeneration (Rg1 = absence of regeneration; Rg2 = presence of regeneration), decline (Dcl) and food value ranking (Val)

Species	Comp.	R^2X	R^2X (Eigenvalue) 1 st component	Q^2 Stone-Geiser	VIP Variable (max. value)	X Weights Reg1 Absence	X Weights Reg2 Presence	X Weights Dcl	X Weights Valley
Ad	6	0.71	0.20 (2.88)	0.9775	Reg (0.95)	Dry	Dcl, Val, Mal		Bad, Pat Ecor, Fire
Well	7	0.86	0.37 (5.9)	0.9999	Reg (0.99)	From, Fire	-	-	Ecor, Char, Boiss
Bs	7	0.79	0.28 (4.55)	0.9991	Reg (0.95)	Fl -Fr, Fe, Sol	-	-	Ecor, Fire
Cf	6	0.88	0.43 (6.43)	0.9994	Reg (0.99)	-	-	Ecor, Boiss, Fe, Fl-Fr, Char	Pat, Dry, Fire
Cn	4	0.71	0.26 (2.59)	0.8974	Reg (0.91)	Dry	-	Wrong	Pat
Of	2	0.66	0.39 (2.72)	0.6061	Reg (0.87)	From, Dry	-	-	-
Bye	3	0.75	0.32 (2.59)	0.8869	Reg (0.96)	Fl -Fr	-	-	Pat
Gb	6	0.84	0.33 (4.88)	0.9964	Char (0.99)	Ecor , Fl-Fr, Sech, Sol	-	Reg1, Ecor	Dry
Ht	3	0.73	0.37 (2.96)	0.8354	Pat (0.90)	-	Acc, Val	Reg2, Val	Reg2, Acc
Lf	4	0.76	0.28 (3.15)	0.8980	Reg (0.98)	Of	Fl -Fr, Boiss	-	Wood
Lm	6	0.76	0.19 (2.65)	0.9759	Reg (0.97)	-	Fl -Fr, Pat	Val, Pat, Ecor, Mal	Acc, Age, Ecor, Pat, Sech
There	2	0.75	0.57 (5.85)	0.6555	Fl -Fr (0.98)	Dry, Sol	Ecor, Char	-	Fe
Lh	3	0.79	0.36 (4.76)	0.8319	Fe (0.97)	From, Ecor, Fire	-	Wrong	Fl -Fr
My	3	0.74	0.37 (5.35)	0.8196	Ecor (0.97)	Valley, Fire, Ecor	Pat, Wood, Char, Dry, Ground	-	Reg1, Ground, Dry, Wood, Char
Mc	7	0.83	0.35 (5.46)	0.9991	Reg (0.96)	Fl-Fr, Char, Wood, Ecor, Fe	Pat, From	Valley, Fire, Age	Acc, Fire, Age
Pb	6	0.75	0.20 (2.83)	0.9843	Reg (0.96)	Dry, Age, Pat	-	Val, Fe	Acc, Sol, Dry, Age
Pr	6	0.87	0.42 (6.36)	0.9990	Reg (0.98)	Dry, Sol	Acc	Reg2	-
Sb	6	0.84	0.41 (6.09)	0.9993	Reg (0.98)	-	Age	Of	Reg1, Sech, De, Pat
You	5	0.69	0.19 (2.49)	0.9357	Reg (0.96)	Dry	-	Val, Age, Fe	Acc, Age, Fe
Tg	2	0.65	0.36 (4.96)	0.4833	Wood (0.98)	Valley, Sun, Evil		Fe	Reg1, Sol, Mal
Vd	3	0.68	0.44 (3.08)	0.5863	Val (0.96)	-	Fl -Fr		Of
Vp	5	0.75	0.29 (3.50)	0.9752	Reg (0.89)	Ecor	-	Wood	Dry
Zm	6	0.79	0.36 (5.69)	0.9986	Reg (0.99)	Valley	Acc	Reg2, Fire	Reg1, From

Boscia senegalensis, Tamarindus indica and *Maerua crassifolia* with a VA of 9 each. Overall, for all species surveyed, there is a perception of decline in populations at the time of the surveys, compared to 10 years previously when these populations were abundant with abundance levels between 2 and 4. Among the 23 species surveyed, nine appear to be facing a regeneration problem. With the exception of *Ziziphus mauritiana*, all species are revealed by respondents as being under severe threat, making them rare with threat levels between 3 and 4 and with drought as the main threat factor.

From the analysis of Table 4, it emerges that the most threatened species are: *A. digitata* (Val = 10) mentioned in the Sudanese region, followed by *Boscia senegalensis* (Val = 9) mentioned in both areas, *Maerua crassifolia* (Val=9) mentioned in the Sahel region and Tamarindus indica (Val = 9) in the Sudanese region. The informants perceive a significant or very significant threat for all species (Average = 3-4), drought represents the most common threat to all species mentioned.

Principal component analysis made it possible to establish the link between all the variables reflecting the dietary importance of woody species, the disappearance and regeneration of species as well as the perception of threats by populations (Table 5).

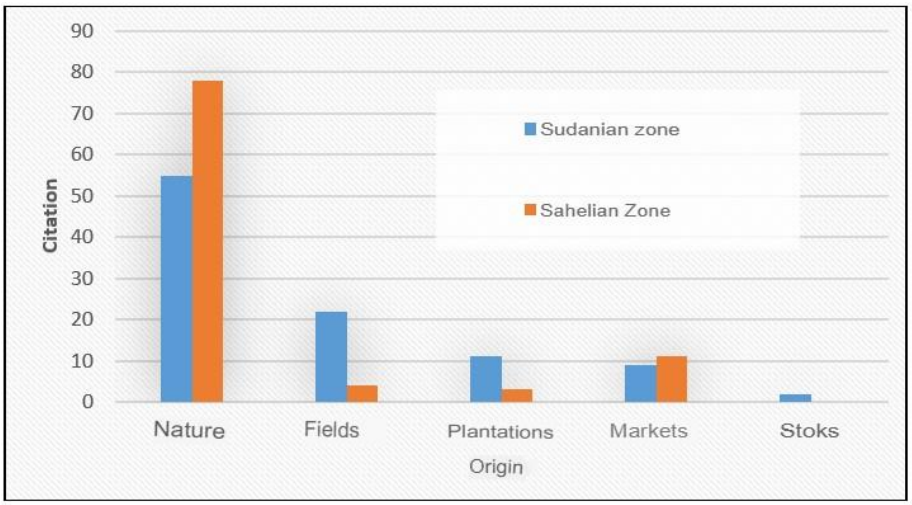

Fig. 2. Distribution of citations according to different sources of supply

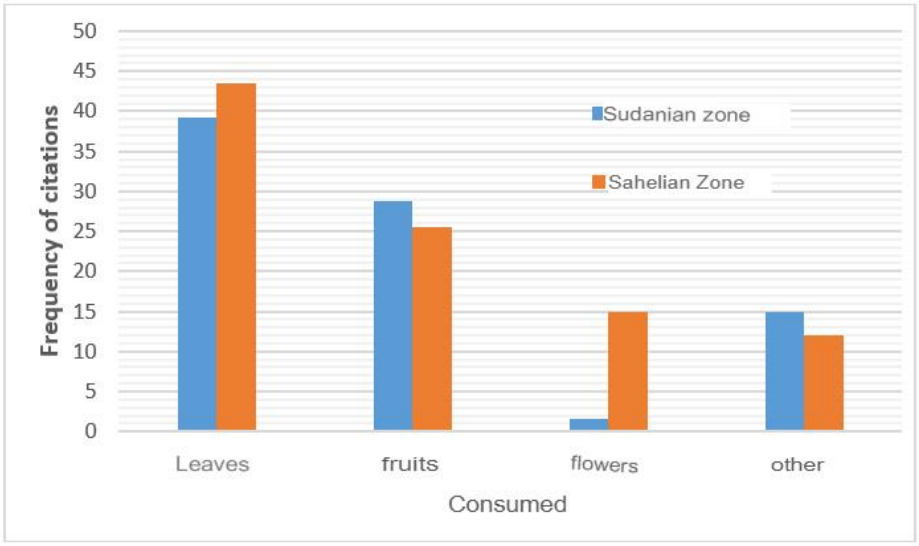

Fig. 3. Frequency of citations of agro-ecological zones according to the organs consumed

Fig. 4. Dying of old plants of the *Adansonia species Digitata* in Weilgorou

(a)

(b)

Fig. 5. Rotting of aging feet in Weilegorou (a) and young feet observed in Tamou (b)

(a)

(b)

(c)

Fig. 6. Sampling of Shea bark in Weillgorou " (a); "Pruned Baobab in Weilgorou " (b); "Sampling of Baobab bark in Weilgorou" (c)

(a) **(b)**

(c)

Fig. 7. cutting branches and collecting leaves of Balanites (a and b); harvesting immature fruits on *Maerua crassifolia* (c) in the Commune of Tondikiwindi.

There is a strong correlation between the dietary importance of species and threat factors, this is the case of the drought factor which is correlated with dietary importance for seven species (*Cadaba farinosa*, *Grewia bicolor*, *Leptadenia arborea*, *Maerua angolensis*, *Parkia biglobosa*, *Sclerocarya birrea*, *Vitellaria paradoxa*), grazing for six species (*Adansonia digitata*, *Cadaba farinosa*, *Combretum nigricans*, *Diospyros mespiliformis*, *Lannea microcarpa*, *Sclerocarya birrea*), anarchic bark stripping (*Adansonia digitata*, *Balanites aegyptiaca*, Boscia senegalensis., *Lannea microcarpa*), the passage of fire (*Adansonia digitata*, *Boscia senegalensis*., *Cadaba farinosa*, *Maerua crassifolia)* and tree age (*Lannea microcarpa*, *Maerua crassifolia*, *Tamarindus indica*, *Parkia biglobosa*) which concerns four species each; and for factors such as fodder collection (*Adansonia digitata*, *Combretum nigricans* , *Cadaba farinosa*, *Diospyros mespiliformis*, *Lannea microcarpa*, *Sclerocarya birrea*), soil quality (*Maerua angolensis*, *Parkia biglobosa*, *Tapinanthus globiferus*) and energy use and service (*Adansonia digitata* L., *Lannea fruticosa* , *Maerua angolensis*), they each concern three species.

The disappearance of three species is linked to the use of the leaves (*Cadaba farinosa*, *Parkia biglobosa*, *Tapinanthus globiferus*), for others, the factor of disappearance is linked to diseases, it is about *Combretum nigricans*, *Lannea microcarpa*, *Leptadenia hastata*.

The regeneration problem is linked to droughts for 8 species, these are *Adansonia digitata*, *Combretum nigricans*, *Detarium microcarpum*, *Leptadenia arborea*, *Parkia biglobosa*, *Piliostigma reticulatum*. *Tamarindus indica* ; to soil quality for five species, including *Boscia senegalensis* , *Grewia bicolor*, *Leptadenia arborea*, *Piliostigma reticulatum* and *Tapinanthus globiferus*; harvesting flowers/fruits (*Boscia senegalensis*, *Diospyros mespiliformis*, *Grewia bicolor*) and anarchic barking concerns four species (*Grewia bicolor, Leptadenia hastata*, *Maerua crassifolia*, *Vitellaria paradoxa*.); and the disappearance of three species is more linked to the passage of fire (*Balanites aegyptiaca* , *Leptadenia hastata*, *Maerua angolensis*).

4. DISCUSSION

Food woody species include all woody plants that provide leaves, flowers, fruits, seeds or other parts used for human consumption (Okafor, 1991; Millogo-Rasolodimby, 2001; Codjia *And al*. 2003; Belem *et al.* 2007; Ouédraogo, 2010). The

ethnobotanical survey conducted among the populations showed that there are woody food species in the agrosystems of two agro-ecological zones cited by the populations as providers of food during the lean season. Thus, 26 species are listed in the Sudanian zone, 17 species in the Sahelian zone and 11 species common to both agro-ecological zones. The list is not as broad as the general list of food plants because the present list only takes into account lean season species. However, these same species are found on the list of food species reported at the national level by Saadou (1998). These listed lean season species are not all appreciated to the same degree by consumers (Belem et *al.,* 2008). There is a preference within these species that seems to be linked to the consistency of the meal obtained to replace the daily meal and the substantial income that could be generated by the sale of products to cope with the lean season as reported by Lamien *et al.* (1995). This preference varies from one area to another. The species declared priorities in the Sudanian zone are different from those in the Sahelian zone. This variation is essentially due to the ecological requirements of the species that determine a precise distribution area for each species. It is in the same vein that Lamien *et al.* (2004) indicated that the species most used by populations are those that develop in their immediate environment and are easy to access. Other authors link the preference to the abundance of species in the land (Belem *et al.,* 2008), or even at the level of the severity of the welding because the harsher the welding, the higher the number of species consumed (Ganaba *And al.,* 2002). In the context of this study, it is rather the consistency of the dish obtained or the income that can be drawn from the sale of the product. It is in this respect that *Adansonia digitata, Vitellaria paradoxa, Tamarindus indica and Parkia biglobosa* are cited as priorities in the Sudanian zone, because their products are widely marketed on local markets. On the other hand, in the Sahelian zone, it is rather *Maerua crassifolia*, *Boscia senegalensis*, and *Balanites aegyptiaca* which are the species, the most priorities. The products of these three species are used in the preparation of the main meal; on the other hand, the fruits of the third are marketed on the markets to be sucked in the form of appetizers. Some species cited as priorities are similar to those found by Millogo-Rasolodimby (2001) and Thiombiano *and al.* (2012). In solving the difficulties related to welding, leaves are highly sought after. They represent about 39 to 40% of the organs consumed. Leaves are organs present on plants almost throughout the year, which makes them available at any time. Most often, they are used as a basis for food preparation. They are consumed boiled or fresh, they can be dried and preserved even before food shortages. Similar observations were made by N' Dri (1986) and Gautier-Béguin (1992) for species such as *Ceiba pentandra*, *Myrianthus arboreus*, *Triplochyton scleroxylon.* According to Thiombiano *et al*. (2012), organs harvested during the lean season can serve as a staple food replacing rice or cowpea, *Boscia senegalensis* for its seeds, *V. paradoxa, L. microcarpa* for their fruits and *P. biglobosa* for the fruit pulp.

The most sought-after listed species are present in savannah formations, depression areas, then in fields and plateaus. This clearly shows the interest given to them by populations who spare them and maintain them during clearing and excessive felling of wood because they present a food and socio-economic interest to them. This form of management is materialized in the field by the establishment of agroecosystems where the density of trees becomes increasingly important in the fields. This situation was mentioned by Sokpon (1994) in Benin; Kokwaro (1990) in Kenya; Bahuchet and *al.* (1987) in southern Cameroon and Campell (1987) in Zimbabwe.

Threat factors have been reported, but vary depending on the area. The most important threat according to respondents in the Sudanian zone is drought, followed by the exploitation of flowers and fruits, attacks by harmful insects and the exploitation of leaves. On the other hand, in the Sahelo-Sudanian zone, droughts, the exploitation of flowers and fruits, and grazing constitute the most important threat factors. These factors are all linked, regardless of the ecological zone, to droughts which generate considerable reductions in yield. This forces populations to pick the edible parts of plants such as leaves, flowers and fruits. And when the exploitation of these parts is repeated, it leads to attacks by harmful insects which can lead to the dieback of trees. It is in the same vein that Darkoh (2003) indicates that the degradation of ecosystems in arid zones is classically linked to climate change factors and human activities. Even if, on the other hand, the effects of climate change remain limited on the disappearance of local species, because they are adapted to the arid conditions of the environment, poor practices

in the use of space or tree exploitation can contribute to the acceleration of the loss of the most sought-after species. In terms of threatened species, the highest priority species are the most threatened according to the population surveyed. And in the face of this threatening situation, it is necessary to agree on the restoration and conservation of species deemed essential to the functioning of the ecosystem and the development of local populations, particularly the most emblematic. This request has already been made by Grime (1997) and Child (2003).

5. CONCLUSION

In view of the initial objectives which focused on the assessment of the diversity and preferences of woody food species of the Sudanian and Sahelian zones in Niger, the study made it possible to list 26 woody food species in the Sudanian zone, 17 species in the Sahelian zone and 11 species common to the two agro-ecological zones. The exploitation of these species is mainly done through the collection of organs such as leaves, flowers, fruits in the agro-ecological zones. The study also made it possible to corroborate the idea that The loss of the diversity of woody food plants is based on the anarchic exploitation of organs such as leaves, flowers, fruits in agroecological zones. Indeed, according to local perception, the excessive exploitation of certain organs seems to be the basis of the scarcity of woody food species. It seems to contribute greatly, due to the lack of regulation, to the weakening of trees and the elimination of large subjects that can be considered as seed trees, with the future consequence of a decline in fruit production and the regeneration rate. Other factors such as droughts, browsing of young shoots or inappropriate exploitation practices, attacks on fruits by insects and soil depletion are implicated in this degradation. Among the species listed, those declared priorities by the populations are the most threatened. These include species such as *Adansonia digitata, Vitellaria paradoxa, Tamarindus indica and Parkia biglobosa* in the Sudanian zone and *Maerua crassifolia*; *Boscia senegalensis*, and *Balanites aegyptiaca* in the Sahelian zone. Some threat factors are specific to priority species.

It therefore appears necessary to undertake participatory conservation through protection and domestication actions using appropriate vegetative multiplication techniques for their propagation. The results of this study constitute a database for assessing the availability and level of conservation of species widely used in localities.

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DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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