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Ethnobotanic and ecology of *Borassus aethiopum* formations in and around Mbam and Djerem national park, Cameroon

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Abstract

Borassus aethiopum is a species prized for its socio-economic potential in Cameroon. However, its stands are deteriorating in both quantity and quality. This study aims to reconcile the conservation of the roan tree with the satisfaction of the needs of the populations of the Mbam and Djerem National Park. Interviews were conducted with 311 informants in eight localities around the park. Inventories were carried out on five 500 m sites, each with 25, 20×250 m plots. The results revealed that fruit remains under strong pressure, followed by sap, with an Index value linked to the plant organs used between 0.70 and 0.98. Food and construction uses dominate in the villages. A total of 1500 trees were inventoried, divided into 76 woody species belonging to 59 genera and 32 families. The most represented species were *B. aethiopum* (27.73%) and *Daniellia oliveri* (5.73%). The most abundant families were Arecaceae (433) and Fabaceae (175). Average diversity index values ranged from 0.7 to 0.9 for Simpson's index, 2.5 bits for Shannon's index and 0.75 to 0.95 for Pielou's equitability. The horizontal and vertical structure shows a preponderance of shrubs and a low number of large trees, indicating vigorous regeneration. This work provides a brief insight into the use and ecological potential of *B. aethiopum*. It could be a tool for sustainable management, which despite its presence in the PNMD area, is suffering from extinction.

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Introduction

In subsistence economies, forests provide many services for the lives of local populations through non-timber forest products (NTFP) (Vandebroek *et al.*, 2004). NTFPs account for a significant proportion of forest products (Bellafontaine *et al.*, 2001). NTFP species are diverse and of vital importance to 80% of local populations (Shackleton *et al.*, 2011). In fact, they are a significant source of income, contribute to food security and provide many essential health and pharmacopoeia products (Bele *et al.*, 2011; Kamga *et al.*, 2021). Despite their importance, these forests are under threat today due to the crucial socio-economic needs of a growing population, the conversion of forests to plantations and the unsustainable exploitation of NTFP. (Ingram, 2010; Anana *et al.*, 2018), Among the NTFP species with multiple uses and high economic potential is a species of palm, *B. aethiopum*, commonly known as Ethiopian Borasse, African rondier, “sentinel of the savannahs” or rônier (Avoutchou *et al.*, 2022). Its uses are multiple and highly diversified in the fields of food, socio-cultural, economics, crafts, medicine, fodder, energy, agriculture and ecology (Gbesso *et al.*, 2017; Avoutchou *et al.*, 2022). In addition, the income-generating activity resulting from the exploitation of rônier seedlings is of interest to part of the local population, to the extent that it is ranked among the important activities in the study area (Cosiaux *et al.*, 2016).

This strong market demand puts the species in the uncomfortable position of being overexploited in the MDNP area, and may gradually lead to its extinction. Multiple uses have led to anthropogenic pressures on *B. aethiopum*, causing a sharp decline in its population (Agyarko *et al.*, 2014; Salako *et al.*, 2018). Thus, the stands in the MDNP area are undergoing profound socio-economic disturbances, leading to a loss of their social and economic value, not to mention the abandonment of traditional practices. This is leading to an unprecedented deterioration in the abundance and quality of roast palm stands and a reduction in income for the communities that depend on them (Ohin *et al.*, 2018; Oumarou *et al.*, 2018).

The various threats facing the rônier stands certainly compromise the conservation objectives of the MDNP, as such a loss of biodiversity within the protected area and its periphery would require increasingly effective and sustainable *B. aethiopum* conservation strategies. What's more, the measures of observable change attributable to the current anarchic exploitation of *B. aethiopum* remain notably as yet unknown. Needless to say, little or no work has so far been devoted to the standing ecological potential, scale and impact of this exploitation on the ecology of the roast palm in the MDNP area (Souare, 2015). Following this uncomfortable situation of deterioration of *B. aethiopum* formations that the present study was conducted to reconcile the conservation of the roasting palm and the satisfaction of the needs of the indigenous populations of the MDNP. More specifically, the aim was to draw up a typology of uses of *B. aethiopum* by local populations that would contribute to its extinction in the MDNP zone, and to measure the observable changes attributable to the current anarchic exploitation of the roast palm on the floristic composition of the MDNP zone. Ultimately, this study should provide the necessary indicators for the appropriate development of non-timber forest product species, with a view to optimizing the contribution of forest resources to improving people's socio-economic conditions.

Materials and methods

Study site

The present study took place on the outskirts of the MDNP, located between 5°30' and 6°13' North latitude, and 12°13' and 13°10' East longitude. The park lies at the intersection, in the heart of Cameroon, between the Centre, Adamaoua and East regions, in the Mbam and Kim, Djerem and Lom et Djerem departments respectively. It lies at the southern edge of the Adamaoua plateau and on the northern edge of the dense forest of the Congo Basin (Fig. 1).

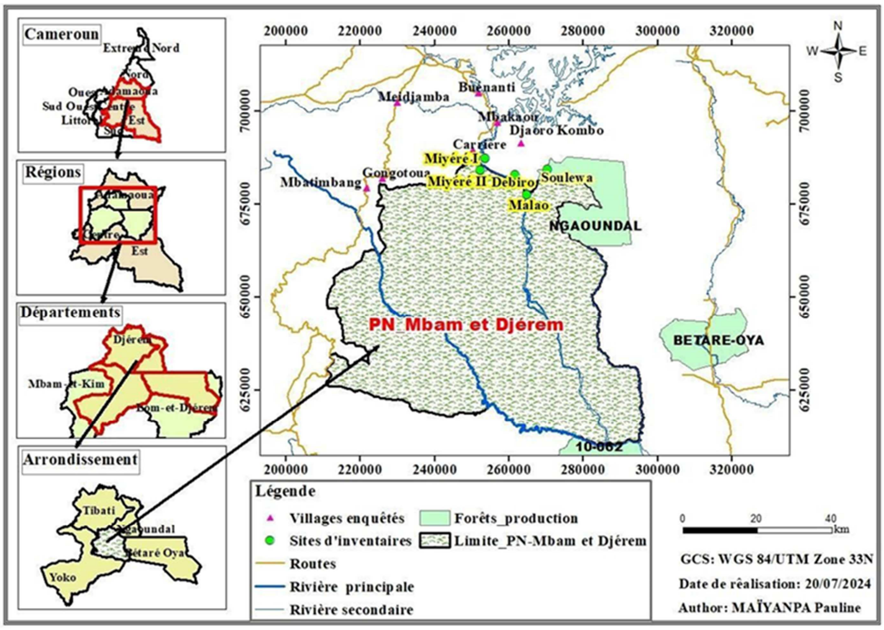

Fig. 1. Location of the study area

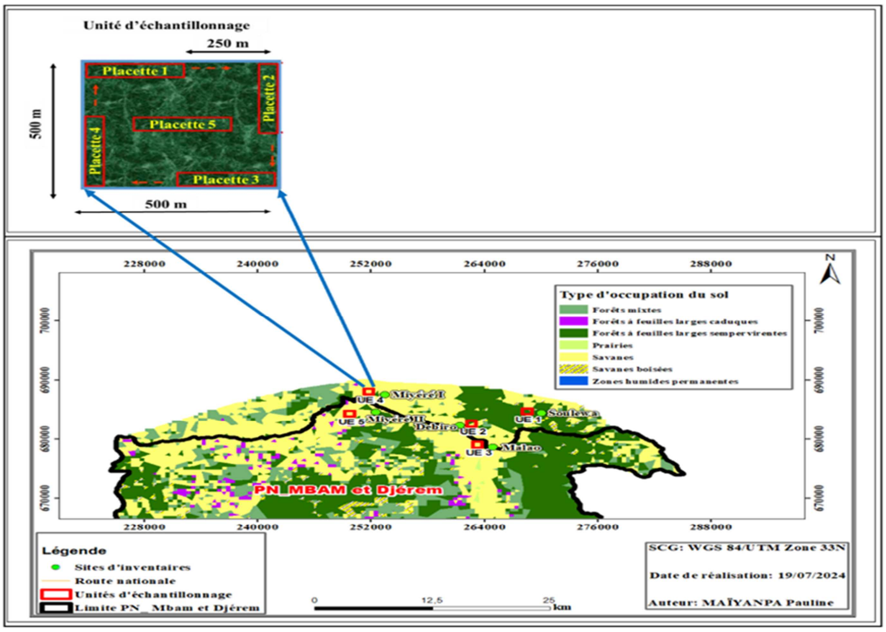

Fig. 2. Plot locations at sampling sites

It has a total surface area of 416,512 ha, half of which is lowland tropical forest and the other half covered by wooded savannah. Between the two, there is a wide ecotone belt, and above all a very wide diversity of habitats and therefore great biodiversity (MINFOF, 2012; Gueguim *et al.*, 2018). The climate in this area is subtropical, with two seasons: a rainy season from the second half of March to early November, and a dry season.

Data collection

Ethnobotanical surveys were carried out using a questionnaire sent to 311 informants in eight villages (Djaoro-kombo, Mbakaou, Carriére, Gongotoua, Bolinting, Medjamba, Mbangti-Mbang, Soulewa) around the MDNP involved in roasting palm exploitation, i.e. less than 15 km from the park, were targeted taking into account their accessibility, in particular by the presence of a road between the villages.

The inventory was carried out in 250 m × 20 m (Fig. 2) nested plots for species in the tree and shrub strata (> 10 m of high). Species were inventoried, and the height and diameter of species with a diameter greater than or equal to 10 cm were measured at 1.30 m (dbh) for individuals without buttresses. For those with buttresses, parameters were measured 30 cm above the buttresses. These individuals were identified and counted. In the case of *B. aethiopum*, all individuals were identified and counted in each survey. Several books were used in the field to identify trees. These included the Flore du Cameroun and the manuel botanique forestière (Letouzey, 1968, 1982), Recueil des noms des plantes en langues ethniques du Cameroun (Onana and Devineau, 2002).

Data processing and analysis

For all individuals with dbh ≥ 10 cm at each sampling site, several floristic parameters were calculated using the Excel spreadsheet to characterize the *B. aethiopum* stand. These were relative abundance, frequency, dominance and density (Onana and Devineau, 2002; Avana-Tientcheu *et al.* 2018; Kamga *et al.*, 2019).

Taxon abundance provides information on the number of individuals of a species or family, regardless of size. It is used to calculate the relative density of taxa (%) and is obtained by the ratio of the number of individuals of a species or family to the total number of individuals in the sample.

The frequency/effectiveness or repetition marks the number of times a taxon appears in a plot. It is expressed as a percentage of the number of records where the taxon is present out of the total number of records.

$$\text{Relative frequency of species} = \frac{\text{Frequency of species}}{\text{Total of all frequencies}} \times 100$$

The dominance of a taxon is based on the percentage of basal area ($G = Di^2/4$, where D is the diameter at breast height) occupied by individuals belonging to this taxon and is expressed in m^2/ha. It takes into account the size of the individuals and highlights which taxa occupy the most space in the vegetation. It thus expresses the proportion of basal area of a species or family in relation to the total basal area.

The density of a species is the number of individuals of that species per hectare. It is evaluated by the formula N = n / S (with N: density (in stems/ha), n: number of stems present on the surface considered, S: surface considered (ha).

The Shannon Weaver Index (H) is used to assess the level of diversity, taking into account the proportions of each species on the plot (Frontier and Pichot-Viale, 1998). It is calculated according to the following relationship:

$$H = -\sum_{I=1}^{S} \frac{Ni}{N} \times \ln\left(\frac{Ni}{N}\right)$$

Where "s" corresponds to the number of species making up the stand, "Ni" to the number of individuals of species i and "N" to the total number of individuals (all species combined) (Thiombiano*et al.*, 2016).

Piélou equitability was calculated using the formula EH = H/lnS.

Simpson's index (D) $\frac{1}{D} = 1/\sum_{i=1}^{S}\left(\frac{Ni}{N}\right)2$

Ecological importance index (EII)

The IVI has been used to determine the place occupied by each species in relation to the total number of species in the plant community. This index is commonly used to assess specific dominance in tropical forests, based on the formula of Curtis and Macintosh (1950).

$$IVI = \left(\sum_{i=1}^{n} \frac{Ni}{N} + \sum_{i=1}^{n} \frac{Gi}{G}\right) \times 100$$

With: the relative dominance of a species is the quotient of its basal area (Gi) with the total basal area (G) of all species multiplied by one hundred; the relative abundance of a species is the ratio of the number of individuals of the species (Ni) to the total number of individuals of all species (N).

Family importance value (FIV) = relative dominance + relative density + relative diversity.

The assessment of total biomass and C stocks also focuses on non-commercial components expressed in tonnes of dry weight. To derive forest biomass and its variations, the indirect method was used in the present study. Which involved measuring attributes of tree samples in the field, such as diameter and height, and applying allometric equations or biomass tables based on these equations, either once or repeatedly (IPCC, 2006). The total biomass of standing woody plants is divided into above-ground biomass (AGB) and below-ground biomass (BGB):

Above-ground biomass: the above-ground biomass (AGB) of associated trees at the sampling sites was estimated using the allometric model of Chave *et al.* (2014), based on dbh, total tree height and specific wood density. AGB= 0,067 * (ρD^2 H) 0,976.

Where: AGB is the above-ground biomass of the tree (in kg); D is the diameter of the tree (in cm); H is the total height of the tree (in m); ρ is the specific density of the tree in ($g.cm^{-1}$).

The specific wood densities of the different species sampled were collected from the Global Wood Density Database (Zanne *et al.*, 2009). The average density of African wood (0.65) was used for species with unknown specific density (IPCC, 2006).

Below-ground tree biomass: the estimation of root biomass (AGB) of standing woody plants followed the guidelines established by the IPCC (2006). According to the IPCC, the root biomass equivalence of standing woody plants is found by multiplying the above-ground biomass value (AGB) by a coefficient R whose value is estimated at 0.24.

BGB= AGB×R

Where: BGB is below-ground biomass; AGB is above-ground biomass and R is the root/stem ratio.

ANOVA was used to compare the density means of the different surveys to see if there was a significant difference, and the DUNCAN test at the 5% significance level (XLSTAT software version 23.0) was used to separate these means.

Results

Parts used and categorizations of the diversity of uses of B. aethiopum

Fig. 3 presents an ethnobotanical use network of *B. aethiopum* with its different parts used. This figure shows that the fruit/nuts and sap are the most frequently used parts in the villages around the MDNP. It illustrates an ethnological network linking the different uses of *B. aethiopum* to actors and their localities around the MDNP. The multiple connections between food and construction uses to the various villages suggest that they are dominant, indicating a strong geographical variability of the uses of the palmyra palm. Some localities may favor one function more than another. On the other hand, medicinal, artisanal, fodder and fertilization uses are limited in number of connections, which could mean that they are practiced by small groups.

Analysis of the Index value linked to the organs used

The evaluation of the pressure exerted on the different parts of *B. aethiopum* is recorded in Table 1. It shows that the Hypocotyl remains under the greatest pressure, with a very high IVO index (0.98). The high intensity of exploitation (5/5) and the large number of users (307) point to potential overexploitation. Sap also retains a high pressure (0.70) due to use by 275 resource persons with high intensity (4/5). The trunk and fruit show similar IVO indices (around 0.19), suggesting moderate but significant pressure of use. Leaves (0.17) and roots (0.006), on the other hand, are under relatively low pressure, especially roots, which are used by only 10 people with very low intensity (1/5).

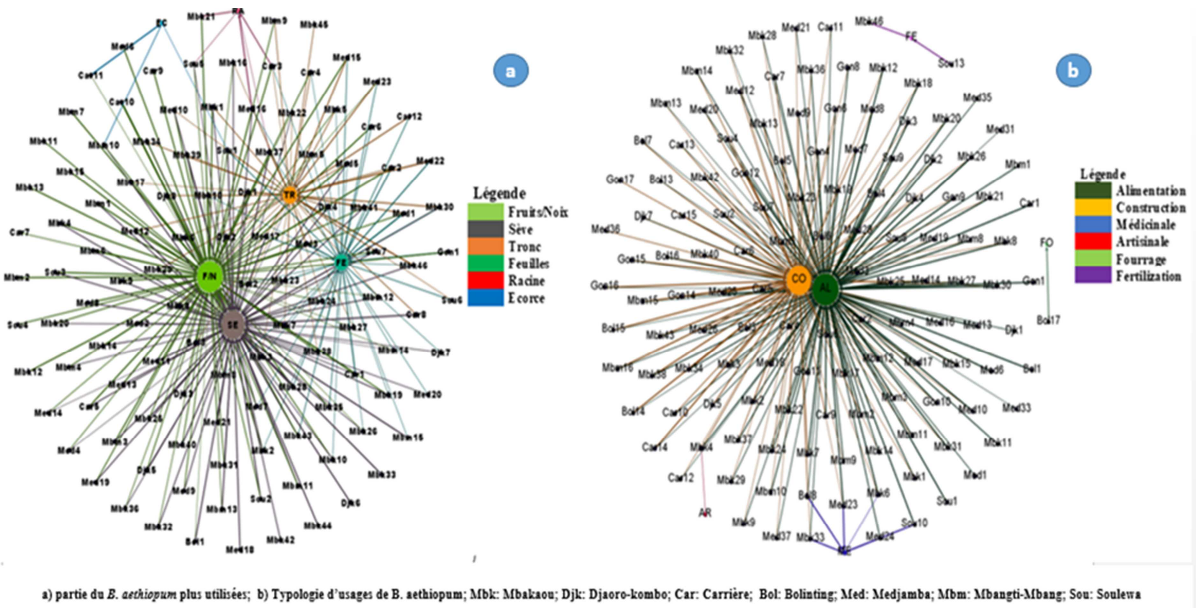

Fig. 3. Parts used and typology of uses according to the villages around the Mbam and Djerem national park

Table 1. Index value associated with the plan organs of *B. aethiopum* exploited by local communities in the Mbam and Djerem national park area

Used parts	Number	Average intensity	Index value
Hypocotyl	307	5	0,98
Sap	275	4	0,70
Trunk	102	3	0,19
Fruits	150	2	0,19
Leaves	90	3	0,17
Root	10	1	0,006

Table 2. Predominant woody families at sampling sites

Family	Debiro	Malao	Miyéré I	Miyéré I	Soulewa	Total
	Nesp	Nesp	Nesp	Nesp	Nesp	Ntesp
Anacardiaceae	2	3	3	3	3	15
Apocynaceae	-	1	-	-	2	3
Araliaceae	1	-	2	1	1	5
Arecaceae	1	2	1	2	1	7
Bignoniaceae	-	-	-	1	1	2
Boraginaceae	1	-	1	1	2	4
Caesalpinaceae	1	1	1	2	1	6
Combretaceae	3	1	2	2	3	11
Fabaceae	4	3	4	7	5	24
Lamiaceae	2	1	1	1	1	6
Malvaceae	1	1	1	-	3	6
Meliaceae	1	1	2	1	2	7
Mimosaceae	-	-	1	1	2	4
Moraceae	6	3	2	4	4	19
Ochnaceae	2	1	1	2	1	7
Phyllanthacaea	5	4	5	2	4	20
Rubiaceae	3	2	1	2	1	9

Floristic diversity of B. aethiopum settlement

A total of 76 species were identified in *B. aethiopum* settlements (dbh ≥ 10 cm), divided into 59 genera and 32 families (Table 2). Of these families, 14 have at least 2 species. The other families are represented by a single species. These include Bignoniaceae (1), Myrtaceae (1), Oleaceae (1) and Urticaceae (1). Of the 76 species, *B. aethiopum* was present in all 25 surveys, i.e. a relative frequency of 100%. The relative frequency and abundance of these families varied according to the sampling sites.

Ecological importance of species recorded at various sampling sites

Table 3 shows the variation in species Importance Value (IVI) across the different sampling sites. The species with the highest overall importance index values (50 to 130) were: *Pseudospongdias microcarpa* (Soulewa: 128.04), *Daniellia oliveri* (Malao: 80.04), *B. aethiopum* (Deboro: 59.79), *Syzyiguim guineense* and *Terminalia albida* (Miyéré II: 58.64 and 38.06 respectively). Other species had index values of relatively low importance (< 20).

These include *Vernonia* spp., *Cussunia arborea*, *Combretum micranthum*, *Terminalia glaucescens*, *Ficus microcarpa* and *Ficus thonningii*.

Table 3. Value importance index of the most preponderant woody species at the sampling sites With Dr: Species Dominance, IVI: Index

Scientific name	Sampling sites									
	Debiro		Malao		Miyéré I		Miyéré II		Soulewa	
	IVI	Dr	IVI	Dr	IVI	Dr	IVI	Dr	IVI	Dr
Pseudospondias microcarpa	-	-	21,89	12,09	11,26	0,13	25,24	2,62	128,04	2,62
Cussonia arborea	9,65	1,10	9,82	-	13,49	4,37	11,83	1,04	28,40	-
Combretum micranthum	9,75	1,91	6,70	-	9,01	0,23	6,90	0,87	23,96	-
Syzygium guineense	13,58	2,84	18,59	-	23,82	0,21	58,64	-	21,32	-
Ficus thonningii	2,34	0,54	0	6,54	7,04	-	2,86	1,63	20,63	6,45
Terminalia glaucescens	19,18	4,65	15,51	8,17	60,13	0,79	-	6,22	19,88	4,83
Vitex doniana	3,79	0,18	-	5,35	19,42	1,74	6,34	10,13	13,10	1,91
Daniellia oliveri	26,91	13,09	80,04	-	5,86	29,70	6,58	13,93	12,67	2,07
Trichilia emetica	19,08	6,75	-	1,55	2,78	6,22	-	21,93	10,31	6,17
Ficus microcarpa	7,52	1,00	4,58	0,23	11,17	1,33	16,21	0,78	8,08	-
Parkia biglobosa	-	-	12,06	-	5,87	3,22	10,87	3,46	6,89	9,00
Berlinia grandiflora	-	-	34,79	29,60	98,16	-	16,16	-	2,95	-
Terminalia albida	20,60	6,34	-	-	-	-	38,06	0,2	-	0,47
Ficus exasperata	16,73	6,42	-	-	-	0,50	24,31	5,41	-	0,15
Borassus aethiopum	59,79	26,57	6,85	31,29	-	44,81	23,00	18,35	-	60,07
Hymenocardia acida	15,56	1,91	4,71	0,67	13,92	0,54	20,90	0,13	-	0,46
Piliostigma thonningii	8,95	1,11	-	0,10	6,61	-	13,33	0,46	-	0,93
Crossopteryx febrifuga	18,80	4,97	-	1,90	2,86	1,2	10,02	4,78	-	-
Afzelia africana	7,30	-	31,12	-	8,53	-	5,67	-	-	-
Lophira lanceolata	40,40	19,54	53,28	0,87	-	3,89	3,00	3,18	-	-
Albizia zigia	7,30	1,00	6,85	1,60	5,86	0,56	16,16	4,72	21,32	4,81

Family importance value

Table 4 showed the Family Importance Values (FIV) for the different sampling sites. it showed that the highest FIVI values were between 30 and 70, for the Fabaceae (Mivéré I: 65.89), Arecaceae (Debiro: 49.54), Combretaceae (Debiro: 36.39) and Moraceae (Debiro: 32.91) families. The least important are Mimosaceae and Sterculiaceae (Miyéré II: 19.34, 15.61 respectively), Anacardiaceae and Mimosaceae (Soulewa: 16.63, 14.65 respectively), Annonaceae (Malao: 10.38) and Annonaceae (Soulewa: 10.30). Other families had relatively low FIVI values (< 20). These included Apocynaceae (6.33), Bignoniaceae (5.10), Meliaceae (5.70) and Sterculiaceae (2.85).

Density of individuals per species in Borassus aethiopum-based formations by site

The average density of roasted palms varied from one sampling unit to another (Fig. 4). The average density of *B. aethiopum* appears to be highest at Soulewa (53.6 ±5.54 stems/ha), followed by Debiro (46.0±8.12 stems/ha); it remains relatively low at the other sites (< 20 stems/ha). On average, there are 46.0±8.12 stems/ha, 15.6±16.45 stems/ha, 32.8±29.07 stems/ha, 18.4±21.69 stems/ha, 53.6±5.54 stems/ha, respectively for the Debiro, Malao, Miyéré I, Miyéré II and Soulewa sampling units. Analyses of variance (dl = 4; p = 0.02) showed that there is a significant difference between the mean density of the different sampling sites. Analysis of the density of individuals per species in *B. aethiopum* formations at the different sites showed that *B. aethiopum* (50.06 stems/ha) has a density of individuals at dbh ≥ 10 cm far higher than those of the other species at the sites studied. This is followed by *Daniellia oliveri* (19.79 stems/ha), *Berlinia grandiflora* (16.27 stems/ha) and *Terminalia glaucescens* (15.50 stems/ha). The other species identified had a density of between 14.50 and 0.21 stems per hectare. These include *Lophira lanceolata*, *Pseudospondias microcarpa*, *Cussonia arborea*, *Ficus thonningii* and *Terminalia glaucescens*. Overall, the average density of species associated with roasted palms varied according to the sampling sites. Average counts were 154.8±70.73 stems/ha, 60.4±26.88 stems/ha, 60.0±14.56 stems/ha, 54.4±14.17 stems/ha, 104.0±36.11 stems/ha, respectively for the Debiro, Malao, Miyéré I, Miyéré II and Soulewa sampling units. Statistical analysis (Kruskal-Wallis test) showed that density in Debiro (154.8 stems/ha) is significantly higher than in the other sampling areas (dl= 4; p = 0.03).

Table 4. Family importance value index for the most preponderant species (Dr: Relative dominance of families)

Family	Sampling sites									
	Debiro		Malao		Miyéré I		Miyéré II		Soulewa	
	FIVI	Dr	FIVI	Dr	FIVI	Dr	FIVI	Dr	FIVI	Dr
Anacardiaceae	9,81	1,93	35,53	11,85	10,62	0,97	27,52	4,38	16,63	2,06
Apocynaceae	-	-	4,83	0,10	-	-	-	-	16,01	1,44
Araliaceae	5,92	0,98	67,23	-	74,80	3,65	47,90	0,84	23,17	1,18
Arecaceae	49,54	23,64	-	28,73	8,94	35,55	-	15,13	10,30	46,17
Bignoniaceae	-	-	-	-	-	-	8,69	0,33	3,01	0,84
Boraginaceae	3,62	0,48	-	-	-		4,56	4,97	9,21	1,42
Caesalpiniaceae	6,73	0,99	4,81	0,08	20,16	0,11	12,84	1,83	-	-
Combretaceae	36,29	11,49	22,40	7,06	7,488	0,10	16,31	5,77	3,19	4,14
Fabaceae	38,50	15,76	55,58	28,00	65,89	30,27	60,51	23,71	84,47	6,08
Lamiaceae	7,11	0,43	12,70	4,62	17,13	1,38	26,84	8,21	5,76	1,47
Malvaceae	3,90	0,56	4,85	0,12	5,70	5,05	-	-	5,2735	4,37
Meliaceae	12,95	6,01	7,745	1,35	13,50	5,87	14,23	17,72	15,83	5,64
Mimosaceae	-	-	-	-	7,31	2,55	11,39	2,80	4,83	7,14
Moraceae	32,91	9,01	23,98	7,01	12,34	1,51	13,63	6,60	14,65	8,48
Myrtaceae	9,46	2,52	-	-	6,66	0,17	-	-	-	-
Ochnaceae	35,94	16,89	6,038	0,75	4,05	3,08	9,75	2,73	6,21	0,80
Oleaceae	-	-	-	-	-	-	-	-	6,21	0,71
Phyllanthaceae	25,02	3,72	30,71	3,99	9,59	6,21	17,63	0,99	22,83	4,84
Rubiaceae	22,23	5,43	23,55	6,28	31,75	0,98	20,31	3,87	26,21	0,09
Urticaceae	-	-	-	-	-	-	-	-	8,70	2,41

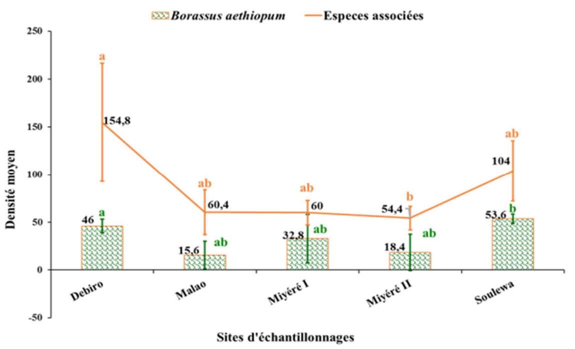

Fig. 4. Average stand density by site in *B. aethiopum* formations

NB: Means with the same letters are not significantly different at the probability threshold P > 0.05

Basal area in B. aethiopum settlements

Fig. 5 shows the variation in basal area (m^2/ha) of species at different sites. Overall, basal area is highest at Debiro (20.98 m^2/ha), followed by Soulewa (16.42 m^2/ha) and lowest at Miyéré I (12.83 m^2/ha). In Debiro, the basal area of associated species (20.98 m^2/ha) was significantly higher than that of *B. aethiopum* (7.58 m^2/ha). The basal area of associated species (13.34 m^2/ha) was higher than that of *B. aethiopum* (4.43 m^2/ha), with a less marked statistical difference than in Debiro. In Miyéré I, associated species had a basal area (12.83 m^2/ha) almost double that of *B. aethiopum* (6.99 m^2/ha), showing co-dominance with similar differences to other localities; while Miyéré II, had the lowest basal area for *B. aethiopum* (2.51 m²/ha) among all sampling units. The difference was significant with associated species (14.00 m²/ha). Soulewa was the only unit where the basal area of *B. aethiopum* (15.32 m²/ha) was almost equivalent to that of associated species (16.42 m²/ha), which is unique compared with the other sites.

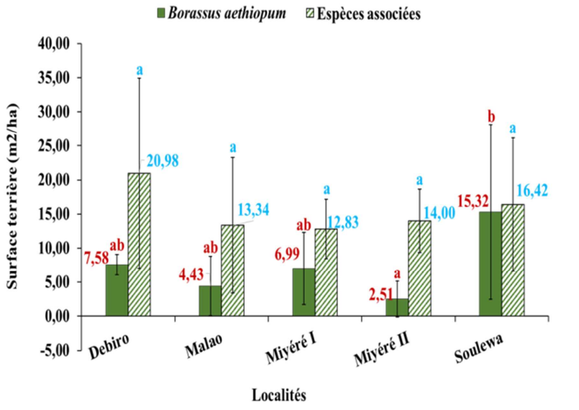

Fig. 5. Comparison of basal area of *B. aethiopum* and associated species in different localities

NB: Means with the same letters are not significantly different at the probability threshold P >0.05.

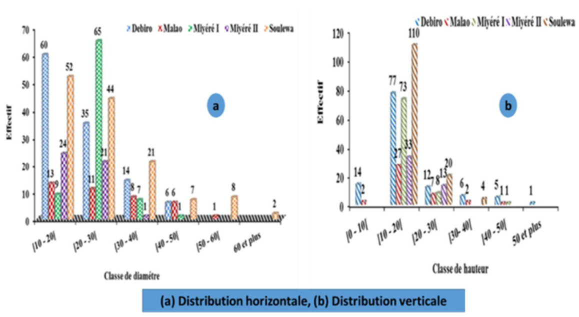

Fig. 6. Height distribution of *B. aethiopum* at different sampling sites

Diameter and height class distribution of B. aethiopum populations

The distribution of *B. aethiopum* individuals according to diameter class at the various sampling sites showed a high representation of young individuals at all sites ([10 - 20[cm and [20 - 30[cm), with a scarcity of large trees (Fig. 6). Between 0 and 30 cm in diameter, Miyéré I and Soulewa had a higher number of individuals than the other sites (21 individuals). The larger diameter classes ([40 - 50[cm and above) showed much lower numbers at all sites.

On the other hand, the distribution of individuals in *B. aethiopum* height classes in the sample units showed that the majority of trees were in the lower height classes, particularly in the [10 - 20[m and [20 - 30[m classes, with a marked peak in the latter class at Soulewa (110). The higher height classes ([30 - 40[m and over) show relatively low numbers at all sites.

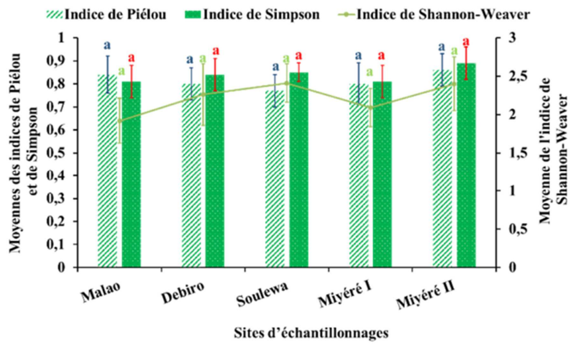

Fig. 7. Average value of diversity index according to study sites

NB: Means with the same letters are not significantly different at p > 0.05.

B. aethiopum settlements diversity indexes

Shannon diversity index (SHI) values range from 2.1 to 2.5 bits for all sites. Piélou equitability varies between 0.83 and 0.90. Simpson's diversity index (D') varies little (0.83-0.92) between plots (Fig. 7). These different indices show variations directly linked to the number of species and individuals inventoried, and to the distribution of individuals between species. However, statistical analysis at the 5% probability level showed that these values were comparable at all sites. On the other hand, Simpson's index values in the different sampling units were mainly between 0.7 and 0.9. Debiro showed greater variability, with a Simpson index fluctuating between around 0.7 and 0.9. Malao had a lower and less variable Simpson index (around 0.8). Miyéré II has the highest Simpson index (around 0.9). The other sampling units (Miyéré I and Soulewa) showed similar indices to Debiro, but with slightly lower variability. The various sampling sites showed fairly similar Piélou equitability indices, all around 0.75 to 0.95. Debiro had a slightly lower equitability index (around 0.75 to 0.90) than the other sites. Malao, Miyéré I, and

Miyéré II showed higher indices, approaching or exceeding 0.85. Soulewa showed a wider variation, with an index around 0.70 to 0.90.

Conclusion

Taken together, the results of the present study show that the typology of *B. aethiopum* uses is fairly diversified and varied by organ used in the villages around MDNP. The average density of *B. aethiopum* on all sites is fairly consistent and significant. The vertical and horizontal structure of *B. aethiopum* shows a strong presence of the intermediate stratum in all the sites studied, reflecting intensive use, notably for food consumption and construction, with the species facing a risk of gradual extinction. The pressure exerted on the hypocotyl and sap, combined with poor regeneration of large trees, is evidence of inadequate and unsustainable management of this resource. As a result of this study, decision-makers and local populations need to be made acutely aware of the social and economic importance of the roast tree. It is therefore imperative to implement appropriate conservation strategies, including raising awareness among local populations, reinforcing sustainable management practices, and making the most of traditional knowledge. Domestication, monitoring and protection appear to be the key solutions for maintaining *B. aethiopum* stands in their natural habitats in the MDNP area. But they are still in their infancy and require much more in-depth investigation. Priority should be given to participatory management, to reconcile the economic needs of communities with the long-term conservation of *B. aethiopum* and its ecosystem.

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