Raphia harvesting and management by traditional communities in the Makoua District, Congo

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Research

Abstract

Background: The survey of traditional knowledge associated with Raphia involves three riverside communities, the largest Raphia plantations in Makoua (Congo). The aim is to perpetuate traditional knowledge and the daily involvement of raffia in strengthening the socio-cultural base.

Methods: In addition to bibliographic research, the ethnobotanical survey is coupled with the collection of samples and tangible evidence of the use of these taxa. Informants, aged at least 15, were classified according to gender and socio-professional category. Data collection took place from 17 February 2021 to 15 March 2021 and from 15 September 2021 to 15 November 2021.

Results: Data collection revealed three species (*Raphia* cf. *gentiliana*, *R. hookeri*, *R. laurentii*), two of which are known to be used in food, phytotherapy and handicrafts. At ethnolinguistic level, the taxa are perfectly serialised by the communities. Ethnobotanical indices (frequency of citation of species and uses (FC), number of uses reported (Nur), relative frequency of citation (FRC), level of fidelity (NF), cultural index of importance of each use category (FC/N), cultural index of importance of all use categories (CI), use value (VU), respondent diversity indices (ID), equitability index (IE)) reveal that all communities, regardless of socio-professional category, use Raphia for the same purposes (food, medicinal, craft), albeit to different degrees. Raphia products come from vegetative and generative organs, and the most prized are leaves, sap, fruits and the beetle larvae that develop on them. Despite some harvesting preferences, these products are a guaranteed source of income for the local population. Although communities are unanimous in their harvesting practices, their anthropic impact on the resource and dependence on it are not expressed with the same acuity. The ever-increasing demand for raffia products on urban and local markets, coupled with the annual harvesting of individuals and unsustainable harvesting techniques, expose Raphia and raffiales to over-exploitation. Traditional communities unanimously approve of the socio-economic and cultural attractions of raffia and its products.

Conclusions: The data from this study is sufficient evidence for us to take another look at these ecosystems. Sustainable management of raffia palm groves and Raphia spp. is more than necessary, both for local populations and for humanity, in the context of the fight against global warming.

Keywords: Ethnobotany, Raphia, endogenous knowledge, ethnobotanical index, sociocultural base, Congo

Background

Palms of the Raphia genus are found in flooded and/or swampy forests in the tropics, particularly in Africa and the Americas (Musset 2020, Bocko *et al*. 2023). Tropical rainforests extend over a large, fragmented area and represent highly complex and diverse ecosystems (Eba Atyi *et al*. 2022). As a source of goods and services for local residents, tropical forests are threatened with extinction through over-exploitation of resources, despite their bio-ecological functions, which are of global importance. The forests of the Congo Basin, the world's second largest tropical forest, accounting for 70% of Africa's forest cover, have not been spared (Tchatchou *et al*. 2015, FAO 2016).

The Congolese forest, covering 12.5% of Congo Basin formations, is subdivided into three main blocks: the Mayombe in Kouilou (1.2 million ha), the Chaillu (3.3 million ha) which stretches from Niari to Lékoumou; and the Nord-Congo massif (10.3 million ha) covering the Cuvette, Sangha and Likouala departments (Tovivo *et al*. 2014, CNIAF 2016, Global Forest Watch 2025). Although these dense tropical rainforests are highly vulnerable, they are rich in biodiversity and play a major ecological and socio-economic role (White *et al*. 2025). The major degradation factors involved, to varying degrees, are excessive collection of wood and non-wood products, inappropriate agricultural practices, urbanization and mobility fluidity, changes in land use and climate change, supporting the loss of resources (Gillet *et al*. 2016).

Riparian populations have always used plants to satisfy their daily needs (food, medicinal, craft and others) (Kimpouni & Nguembo 2018, Lhoest 2020). The satisfaction of local residents has as its corollary not only the accentuation of anthropic pressure on ecosystems, but also the disappearance of taxa and the intensification of the erosion of knowledge about the benefits of plants (Lougbegnon *et al*. 2015, Randrianarivony 2015, Kimpouni *et al*. 2024).

At a time when young people, obsessed with the mundane, take little interest in perpetuating ancestral knowledge, the devotion given to the knowledge and uses of raffia by the linguistic communities of Makoua is more than necessary. Ethnobotanical research carried out in the Congo on raffia and targeting a few localities, far from identifying all the associated knowledge, reveals that this resource is best known through textile fibres, by the local populations of the Cuvette Department (Baudon 1931). Despite its many uses in West Africa, Congolese research on Raphia has focused almost exclusively on pharmacognostic aspects (Bouquet 1969, Adjanohoun *et al*. 1988, Silou *et al*. 2000, Syllou-Kongo *et al*. 2023). To compensate for this lack of data, an ethnobotanical study of Raphia was carried out in three traditional communities in Makoua, which use the main raffia plants in the region.

The aim is to draw up an inventory of traditional knowledge associated with genetic resources with high economic and promising potential. This will be achieved by (i) identifying raffia species and their associated uses, (ii) assessing community knowledge, harvesting techniques and the quantity of products harvested, and (iii) detecting differences in resource use and exploitation between socio-professional categories.

Materials and Methods

Study area

The Makoua district is located in the Cuvette department (Fig. 1), is crossed by the equator and has an average altitude of 379 m (Yoka *et al*. 2013). The Am-type climate is marked by relatively high temperatures and high rainfall, with an annual average temperature of around 25.5 °C and average rainfall of 1657 mm (Kotek *et al*. 2006, Yoka *et al*. 2013, Beck *et al*. 2018). July is considered the coolest month, with minimums of 19.9 °C, and maximums of 31.9 °C are observed in March, which is considered the hottest month (Yoka *et al*. 2013). April and October are the wettest months, with a decrease in precipitation from June to August and December to January. Average annual relative humidity is always high at 98% (Yoka *et al*. 2013). The hydrographic network of the Congolese cuvette is centered around the Kouyou, Alima and Likouala-Mossaka rivers (Stauch 1961). The Makoua district is watered by the Likouala-Mossaka (Vennetier 1966). Phytogeographically, the Makoua region belongs to the Alima and Likouala phytogeographical districts (Kimpouni *et al*. 1992). The vegetation consists of forests and savannahs dotted with shrubs, lousséké steppes, *Loudetia simplex* (Nees) C.E.Hubb. and *Trachypogon spicatus* (L.f.) Kuntze savannahs (Descoings 1969, 1975). In previous studies, the richness of Raphia in the study area showed three species, namely *Raphia hookeri* G.Mann & H.Wendl, *Raphia* cf. *gentiliana* De Wild and *Raphia laurentii* De Wild (Massamba-Makanda 2020).

Ethnobotanical surveys are carried out in three communities in the Makoua district. With the center of gravity being the town of Makoua, the target communities are 61 km from Abela, 45 km from Môh and 32 km from Epéré. Spatially, the distances separating these communities are 98 km for Abela-Môh, 55 km Abela-Epéré and 76 km Epéré-Môh. The population

of Makoua district is 40 004 (INS 2024). These populations mainly belong to the Akwa, Ngaré and Likwala sub-groups of the Mbôsi group (Bouquet 1969). Mostly farmers, the inhabitants of the areas studied depend on agriculture, hunting, gathering and fishing.

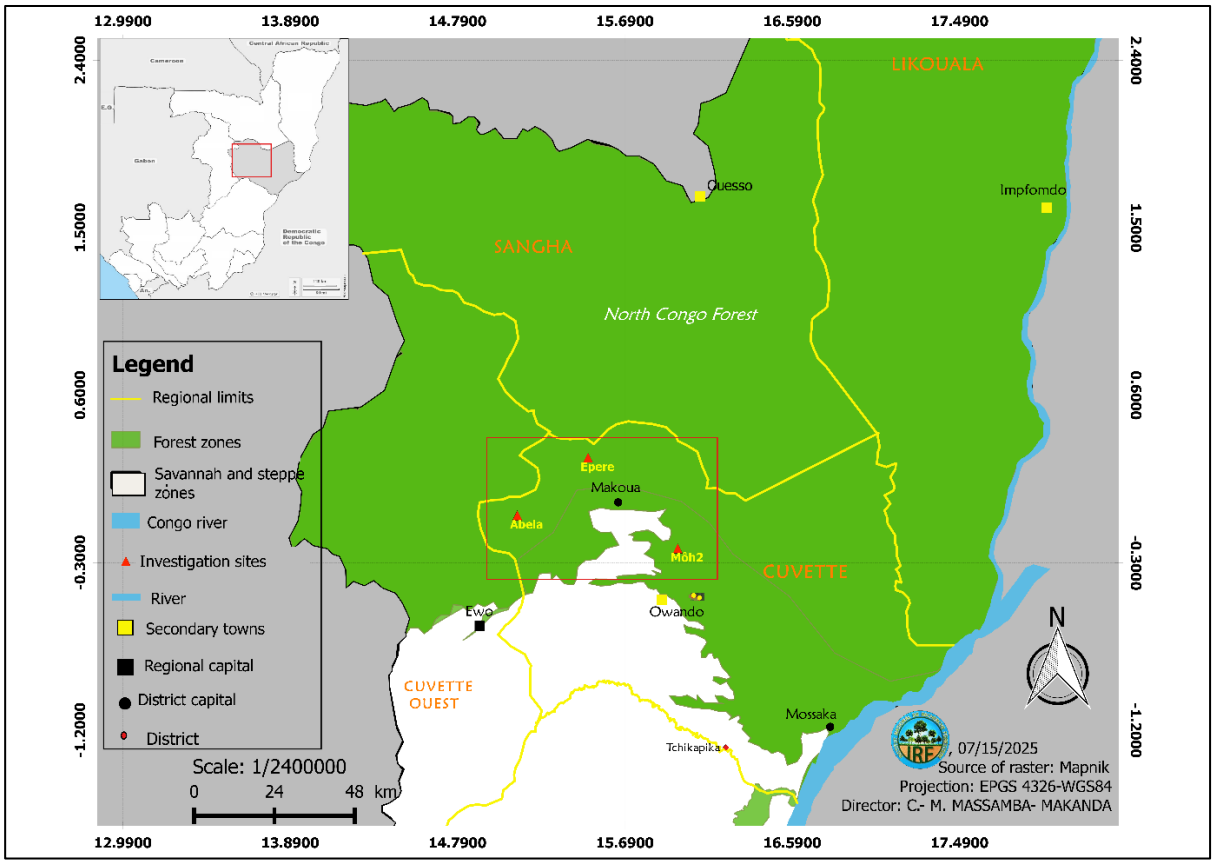

Figure 1. Location of study area

Material

The study material is centred around the three species identified, namely *R. hookeri* G.Mann & H.Wendl., *R.* cf. *gentiliana* De Wild. and *R. laurentii* De Wild. The ordination adopted was that of APG IV (2016) and the taxonomic nomenclature is in agreement with Lebrun and Stork (1991-2015). Identification was made in situ using reference manuals (Flora of Gabon, Flora of Central Africa, Diagnoses of Pauwels, Trees of the Sangha). However, these identifications were confirmed at the Congo herbarium (IEC) located at the Institut national de Recherche en Sciences Exactes et Naturelles (IRSEN).

Notwithstanding the data collected by the survey, these three species were monitored in the field in order to make an inventory in situ of the products cited by the populations and their uses. These products included, but were not limited to, the leaves, sap, apical meristem, fruit and larvae of *Rhynchophorus phoenicis* Fabricius.

Data collection methods

Criteria and choice of target population/surveyed

Without taking the notion of gender into account, the population targeted by the survey was chosen on the basis of being at least the possessor of traditional knowledge about raffia. The inclusion of minors (under the age of 18) in the study is explained by the fact that in the traditional communities investigated, 15 is the age at which, regardless of gender, an individual is likely to take responsibility for himself or herself and start a family. Finally, to be a permanent resident of the sites involved in the study and to carry out at least one of the activities associated with Raphia.

Bibliographic research

A review of the literature on raffia taxa and raffiales provided an overview of the subject. The findings of this research highlight the fact that these ecosystems are very little studied in the Congo, compared with neighbouring regions. Although not exhaustive, the ethnobotanical study of interactions between traditional Congolese communities and raffia and raffiales

raises the issue of sustainable management of these ecosystems, which are often described as fragile.

Sampling

A preliminary survey using non-probability sampling was carried out in the town of Makoua on a random sample of 516 people. This survey made it possible to determine the strata or villages close to the raffiales. For better representativeness of the study area, within the villages, proportional stratified random sampling was carried out to determine the informant sample (Tahri *et al*. 2012, Salhi *et al*. 2010, Benkhnigue *et al*. 2011). This sampling method enabled us to draw 40% of the male and female population aged 15 and over in Abela and Môh villages, and 30% of the same age group, all genders combined, in Epéré (Table 1).

Table 1. Distribution of population and respondents by study village.

Villages	Target population			Sample surveyed		
	Men	Women	Total	Men	Women	Total
Abela	47	56	103	20	22	42
Môh	45	53	98	18	22	40
Epéré	89	74	163	26	25	51
Total	181	183	364	64	69	133

Ethnobotanical surveys

Data collection, took place from 17 February 2021 to 15 March 2021 and from 15 September 2021 to 15 November 2021. Those data were collected using a structured questionnaire. Knowledge of Raphia was required prior to the interview. The questionnaire, written in French, was orally translated into local languages. Oral consent was obtained from each respondent prior to the questionnaire. The questionnaire was based on socio-professional data (age, gender, level of education, social situation and qualifications), knowledge of the types of use (food, medicinal and artisanal) of Raphia by the local population, the species used, the parts harvested, the frequency of harvesting and the marketing of the organs involved.

Data analysis

Ethnobotanical indexes

Knowledge assessment was based on ethnobotanical parameters (Randrianarivony 2015, Houéhanou *et al*. 2016, Olou *et al*. 2018). A total of nine parameters were monitored.

The citation frequency (FC) is equal to the number of citations (n_i) of a given usage category (Dossou *et al*. 2012)

$$FC = \sum n_i \quad (1)$$

The number of reported uses (Nur) is equal to the number of times a use category or species was mentioned (Houéhanou *et al*. 2014). It is therefore the sum of citations.

$$N_{ur} = \sum FC \quad (2)$$

The relative frequency of citation (RFC) is equal to the percentage of citations for a given use category. This data, which enables us to identify and detect differences, is calculated according to the formula used by Dossou *et al*. (2012)

$$RCF\ (\%) = \frac{FC}{N} \times 100 \quad (3)$$

With "S" the number of people who gave a response for a given use; "N" the total number of people interviewed.

The fidelity level (LF) of a species was calculated using the method of Friedman *et al*. (1986). The level of fidelity is equivalent to the number of informants having affirmed the use of a species in a given category (Np) in relation to the number of informants interviewed (N). This index measures the relative degree of use of each of the plants concerned (Olou *et al*. 2018). Index values range from 0 to 100%. The plant is recognized as single-use when the LF is higher (LF > 60%), fairly high when its value is in a range between 40 and 60% (40% < LF ≤ 60%), and lower (LF < 40%) when the plant is known as multiple-use (Randrianarivony 2015).

$$NF=\frac{N_p}{N}*100 \quad (4)$$

The cultural index of importance (CI) for each use category is equal to the ratio between the number of citations and the total number of people interviewed. The cultural index of importance for all use categories is equal to the sum of the cultural indices of importance for each use category. The cultural index of importance provides a special way of measuring the variation in knowledge between different communities and assessing the importance of a plant in a given use category (Houéhanou *et al*. 2016). The calculation is based on the formula of Tardio and Pardo de Santayana (2008).

$$CI = \sum_{u=u_1}^{u_{NC}} \sum_{I=1}^{I_N} \frac{UR_{ui}}{N} \quad (5)$$

Use value (UV) expresses the relative importance of each species for the population. An ethnobotanical use value was calculated using the formula defined by Phillips *et al*. (1994). This use value was calculated for each species in the three villages surveyed.

$$UV = \frac{\sum U}{n} \quad (6)$$

Where "U" is the number of citations per species and "n" the number of informants.

The informant consensus factor (ICF) ranges from 0 to 1. A high ICF value (close to 1) is obtained when a single or small number of species is cited by a large proportion of informants for a particular use category. A low CFI value reflects a high diversity of species cited for the same plant use category (Nzuki Bakwaye *et al*. 2013, Randrianarivony 2015). The Heinrich *et al*. (1998) formula is used to calculate this index.

$$ICF = \left(\frac{N_{ur-N_t}}{N_{ur-1}}\right) \quad (7)$$

With "Nur" the number of citations for each use category; "Nt" the number of species for the same category.

Survey diversity indices

The value of the diversity index (DI) of respondents by gender and social category was calculated by the formula used by Lougbegnon *et al*. (2015). This index measures respondents' level of knowledge about the different types of use of a given species. Values range from [0 to n]. The value is low when the index is below 3 (ID < 3); then medium when ID is between 3 and 4; high when the index value is greater than or equal to 4 (ID ≥ 4). When a small group of respondents hold the knowledge the value of ID < 3; a large number of respondents hold the knowledge then ID ≥ 4 and this knowledge is fair if ID is between 3 and 4 (Wédjangnon *et al*. 2016).

$$ID = -\sum (n_i/N)\log_2(n_i/N)\,; ID\ \mathcal{E}[0,n] \quad (8)$$

Where "ni": number of citations for a use category; "N": total number of citations for all use categories.

- The equitability index (EI) is the diversity value (ID) divided by the maximum diversity value index (ID max) obtained. The maximum index value is equal to :

$$ID_{max} = \log_2 n \quad (9)$$

Where "n" is the total number of respondents.

This index, which is given by the formula: IE =ID/IDmax, measures the degree of homogeneity of respondents' knowledge and ranges from [0 to 1] (Wédjangnon *et al*. 2016). If IE < 0.5 the diversity of respondents' knowledge is not homogeneous; on the other hand, if IE ≥ 0.5 this diversity is homogeneous. In the latter case, the distribution of knowledge is equitable within the populations surveyed, for Raphia palm use (Lougbegnon *et al*. 2015). Both indices were calculated to determine the variation in knowledge between gender and social categories.

Results

Socio-demographic profile of respondents

Of the informants involved (Table 2), the frequency by village is 32% in Abéla, 30% in Môh and 38% in Epéré. Gender categorization reveals a relative dominance of women at 52%, against 48% of men. The age criterion classifies informants into 4 groups, according to a 10-year interval. The contribution by age group shows a proportional increase in knowledge with the age of the subjects. The majority of informants (58%) are in the 35+ age bracket. This would appear to be the age group whose respondents are most active in the raffia industry. The group of informants treated according to level of education shows 5% with no schooling, and the remainder ranging from primary school to university. There is a clear predominance of respondents who have completed lower secondary school. Classification of respondents by socio-professional group reveals a wide variety of trades. Farmers and fishermen and/or hunters form the largest group, with 75% of respondents. In terms of marital status, 62% of respondents were married, compared with 48% who were single. These data show that, in the Makoua district, it is farmers and scholars, particularly those with lower secondary education, who influence the exploitation of Raffia.

Table 2. Frequency of citing Raphia uses by social category among those with at least one acquaintance

Characteristics		**Villages**					
		Abela		Môh		Epéré	
		FC	RFC (%)	FC	RFC (%)	FC	RFC (%)
Gender	Men	20	47.6	18	45	26	51
	Women	22	52.4	22	55	25	49
Marital status	Single	8	19	11	27.5	16	31.4
	Married	31	73.8	22	55	30	58.8
	Widower	1	2.4	6	15	3	5.9
	Divorced	2	4.8	1	2.5	2	4
Education level	Unschooled	1	2.4	3	7.5	2	3.9
	Primary	12	28.6	8	20	4	7.8
	1st level secondary	23	54.8	25	62.5	27	52.9
	2nd level secondary	6	14.3	2	5	17	33.3
	Bachelor	0	0	1	2.5	1	2
	Master's degree	0	0	1	2.5	0	0
Socio-professional status	Farmer	32	76.2	28	70	39	76.5
	Retailer	4	9.5	8	20	1	2
	Artisan	0	0	3	7.5	0	0
	Professional framework	1	2.4	0	0	3	5.9
	Worker	1	2.4	1	2.5	3	5.9
	student	4	9.5	6	15	8	15.7
	Other *	11	26.2	10	25	8	15.7
Age ranges	15-25 years	7	16.2	8	20	11	21.6
	26-35 years	11	26.2	10	25	7	13.7
	36-45 years	12	28.6	9	22.5	18	35.3
	Over 45	12	28.6	10	25	15	29.4

*hunter and/or fisherman.

Types of use for Raphia palms

Of the three Raphia species identified (*R. laurentii*, *R. cf gentiliana* and *R. hookeri*), three types of use were highlighted by the informants. In order of importance, these uses were for food (45%), handicrafts (41%) and medicinal purposes (14%).

Knowledge of communities, harvesting techniques and quantity of products harvested

Informant consensus factor

The consensus factor (Table 3) is high in all three use categories. However, in Abela the consensus on medicinal use is low.

Table 3. Degree of consensus among informants, by community, on *Raphia* palm products

Communities	Use categories		
	Alimentary	Medicinal	Artisanal
Abela	0.96	0.33	0.96
Môh	0.97	0.90	0.92
Epéré	0.97	0.94	0.96

Products and organs collected

The parts of Raphia palms used are numerous and their frequency of citation very uneven (Table 4). Vegetative parts (leaves, meristems and stipes) are more frequently collected than generative parts and sap.

Table 4. Frequency of citations for parts or organs used in Raphia palms

Organ or part	Abela		Môh		Epéré		Average ± SE	
	FC	RFC (%)	FC	RFC (%)	FC	RFC (%)	FC	RFC (%)
Leaves	40	95.24	32	80.00	51	100.00	41.00 ± 5.51	91.75 ± 6.03
Fruits	28	66.67	41	100.00	36	70.59	35.00 ± 3.79	79.09 ± 10.52
Sap	12	28.57	41	100.00	30	58.82	27.67 ± 8.45	62.46 ± 20.70
Meristems	13	30.95	35	87.50	12	23.53	20.00 ± 7.51	47.33 ± 20.20
Stem (stipe)	08	19.05	02	5.00	03	5.88	04.33 ± 1.86	09.98 ± 4.54
Inflorescence	00	0.00	01	2.50	00	0.00	00.33 ± 0.33	00.83 ± 00.83

Knowledge and importance of Raphia

In taxonomic and ethnic-linguistic terms, three species have been identified and are known to local residents in the study area. These species are *R. laurentii* (Ibu in Mbosi, Avugu in Akwa), *R. hookeri* (Abongo and Bongo in Akwa, Olènguè in Mbosi) and *R. cf. gentiliana* (Opégu in Akwa). These species are used for food, herbal medicine and handicrafts. Raphia, a spontaneous forest or savannah plant found in swampy to flood-prone environments, is unanimously used for socio-economic and cultural purposes in the traditional communities studied.

R. laurentii, a species with high ethnobotanical potential, is cited less frequently than *R. hookeri* and *R. cf. gentiliana*. Like the frequency of citation, the use value is not constant in the three communities. The highest value is found in Môh with *R. laurentii* and the lowest in Epéré with *R. cf. gentiliana*. The high potential use of *R. laurentii* can be explained by the fact that its products are sought after and used in all the categories recognized by the informants (Table 5).

Table 5. Variation in the use value of Raphia within communities

Species	Use value		
	Abela	Môh	Epéré
R. laurentii	1.31	1.85	1.51
R. hookeri	0.81	0.75	0.78
R. cf. gentiliana	0.30	0.10	0.06

Importance of using Raphia palms

Ethnobotanical surveys have identified the uses associated with Raphia palms in the region (Table 6). Despite some minor variations in the rate of items cited between villages, the use of Raphia palms is seamless for all communities. This observation is supported by the various parameters monitored, notably the level of loyalty, which, with the exception of the medicinal category, is fairly high without reaching 50%. The particularity of the medicinal category reveals the multiple-use attribute of raffia. The cultural importance index, ranging from 1.8 to 2.2, shows that there are few differences between communities in terms of the services provided by *Raphia* spp..

Community use of raffia taxa

The three communities unanimously share the same uses for the three taxa identified in the study area (Table 7). Despite this convergence of uses, ethnobotanical indices (RFC, LF and CI) reveal unequal exploitation of the resource between communities. On the whole, *R. hookeri* and *R. laurentii* are the most prized for food, as evidenced by the RFC and LF data. On the other hand, these same indices indicate that *R. laurentii* is the species par excellence associated with handicrafts. Finally, the medicinal aspect does not highlight any particular species. Analysis of the cultural importance index (CI) reveals

a clear difference in the use of taxa within and between communities. *R. cf. gentiliana* is the least well-known species at intra-site level, as evidenced by the ethnobotanical indices (RFC, LF, CI).

Table 6. Synopsis of Raphia ethnobotanical indices

Sites	Usages	FC	N_{ur}	RFC (%)	LF (%)	$\frac{FC}{N}$	CI
Abela	Alimentary	34	82	81.0	41.5	0.8	2.0
	Medicinal	8		19.1	9.8	0.2	
	Artisanal	40		95.2	48.8	1.0	
Môh	Alimentary	40	88	100.0	45.5	1.0	2.2
	Medicinal	19		47.5	21.6	0.5	
	Artisanal	29		72.5	33.0	0.7	
Epéré	Alimentary	41	88	80.4	46.6	0.8	1.8
	Medicinal	9		17.6	10.2	0.2	
	Artisanal	38		74.5	43.2	0.8	

FC = frequency of citation; FRC= relative frequency of citation; NF= level of fidelity; CI= index of cultural importance; Nur= reported number of uses.

Table 7. Comparative ethnobotanical indices for Raphia within sites

Location	Taxa	Uses	FC	N_{ur}	RFC (%)	LF (%)	$\frac{FC}{N}$	CI
Abela	*R. laurentii*	Alimentary	19	57	45.2	33.3	0.5	1.4
		Medicinal	5		11.9	8.8	0.1	
		Artisanal	33		78.6	57.9	0.8	
	R. hookeri	Alimentary	28	36	66.7	77.8	0.7	0.9
		Medicinal	2		4.8	5.6	0.1	
		Artisanal	6		14.3	16.7	0.1	
	R. cf. gentiliana	Alimentary	3	17	7.1	17.7	0.1	0.5
		Medicinal	2		4.8	11.8	0.1	
		Artisanal	12		28.6	70.6	0.3	
Môh	*R. laurentii*	Alimentary	40	73	100	54.8	1	1.9
		Medicinal	10		25	13.7	0.3	
		Artisanal	23		57.5	31.5	0.6	
	R. hookeri	Alimentary	17	30	42.5	56.7	0.4	0.7
		Medicinal	9		22.5	30	0.2	
		Artisanal	4		10	13.3	0.1	
	R. cf. gentiliana	Alimentary	2	4	5	50	0.1	0.2
		Medicinal	2		5	50	0.1	
		Artisanal	0		0	0	0	
Epéré	*R. laurentii*	Alimentary	37	77	72.6	48.1	0.7	1.5
		Medicinal	9		17.7	11.7	0.2	
		Artisanal	31		60.8	40.3	0.6	
	R. hookeri	Alimentary	22	40	43.1	55	0.4	0.8
		Medicinal	3		5.9	7.5	0.1	
		Artisanal	15		29.4	37.5	0.3	
	R. cf. gentiliana	Alimentary	1	3	2	33.3	0.02	0.1
		Medicinal	0		0	0	0	
		Artisanal	2		3.9	66.7	0.04	

Extraction of woody and non-woody Raphia products

Ethnobotanical indices (Table 8) reveal a unanimity of communities and a consensus on the quantities harvested. Generally, 1 to 11 leaves are harvested per individual, while 1 to 5 trunks are harvested simultaneously per person. As for sap extraction, the consensus is between 1 and 5 liters per day per raffia palm stipe. Finally, fruit collection data are variable, and dependence in descending order highlights the communities of Môh and Epéré. However, fruit collection is not a major

preoccupation for these communities, ahead of harvesting sap (raffia wine) and leaves as roofing material (especially known as "tile").

Table 9 shows the relative frequency with which the different methods of harvesting raffia products are cited. Harvesting for artisanal purposes is carried out by felling leaves, regardless of the community. The relative frequencies of citations for leaves are over 85% for all communities. As for the exploitation of stipe products for handicrafts, this harvesting method is specific to the Abela community. Lastly, for all communities, the food trait involves two harvesting methods: (i) standing and (ii) felling. Likewise, the collection of sap from standing trees is a practice common to all communities. The relative frequencies of citations for the felling of individuals are generally low for all communities. The highest proportion is recorded in Abela (21.4%), which is 4 times higher than Epéré and almost 9 times higher than Môh. Data on the standing harvest of Raphia products show decreasing citation frequencies from Môh to Epéré to Abela.

Table 8. Frequency with which Raphia products are cited for picking

Organs or products	Quantity withdrawn	Abela		Môh		Epéré		Average ± SE	
		FC	RFC (%)	FC	RFC (%)	FC	RFC (%)	FC	RFC (%)
Leaves	01-11	21	84	25	92.5	29	80.6	25.00 ± 2.31	85.70 ± 3.54
	12-14	0	0	1	3.7	2	5.6	01.00 ± 0.58	03.10 ± 1.64
	15-20	3	12	1	3.7	5	13.9	03.00 ± 1.15	09.87 ± 3.13
Stem (stipes)	01-05	21	91.3	22	84.6	27	87.1	23.33 ± 1.86	87.67 ± 1.95
	06-09	2	8.7	2	7.7	1	3.2	01.67 ± 0.33	06.53 ± 1.69
	10-plus	0	0	2	7.7	3	9.7	01.67 ± 0.88	05.80 ± 2.96
Sap (in liters)*	03-05	2	100	16	55.2	9	75	09.00 ± 4.04	76.73 ± 12.96
	06-10	0	0	13	44.8	3	25	05.33 ± 3.93	23.27 ± 12.96
Fruits	01-19	2	28.6	6	54.5	1	50	03.00 ± 1.53	44.37 ± 7.99
	20-39	2	28.6	3	27.3	1	50	02.00 ± 0.58	35.30 ± 7.36
	40-plus	3	42.9	2	18.2	0	0	01.67 ± 0.88	20.37 ± 12.43

(*) quantity harvested per day and per plant

Table 9. Frequency with which Raphia products are cited for sampling

Purpose of sampling	Extraction technique	Abela (FRC %)	Môh (FRC %)	Epéré (FRC %)	Average ± SE
Artisanal use	Standing cutting	97,62	65,00	68,63	77,08 ± 10,32
	Trunk cutting	38,09	0,00	0,00	12,7 ± 12,7
Alimentary use	Standing cutting	73,81	87,5	74,51	78,61 ± 4,45
	Trunk cutting	21,43	0,00	0,00	7,14 ± 7,14
Medicinal use	Standing cutting	7,14	45,00	15,69	22,61 ± 11,46
	Trunk cutting	4,76	0,00	0,00	1,59 ± 1,59

Picking frequency for prized products

Citations by product category

Tracking the frequency of product sampling reveals that communities do not invest the same amount of time and effort in all product categories. While the food aspect is almost universally appreciated by the three communities, without reaching a frequency of citations of 50%, traditional herbal medicine and handicrafts are not as popular (Fig. 2). Peak collection periods for Raphia products vary according to use category, and even within communities. While the Abela community focuses almost regularly on food and handicrafts, the other two exploit all three compartments with varying frequency and periodicity.

Citations by product type

While there is unanimous agreement that all types of products are used by the communities, the rate at which each is harvested, as measured by the frequency with which they are cited, varies greatly from one community to another (Fig. 3). Although available all year round, these products are not collected on a sustained basis in all communities. In addition to these aspects, the data suggest a certain degree of specialization or even preference among communities in the use of raffia products.

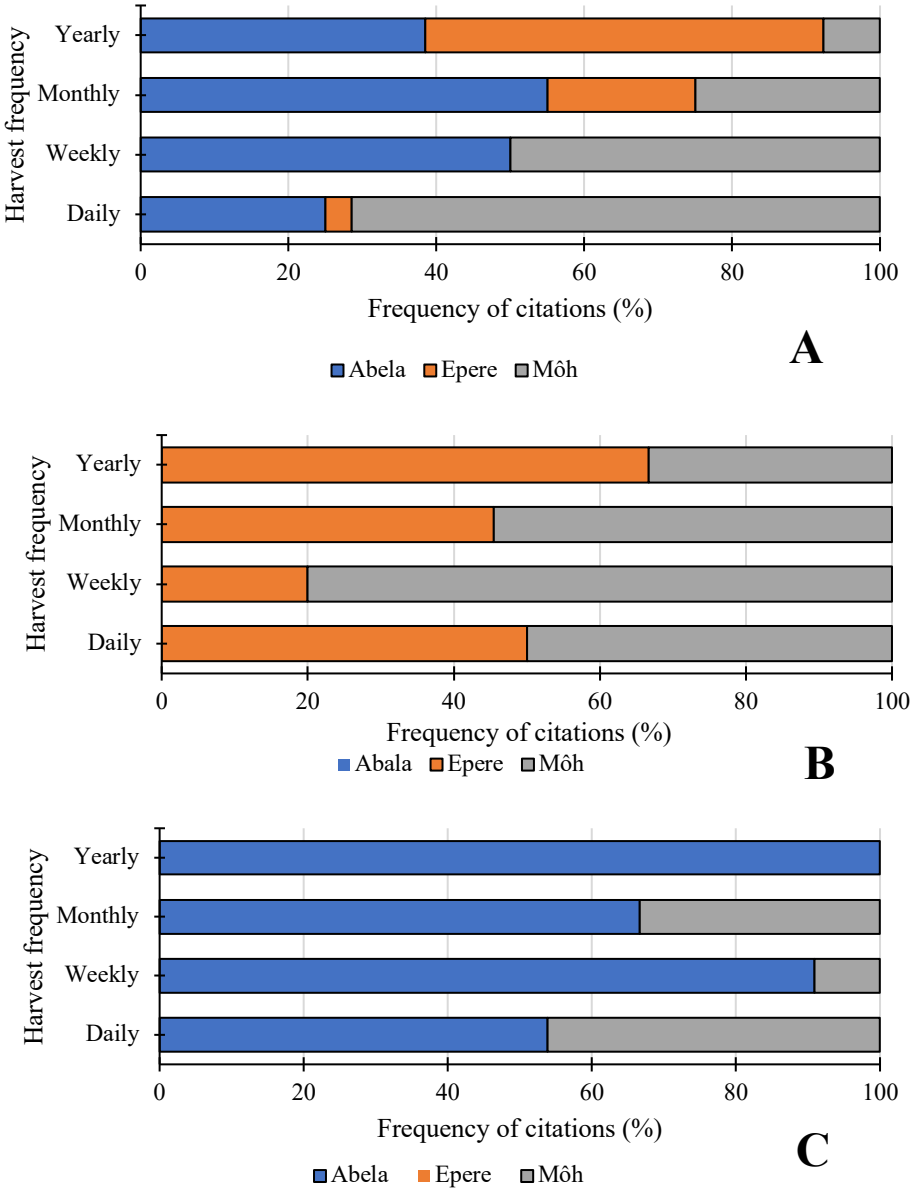

Figure 2. Raphia harvesting frequencies as a function of time. Food (A); Medicine (B); Crafts (C)

Valuation of incomes from Raphia products

The income generated by Raphia products varies from one community to another, but is at least significant, even if the frequency of citations is generally low (Fig. 4). Depending on the community, income is generated by sap, fruit, leaves and meristems. The highest incomes seem to be found in Môh and Abela, with Epéré recording less significant incomes.

Differences in the use and exploitation of resources according to socio-professional category

Categories of raffia use by socio-professional category

Table 10 shows the knowledge of the socio-professional groups regarding the uses of Raphia. An analysis of this data shows that people are familiar with the food and craft uses of Raphia, regardless of the group to which they belong. However, few people know anything about the medicinal uses of the species inventoried.

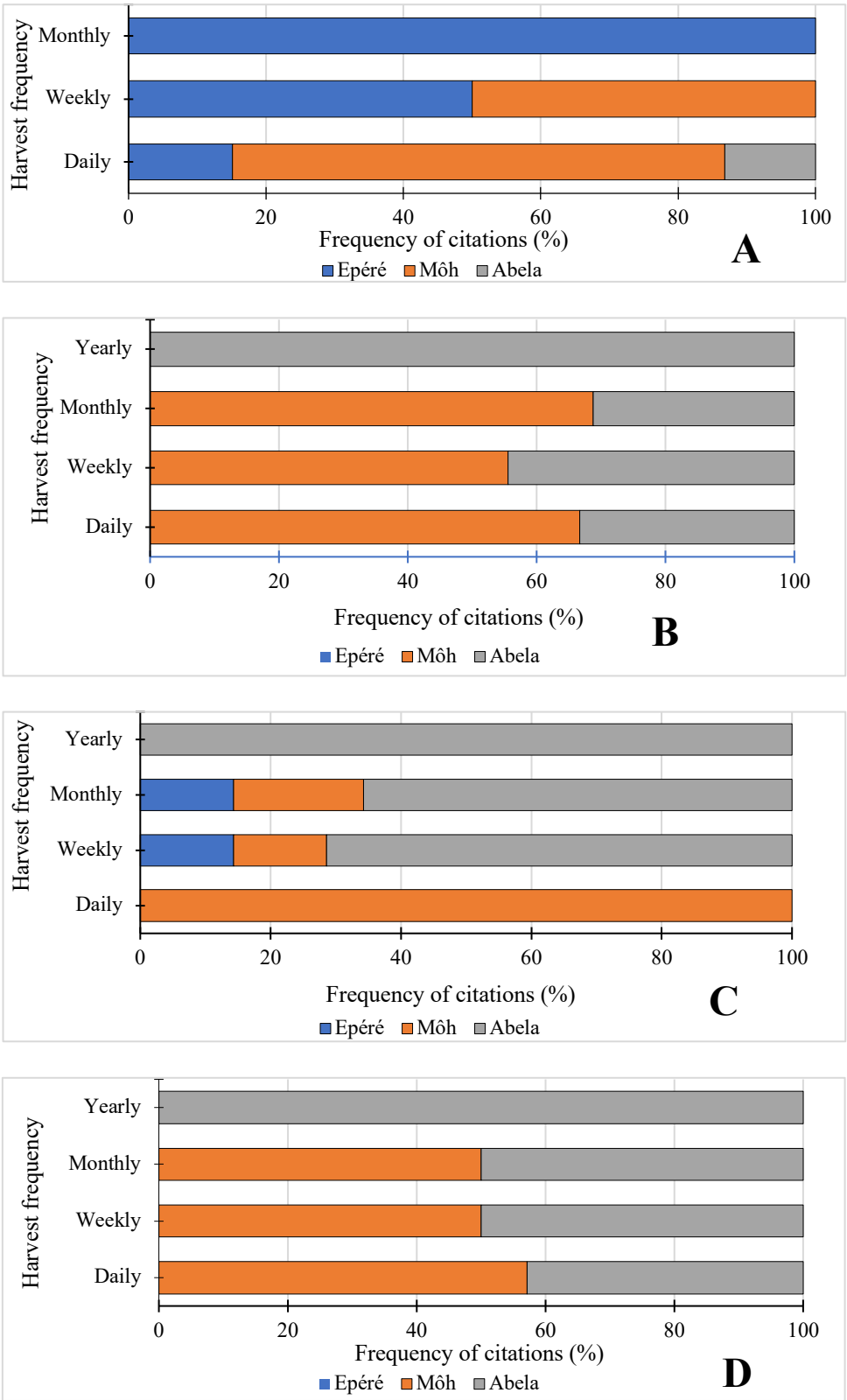

Figure 3. Temporal frequencies of Raphia product sampling. Sap (A) : Fruits (B), Larvae (C), Meristems (D)

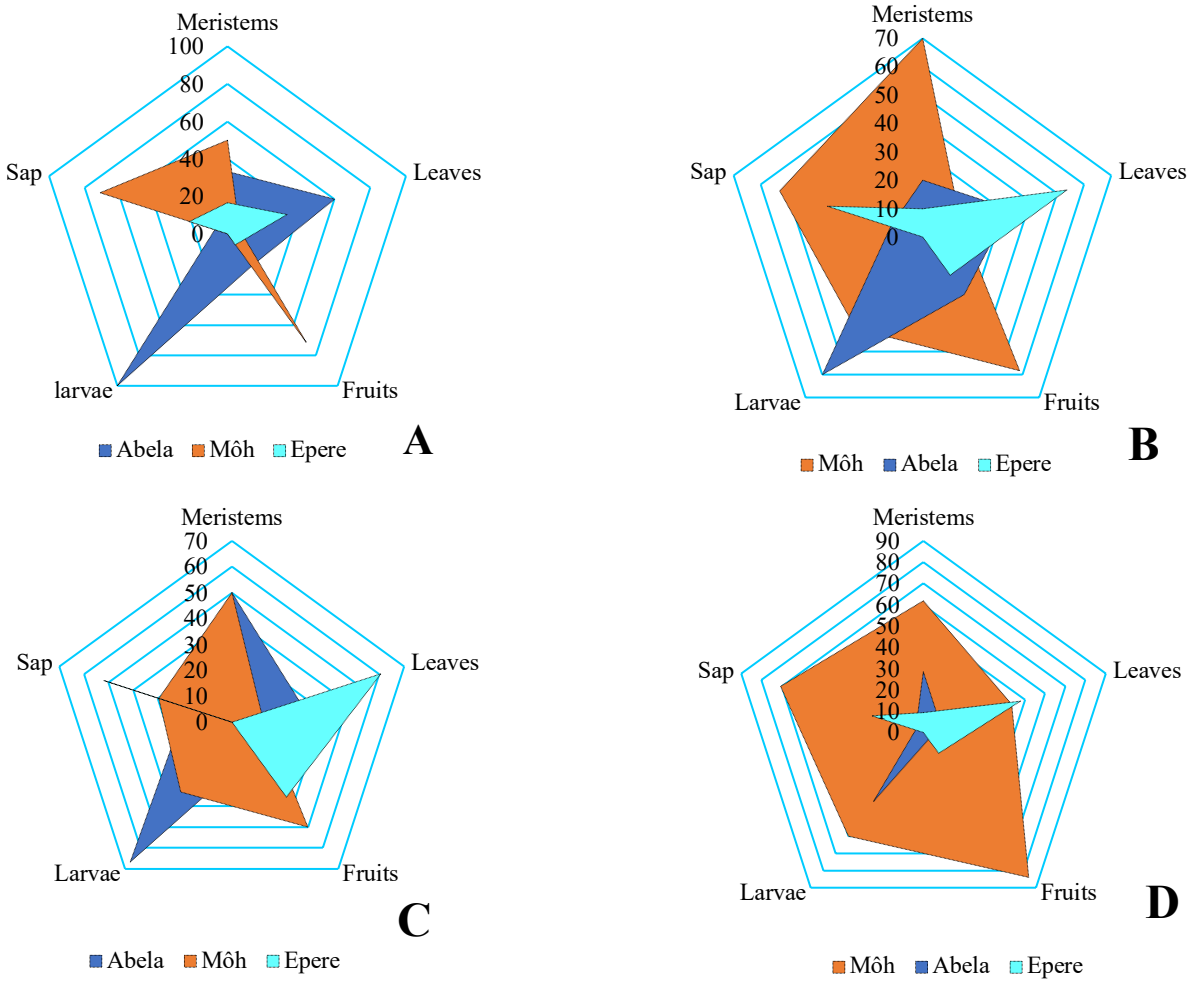

Figure 4. Appreciation of Raphia harvesting in income generation. not important (A), not very important (B), fairly important (C), very important (D)

Table 10. Citation of uses of raffia by socio-professional category

Socio-professional categories		Categories of use							
		Alimentary		Medicinal		Handicrafts		Average ± ES	
		FC	FRC (%)	FC	FRC (%)	FC	FRC (%)	FC	FRC (%)
Gender	Men	60	86.96	15	21.74	57	82.61	44,00 ± 14,53	63,77 ± 21,05
	Women	55	85.94	16	25.00	55	85.94	42 ,00 ± 13,00	65,63 ± 20,31
Marital status	Single	30	85.71	9	25.71	27	77.14	22 ,00 ± 6,56	62,86 ± 18,74
	Married	71	85.54	21	25.30	75	90.36	55,67 ± 17,37	67,07 ± 20,93
	Widower	10	100.00	1	10.00	6	60.00	5,67 ± 2,60	56,67 ± 26,03
	Divorced	4	80.00	0	0.00	4	80.00	2,67 ± 1,33	53,33 ± 26,67
Education level	Unschooled	6	100.00	2	33.33	5	83.33	4,33 ± 1,20	72,22 ± 20,03
	Primary	22	91.67	3	12.50	23	95.83	16,00 ± 6,51	66,67 ± 27,11
	1st level secondary	65	86.67	21	28.00	62	82.67	49,33 ± 14,19	65,78 ± 18,92
	2nd level secondary	19	76.00	4	16.00	20	80.00	14,33 ± 5,17	57,33 ± 20,69
	Bachelor	2	100.00	0	0.00	1	50.00	1,00 ± 0,57	50,00 ± 28,87
	Master's degree	1	100.00	0	0.00	1	100.00	0,67 ± 0,33	66,67 ± 33,33
Ranges of age	15-25 years	20	76.92	7	26.92	21	80.77	16,00 ± 4,51	61,54 ± 17,34
	26-35 years	24	85.71	8	28.57	21	75.00	17,67 ± 4,91	63,09 ± 17,54
	36-45 years	34	87.18	8	20.51	34	87.18	25,33 ± 8,67	64,96 ± 22,22
	Over 45	34	91.89	7	18.92	33	89.19	24,67 ± 8,84	66,67 ± 23,89

Informant consensus factor

The values of the informant consensus factor (Table 11) are high overall. However, low values were noted for medicinal use among widowers, the uneducated, those with an elementary level of education and university graduates. This trend is also observed for food use among divorcees and masters-level scholars. For craft use, only master's level scholars show a low consensus. The values of the informant consensus factor differ very little between the genders.

Table 11. Degree of consensus among informants on categories of uses for Raphia palm

Social groups		**Categories of use**		
		Alimentary	Medicinal	Handicrafts
Gender	Men	0,98	0,94	0,97
	Women	0,97	0,88	0,96
Age group	15- 25 years	0,96	0,71	0,92
	26 - 35 years	0,97	0,71	0,90
	36 - 45 years	0,96	0,91	0,94
	Over 45	0,96	0,86	0,95
Marital status	Married	0,98	0,90	0,97
	Single	0,97	0,75	0,92
	Widower	0,78	0,00	0,80
	Divorced	0,33	1,00	0,67
Education level	Unschooled	0,86	0,00	0,75
	Primary	0,93	0,33	0,91
	1st level secondary	0,98	0,92	0,98
	2nd level secondary	0,93	1,00	0,96
	Bachelor	0,50	0,00	0,50
	Master's degree	0,00	0,94	0,00

Diversity and equity of knowledge

Table 12 shows the knowledge diversity indices for the three communities (Abela, Môh and Epéré). With a low knowledge diversity index (ID < 3), a small group of informants have information on the uses of Raphia. When the knowledge equitability index is high (IE > 0.5), a homogeneity of knowledge within the communities is revealed. Equitability of knowledge about the Raphia palm within the community is also observed at the gender level. Notwithstanding this observation, women and men have equally diverse knowledge. Married and single people have a greater diversity of knowledge than others. People over the age of 45 have the least knowledge, which suggests that young people are interested in preserving endogenous knowledge about Raphia. In terms of level of education, the knowledge of scholars is not very diversified and is not equitable in relation to other levels of education.

Table 12. Knowledge diversity indices as a function of socio-cultural parameters

Categories	**Informants**	**Abela**		**Môh**		**Epéré**		**Average ± ES**	
		ID	IE	ID	IE	ID	IE	ID	IE
Gender	Men	1,36	0,86	1,56	0,96	1,33	0,84	1,42 ± 0,06	0,89 ± 0,03
	Women	1,36	0,86	1,50	0,95	1,41	0,89	1,42 ± 0,03	0,90 ± 0,02
Marital status	Single	1,30	0,82	1,52	0,96	1,45	0,91	1,42 ± 0,05	0,90 ± 0,03
	Married	1,73	0,74	1,55	0,98	1,36	0,86	1,55 ± 0,09	0,86 ± 0,06
	Widower	1,00	1,00	1,22	0,77	1,00	1,00	1,07 ± 0,06	0,92 ± 0,06
	Divorced	1,00	1,00	0,00	0,00	0,92	0,92	0,64 ± 0,26	0,64 ± 0,26
Ranges of age	15-25 years	1,28	0,81	1,52	0,96	1,38	0,87	1,39 ± 0,06	0,88 ± 0,04
	26-35 years	1,46	0,92	1,53	0,96	1,38	0,87	1,46 ± 0,04	0,92 ± 0,02
	36-45 years	1,31	0,83	1,51	0,95	1,38	0,87	1,40 ± 0,05	0,88 ± 0,03
	over 45	1,32	0,83	1,52	0,96	1,30	0,82	1,38 ± 0,06	0,87 ± 0,04
Education level	Unschooled	1,00	1,00	1,46	0,92	1,52	0,96	1,33 ± 0,13	0,96 ± 0,02
	Primary	1,40	0,89	1,48	0,94	0,99	0,99	1,29 ± 0,12	0,94 ± 0,02
	1st level secondary	1,39	0,88	1,55	0,98	1,38	0,88	1,44 ± 0,04	0,91 ± 0,03
	2nd level secondary	0,97	0,97	1,50	0,95	1,38	0,87	1,28 ± 0,13	0,93 ± 0,02
	Bachelor	0	0	0	0	1,00	1,00	0,33 ± 0,27	0,33 ± 0,27
	Master's degree	0	0	1,00	1,00	0	0	0,33 ± 0,27	0,33 ± 0,27

ID = knowledge diversity index ; IE = knowledge equitability index

Discussion

Identification of Raphia and endogenous knowledge

The importance attached to food and handicrafts could be explained by the value placed on the sum of folk knowledge that lies dormant in each individual. This observation is all the more plausible given that traditional practitioners are almost non-existent in the study area. From an ethnic-linguistic and floristic point of view, populations clearly differentiate between *R. laurentii*, *R. hookeri* and *R. cf. gentiliana*. Indeed, there is no ambiguity in the identification of the three species, each of which has a different vernacular name. This distinction or even recognition is more plausible insofar as these three taxa occupy specific ecological niches.

The people of the Makoua district have knowledge of the three Raphia species identified, which play a key role in satisfying their needs, as evidenced by their use values. The reason for this is linked to their distribution, potential and the habits and customs of the local population. Raffia is best associated with food and craft uses, confirming the observations made by Donou Hounsodé *et al*. (2014, 2016) in Benin and Nkontcheu Kamta *et al*. (2021) in Cameroon. The medicinal use of raffia, less well known to the populations investigated, would appear to be the prerogative of certain individuals. The use of the three species is not indifferent among the populations; a certain preference is noted for *R. laurentii* and *R. hookeri*, due to the availability of the resource.

With regard to the transmission of endogenous knowledge about raffia within the traditional societies surveyed, individuals of different ages have a relatively similar level of knowledge on a global scale. In addition to the level of knowledge, the transmission of endogenous knowledge is gender-neutral, with young people possessing more diversified knowledge than their elders. In the general population, as the transition from one age group to another is followed by a decline in the number of individuals (INS 2023), so the transmission of knowledge from older to younger people.

Despite the knowledge gathered on Raphia and raffiales in the Makoua area, this study could be extended to other localities (Adjanohoun *et al*. 1988, Diop *et al*. 2019). This finding, although revealing the limitations of this study, is not typical of the Makoua raffiales. Although this study is specific to this area, it has highlighted the level of knowledge of local populations about Raphia.

Survival of raffia stands and human activities

In the context of daily use, the survival of an individual depends on the parts that are harvested (Betti 2001). While the removal of a few leaves or sap poses no major risk to the populations of each raffia species, felling irreversibly condemns the plant. Despite the unanimity of communities in exploiting raffia products through the same practices, the intensity or degree of anthropic pressure on the resource differs greatly. Community dependence is not expressed with the same acuity and varies from one community to another. Overall, anthropic pressure on Raphia is more marked in Abela, where stipe felling is more widespread, than in the other two communities (Môh and Epéré).

In all the sites surveyed, only *R. laurentii* is found in pure stands (raffiale), while the other two (*R. hookeri* and *R. cf. gentiliana*) are found in the form of often isolated individuals. These data reveal that the various species are not subject to the same degree of anthropic pressure, and do not have the same socio-economic and cultural value.

Construction and craft equipment

The models of traditional dwellings and the various objects made from Raphia are the concrete translation of people's knowledge and know-how in mastering the uses of these taxa (Kouakou *et al*. 2020). Knowledge of the artisanal use of plants is more pronounced in Abela and Epéré than in Môh. What's more, for this use, *R. cf. gentiliana* is less well known than *R. laurentii* and *R. hookeri*. In the age of modernity, and as a result of the pressures experienced, raffia products and those brought in by modernism coexist in habitat construction. However, at the study sites, corrugated iron roofs dominate over straw (essentially R. spp. leaves). It's worth noting that in the region, traditional building materials are in decline in the face of the modern world. Raphia's use in construction is tending to disappear, although this is noted by the people we interviewed. The reason for this is that modern materials offer greater resistance to the elements. In view of this trend, anthropic pressure on raffia and raffiales could be reduced, helping to conserve ecosystems and biodiversity. Ipso facto, to combat the erosion of knowledge due to the disappearance of the basic material.

As far as the manufacture of objects and utensils is concerned, this need often covers the performance of operations linked to daily activities. Objects and utensils are used for drying or smoking food, games, hygiene, fishing, worship, textiles and culture. Similar uses are noted in other traditional communities, in Congo and elsewhere, where raffia is present (Ndenecho,

2007, Donou Hounsodé *et al*. 2014, 2016, Ouattara *et al*. 2015, Nkontcheu Kamta *et al*. 2021). The use of Raphia for these purposes reflects the habitus of the Makoua populations, synonymous with a certain conservation of endogenous knowledge. Although modern objects are often easier to use and supposedly more resistant (Kouakou *et al*. 2020, Litta *et al*. 2021), the prohibitive cost compared to the relative gratuity of Raphia exploitation consolidates the place of these plants within the traditional communities of Abela, Môh and Epéré. However, although recognized and mastered, the manufacture of textile fibers and/or textiles is only used for cultural purposes, notably during traditional ceremonies or for marketing (Kimpouni & Nguembo 2018). From a fishing perspective, despite the manufacture of creels, Kimpouni *et al*. (2011) also noted ichthyotoxic effects of fermented immature Raphia fruits in related communities.

Contribution to phytotherapy and nutrition

The use of Raphia in traditional medicine is little known to the populations surveyed, and seems to be the preserve of a few knowledge-holders. Indeed, the species investigated for this study show a relatively low consensus of phytotherapeutic use. The use of raffia oil is mentioned more or less everywhere, with a frequency barely higher than that of leaf ash, which is clearly rarer. Nut pulp, not mentioned by Makoua's traditional communities, is in common use in Benin (Donou Hounsodé *et al*. 2014, 2016). The use of raffia products (oil, leaves and pulp) is supported by pharmacological studies highlighting their antioxidant properties (Abimbola *et al*. 2018, Syllou-Kongo *et al*. 2023). Overall, studies carried out in several African communities recognize few medicinal uses (Ndenecho 2007, Donou Hounsodé *et al*. 2014, 2016, Ouattara *et al*. 2015, Nkontcheu Kamta *et al*. 2021).

Strictly speaking, the contribution to the diet is limited to wine from the sap and oil from the nuts of the various raphias. Sensu lato, the collection of R. phoenicis larvae is added to the raffia wine.

Source of income

Most of the traditional societies investigated are peasant farmers. The sale of Raphia products would be a means of diversifying sources of income. As asserted by Paumgarten (2005) and Kar and Jacobson (2012), NTFPs act as a safety net to fill gaps in the event of an agricultural deficit or other type of emergency, as a food supplement or household income. As incomes vary greatly from one community to another, NTFPs are not the main activity, but rather a bridging activity for most. In fact, the harvesting of raffia products is not seasonal, even if some minor differences are observed (Elenga Pea 2023). For traditional communities, the exploitation of NTFPs, depending on the type, instead of serving as an "economic buffer in difficult times", is sometimes the annual basis of household income. This observation is illustrated by the examples of raffia wine harvesting, a permanent activity and a guarantee of household income, and R. phoenicis larvae intended solely for food and not for marketing, except in exceptional cases.

Conclusion

The study materializes the inventory of traditional knowledge associated with genetic resources with high economic and promising potential, including raffia. The study identified three species (*R. laurentii*, *R. hookeri* and *R. cf. gentiliana*) that contribute to satisfying the daily and basic needs of local residents. Endogenous knowledge relating to raffia is essentially associated with food and handicrafts. Indeed, the medicinal properties of raffia trees are not widely known in Africa in general, and in the Congo in particular.

Product collection methods, coupled with the pace of harvesting, have led to a rarefaction of certain raffia taxa. The corollary for these taxa, with the exception of *R. laurentii*, is the failure to form pure stands. Thus, the combined effects of vulnerability, forest degradation through agricultural activities, timber harvesting and housing development may be a source of erosion of endogenous knowledge, which is likely to disappear. This would be a disaster both for the ecosystems and for the people living near the raffia plantations, given the income derived from the sale of raffia products.
Future studies could focus on: (i) natural regeneration mechanisms; (ii) domestication trials of taxa of the genus Raphia and (iii) a market study with a view to estimating demand as a function of resource availability.

Declarations

List of abbreviations: Non-Timber Forest Products: NTFP, Food and Agriculture Organisation: FAO,
Ethics approval and consent to participate: The purpose of the study was explained to the community members interviewed, and they were asked to give an explicit oral consent. The study adheres to the Nagoya Protocol under the Convention on Biological Diversity, ensuring fair and equitable benefit sharing.
Consent for publication: Not applicable

Availability of data and materials: Data will be available from the corresponding author upon reasonable request.
Competing interests: The authors do not have any competing interests.
Funding: This research did not receive funding.
Author contributions: VK: Conceptualization, Methodology, Supervision, Validation. CMMM, JCM and NPEP: Methodology, Data collection, Interviews, Writing-original draft. OCTBN and GBB: Data curation, Formal analysis, Writing-original draft. All authors read, reviewed and approved the final version of the manuscript.

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Photographic plate

Photo 1: Palisade made of petioles of *Raphia laurentii* and roof covered with leaves of the same species.

Photo 2: Broom made of the leaves of *Raphia* spp.

Photo 3 : Cassava spread made from the petioles of *Raphia* spp.

Photo 4 : *Raphia cf. gentiliana* in a cassava field

Photo 5 : *Raphia laurentii* pruned for sap harvesting.

Photo 6 : Toy based on the parenchyma of the petioles of *Raphia laurentii*