Application of Ethnobotanical Indices to Assess the Diversity of Medicomagic Knowledge on Four Herbaceous Species in Benin.

Hubert Olivier Dossou-Yovo (✉ dohuoly@yahoo.fr)

Laboratory of Applied Ecology <https://orcid.org/0000-0001-9913-6626>

Valentin Kindomihou

Laboratory of Applied Ecology, Faculty of Agronomic Sciences, University of Abomey-Calavi.

Brice Sinsin

Laboratory of Applied Ecology, Faculty of Agronomic Sciences, University of Abomey-Calavi.

Research

Keywords: Ethnobotanical Indices, Herbaceous, Medicinal, Magic Exploitation

Posted Date: October 27th, 2020

DOI: <https://doi.org/10.21203/rs.3.rs-96891/v1>

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Abstract

Background

Ethnobotanical knowledge on four herbaceous species, *Phyllanthus amarus*, *Spilanthes uliginosa*, *Momordica charantia* and *Acalypha ciliata* in Benin was investigated.

Methods

Thirty-six herbal medicine traders in six different markets were interviewed using a semi-structured questionnaire. The Relative Frequency Citation, Fidelity Level, Use Value and Rahman Similarity Index were calculated to assess the diversity of medico-magic knowledge.

Results

All informants traded *P. amarus*, *M. charantia* and *A. ciliata* and the majority traded *S. uliginosa*. Purchase in traders' own markets was the predominant source of *P. amarus*, *M. charantia* and *A. ciliata* while *S. uliginosa* was mostly purchased in other more distant markets. A noticeable proportion of traders also collect *P. amarus* and *M. charantia* from wild populations. *Phyllanthus amarus* was the species most demanded by customers followed by *M. charantia*. Traders confirmed the scarcity of all species in recent years and climate change as well as destruction of natural habitats for logging were the most cited causes. The entire plant of *P. amarus* was used mainly to treat malaria, diabetes and constipation and decoction with oral administration the most frequent preparation for malaria treatment. To treat diabetes, informants mixed *P. amarus* with *M. charantia* used as a decoction with oral administration. *Momordica charantia* was also used to treat measles and chicken pox. *Spilanthes uliginosa* and *A. ciliata* were mostly used for their spiritual use for luck, predominantly by chewing fresh leaves or flowers, and by bathing with the ground plant mixed with soap, respectively. Overall, *M. charantia* had the greatest use value followed by *P. amarus*. The majority of traders do not plant the species.

Conclusions

The harvesting and trade of the species threaten their natural populations and urgent tools, including *in-situ* and *ex-situ* conservation, are needed to ensure their long-term sustainable exploitation.

Introduction

The green medicine is obviously of major importance to mankind [1–3]. Gathering of high value products including medicinal plants from the wild continues in developing countries [3, 4]. Moreover, medicinal plants harvested from the wild serve as raw materials for commercial pharmaceutical factories [3, 5]. Thus, medicinal plants are important in both developed and developing countries and there is an increasing need to gather knowledge related to their exploitation and to define conservation strategies for long-term exploitation. Amongst medicinal plants, herbs have a great importance [6, 7] as they are accessible to many people.

Ethnobotanical indices have been applied to evaluate ethnobotanical knowledge on plant species in other parts of the world [8–10] but not in Benin. Indeed, quantitative ethnobotany is concerned with measuring the importance of plants and vegetation for human well-being, as well as it relies on cultural significance indices as quantitative tools for qualitative data [11–13]. Because this approach is likely to generate data that lend themselves to hypothesis testing, statistical validation and comparative analysis [10], applying specific ethnobotanical indices may either serves in analysing the range of information related to plants used for medico-magic purposes. The present research focused on four herbaceous species known as medicinal plants in Benin, *Phyllanthus amarus* Schumach. & Thonn., *Spilanthes uliginosa* Sw., *Momordica charantia* L. and *Acalypha ciliata* Farssk.. These species have been reported as used in green medicine in many parts of the world [14–17]. There is a lack of ethnobotanical information on them in Benin although Boko-Haya et al. [18] reported the ethnic differences in use of *P. amarus* in Northern Benin. Many years ago, this species was also tested for its antiparasmodial activity in Benin [19]. The aim of the present research was to document the medico-magic knowledge held by herbal medicine traders on these herbaceous species in Southern Benin through the application of four ethnobotanical indices i.e. Relative Frequency Citation [20, 21, Fidelity Level [22–24], Use Value [20, 21, 25], and the Rahman Similarity Index [26].

Material And Methods

1- Study species

Phyllanthus amarus Schumach. & Thonn., (Hinlinwé in Fon), belongs to Euphorbiaceae, is an annual herb, 60–75 cm tall and quite glabrous. Its roots are stout and woody; the stems are branched at the base and angular with numerous leaves. The plant naturally grows in tropical and subtropical climates on well drained sandy-loam soils [27]. It protects the liver and limits the effects of viral hepatitis A, B, and C, reduces type 2 diabetes, helps fighting cancer and detoxify the body [28].

Spilanthes uliginosa Sw. (Awélékpékpé in Fon), as an Asteraceae, is an annual herb with simple leaves and pungent flowers [29], liking humid places and superficially drained Sudanian swamps, and sometimes ruderal. The species is used for dental problems and for its antiseptic, homeostatic, analgesic, insecticidal and anti-inflammatory activity [30].

Momordica charantia L. (Yinsinkin in Fon), from Cucurbitaceae, commonly called bitter-melon or ampalaya, grows 12 to 20 cm long. Its fruits ripen from green to yellow and ripe fruits are ornamentally attractive but malodorous [31]. It is a pantropical vegetable originated in tropical Africa [32]. Fruit also is carminative, tonic, stomachic, aphrodisiac, anthelmintic, astringent to bowels and useful in treatment of syphilis, rheumatism, spleen troubles, and effectiveness in treating diabetes [33].

Acalypha ciliata Farssk. (Viviman téton in Fon), is an Euphorbiaceae occurring widely in Africa. It is uncommon crop weed in heavily watered areas [34, 35], a monoecious annual herb tilled up to 1 m with simple leaves at 2 mm long stipules linear at blade ovate. Fruits are 3-lobed capsule, smooth, almost glabrous [36]. Foliar powder or infusion is used for maggot-infested wounds [37].

2. Ethnobotanical data collection

Two markets in each of three districts of Benin were surveyed, Pahou and Zobê in Ouidah District, Cococodji and Godomey in Abomey-Calavi District, Vêdoko and Dantokpa in Littoral District. Six herbal medicine traders were randomly selected in each market and ethnobotanical data were gathered from them on each of the four study species. A total of 36 traders were thus surveyed. A semi-structured questionnaire was used in collecting data on the trade, sources and importance of each species. Traders were asked to rank the four species according to consumer demand and the availability versus scarcity of each species in recent years. The various causes of scarcity were also recorded. In addition, herbal medicine traders were asked to list all diseases, disorders and magic issues treated using each species as well as all types of preparation used for these purposes. In order to assess traders' contribution to the research species conservation, the plantation or *in-situ* conservation of each species by traders and their motives were investigated. Each time an informant confirmed the trade of a species, they were asked to show a sample for positive identification. All interviews were conducted in the local language, Fon, well spoken and understood by all informants.

3. Ethnobotanical indices calculation for data analysis

(a) The Relative Frequency Citation (RFC) [20, 21], was calculated using the following formula:

$$RFC = \frac{n_i}{N} \times 100, (1)$$

where n_i is the number of informants who mentioned the concerned species, thing or aspect and N is the total number of surveyed traders.

(b) The Fidelity Level (FL) [22 – 24] was determined for the diseases as follows;

$$FL(\%) = \frac{I_p}{I_u} \times 100, (2)$$

where I_p is the number of informants who mentioned the use of a species for a specific disease, disorder or magic issue and I_u is the total number of informants who mentioned the species for any use. The FL was also calculated in a similar way for the types of preparation recorded for each disease, disorder or magic issue. The FL served to assess the informants' preference for a species to treat a specific disease, disorder or magic issue. It also served to assess the preference for a specific type of preparation. FL ranges from zero to a hundred per cents and a value close to 100% means a high preference.

(c) The Use Value (UV) of each species was determined [20, 21, 25].

$$UV = \frac{n_d}{I_u}, (3)$$

where n_d is the total number of use reports (diseases, disorders or magic utilization) mentioned for a species and I_u is the total number of informants who mentioned the species for any use. The use value served to compare the relative importance of the study species in terms of uses.

(d) The ethnobiological Rahman Similarity Index (RSI) [26], to assess the similarity between species in terms of uses, was calculated as follow:

This formula is similar to the Jaccard Similarity Index. Rahman et al. [26] considered an ailment recorded in two communities and treated with a number of medicinal plant species, species commonly used in both communities. In the present research, this approach was adapted to similarity of uses of pairs of species with, respectively, n_a and n_b as number of use reports in species a and b and, the number of common uses recorded for the two species as n_c . RSI can range from 0 to 100% and an RSI lower than 50% means low similarity in terms of uses between the two species while an RSI higher than 50% indicates a high similarity of uses between the two species.

Results

1. Sources of the species traded.

All informants traded *P. amarus*, *M. charantia* and *A. ciliata* while 95% of informants traded *S. uliginosa*. Samples of each species were shown by each trader as proof. With regards to the sources of each species traded (Table 1), six different sources were recorded and the majority of informants purchase *P. amarus*, *S. uliginosa* and *M. charantia* in both their own markets and other distant markets. In addition to these sources, a relatively large proportion of traders collect plants from wild populations of *P. amarus* and *M. charantia*. Traders mostly got *A. ciliata* by purchasing it in their own markets and collecting the species from the wild. The single most important source of each species reported by herbal medicine traders was their own market for *P. amarus* (44% of traders), *M. charantia* (50% of traders) and *A. ciliata* (39% of traders), while for *S. uliginosa* it was distant markets (39% of traders).

Table 1
Sources of the study species according to traders.

	Purchase in their markets	Purchase in nearby markets	Purchase in distant markets	Purchase in gardens	Collection from the wild populations	Collection from own gardens
	RFC (%)*	RFC (%)	RFC (%)	RFC (%)	RFC (%)	RFC (%)
<i>Phyllanthus amarus</i>	83	17	50	6	33	0
<i>Spilanthes uliginosa</i>	72	11	50	17	0	6
<i>Momordica charantia</i>	78	11	44	0	44	6
<i>Acalypha ciliata</i>	56	11	33	0	44	0
*RFC (%) = Relative Frequency Citation (%). Number of traders = 36.						

2. Ranking of the species in terms of demand and availability.

With regards to their demand, *P. amarus* was ranked as first by 72% of traders, *S. uliginosa* by 22%, *M. charantia* by 6%, and *A. ciliata* by 0% (Table 2). The majority of surveyed traders confirmed the scarcity rather than easy availability of all four species in recent years. The percentage of traders reporting scarcity was 94% for *M. charantia*, 89% for *P. amarus*, 83% for *A. calypha* and 67% for *S. uliginosa*. Eight different factors causing scarcity were reported by the herbal medicine traders (Table 3). Climate change and destruction for logging were the top two causes for all four species with overexploitation also mentioned as an equal second cause for *S. uliginosa*.

Table 2
Ranking of the study species by demand according to their traders

	RFC (%)*			
	1st rank	2nd rank	3rd rank	4th rank
<i>Phyllanthus amarus</i>	72	6	16	6
<i>Spilanthes uliginosa</i>	22	22	36	11
<i>Momordica charantia</i>	6	56	22	17
<i>Acalypha ciliata</i>	0	16	28	56
*RFC (%) = Relative Frequency Citation (%). Number of traders = 36 except for <i>S. uliginosa</i> where n = 34.				

Table 3
Causes of scarcity of the study species according to traders.

	RFC (%) [*]							
	Destruction for logging	Climate change	Population growth	Over-exploitation	International trade	Over-exploitation due to Covid-19 pandemic	Cultivation of humid areas	Loss of soil fertility
<i>Phyllanthus amarus</i>	44	67	6	17	6	11	0	6
<i>Spilanthes uliginosa</i>	17	44	0	17	0	0	0	0
<i>Momordica charantia</i>	39	78	6	17	0	11	0	0
<i>Acalypha ciliata</i>	28	67	6	6	0	0	6	6
[*] RFC (%) = Relative Frequency Citation (%). Number of traders = 36 except for <i>S. uliginosa</i> where n = 34.								

3. Uses recorded for each species.

Ten uses were recorded for *P. amarus* parts or the entire plant (Table 4). The most frequently (FL in %) reported use was to treat malaria using the entire plant as medicine, followed by treatment of diabetes, while the same proportion of traders reported the use of this species to treat constipation and stomach aches. Most informants (14 out 16; 88%) who mentioned use of *P. amarus* to treat diabetes insisted on its combination with *M. charantia*. Three spiritual and one medicinal uses were recorded for *S. uliginosa* (Table 4). All herbal medicine traders reported the spiritual utilization of this species for luck, but it was also used to treat mouth sores. Fifteen uses were recorded for *M. charantia* (Table 4). All traders mentioned the use of this species to treat measles and chicken pox. All informants who mentioned the use of this species to treat diabetes (39%) insisted on its mixture with *P. amarus*. *Acalypha ciliata* was recorded as used to treat eight diseases, disorders and magic issues (Table 4). The most reported use of this species (FL = 86%) was its spiritual use for luck.

Table 4
Fidelity Level (FL%) of recorded diseases, disorders and magic uses per study species.

List of Social situations recorded		Plant species and FL (%)*			
Situations types		<i>Phyllanthus amarus</i>	<i>Spilanthes uliginosa</i>	<i>Momordica charantia</i>	<i>Acalypha ciliata</i>
Diseases	Diabetes	44	0	39	0
	Infant intelligence stimulation	0	0	0	6
	Malaria	67	0	22	9
	Tiredness of old persons	6	0	0	0
Magic utilization	Spiritual use for luck	0	100	0	86
	Spiritual use to in Vodun [†]	0	12	22	0
	Spiritual use for self- protection	0	6	0	0
	Spiritual use for love	0	0	0	3
Infections	Chicken pox	0	0	100	0
	Constipation	33	0	14	0
	Cough	0	0	0	17
	Deworming	6	0	0	0
	Dog bite	0	0	6	0
	Eye infection	0	0	6	0
	Fever	0	0	14	0
	Mouth sore	0	6	0	0
	Measles	0	0	100	0
	Laxative use	0	0	8	0
	Skin infection	0	0	6	0
	Stomach infection	28	0	17	0
	Vaginal infection	0	0	6	0
	Urinary tract infection	0	0	6	0
Disorders	Male aphrodisiac	0	0	0	11
	Female aphrodisiac	0	0	0	11
	Male impotence	0	0	0	6
	Stomach ache	33	0	0	0
	Liver disorder	6	0	0	0

[†]A West African religion. *FL (%) = Fidelity Level (%). Number of traders = 36 except for *S. uliginosa* where n = 34.

4. Relative importance of species and their similarity in terms of uses.

All species exhibited a Use Value lower than 0.5 (Table 5). However, *M. charantia* was relatively the most important in terms of uses. The Rahman Similarity Index for uses of pairs of species (Table 5) confirmed an absence of similarity of use between *P. amarus* and both *A. ciliata* and *S. uliginosa*, and also between *M. charantia* and *S. uliginosa*. However, there was a moderate similarity of use between *P. amarus* and *M. charantia* with both used to treat stomach complaints, malaria, diabetes and constipation. There were very low similarities of use between *M. charantia* and *A. ciliata*, and between *S. uliginosa* and *A. ciliata* with these pairs of species used in common to treat malaria and for good luck, respectively.

Table 5
Relative importance of the study species (Use Value)

Species	Total no. of uses	Use Value (UV)	Number of shared uses/ Rahman Similarity Index (RSI %)		
			<i>Phyllanthus amarus</i>	<i>Spilanthes uliginosa</i>	<i>Momordica charantia</i>
<i>Phyllanthus amarus</i>	10	0.27	-	-	-
<i>Spilanthes uliginosa</i>	4	0.11	0 0	-	-
<i>Momordica charantia</i>	15	0.41	4 19	0 0	-
<i>Acalypha ciliata</i>	8	0.22	0 0	1 5	1 5
Number of traders = 36 except for <i>S. uliginosa</i> where n = 34.					

5. Preparation and modes of administration

Phyllanthus amarus

Based on the Fidelity Level, the three major conditions treated with this species were malaria, diabetes and constipation, the last chosen in this table instead of stomach ache although having equal FL (Table 6). Four types of preparation were mentioned by informants for malaria treatment and three for the other two conditions. For each condition, the majority of traders suggested the use of the entire plant as a decoction and the route of administration was oral. An infusion of the entire plant in a traditional alcoholic drink or in hot water was also mentioned by a minority of the traders to treat all three conditions. A mixture of the dried, powdered plant in an alcoholic drink was reported as a treatment only for malaria.

Table 6
Fidelity Level (FL %) of the preparations used for the main purposes for each species.

Preparation	FL (%) [*]							
	<i>Phyllanthus amarus</i>			<i>Spilanthes uliginosa</i>	<i>Momordica charantia</i>		<i>Acalypha ciliata</i>	
	Malaria n = 24 [†]	Diabetes n = 16	Constipation n = 12	Luck n = 34	Measles n = 36	Chicken pox n = 36	Diabetes n = 14	Luck n = 31
Decoction of the entire plant for drinking	88	88	50	-	-	-	-	-
Entire plant dried, powdered and mixed in traditional alcoholic drink 'sodabi'	17	0	0	-	-	-	-	-
Entire plant infused in traditional alcoholic drink	21	13	37	-	17	17	14	-
Entire plant infused in hot water for drinking	8	25	17	-	0	0	29	-
Leaves chewed	-	-	-	82	-	-	-	16
Flowers chewed	-	-	-	62	-	-	-	-
Leaves and flowers chewed	-	-	-	6	-	-	-	-
Entire plant infusion in traditional alcoholic drink	-	-	-	24	-	-	-	-
Entire plant pounded and mixed with soap for bathing	-	-	-	24	-	-	-	13
Infusion of leaves and stems in water used as a spray	-	-	-	6	-	-	-	19
Infusion of pounded entire plant in water used as a spray	-	-	-	24	-	-	-	6
Decoction of leaves and stems in water for drinking	-	-	-	-	25	25	86	-
Leaves and stems ground in water for bathing	-	-	-	-	17	17	0	-
Plant ground in water for drinking	-	-	-	-	22	22	0	-
Plant ground in water for drinking and bathing	-	-	-	-	28	28	0	-
Leaves and stems ground in traditional alcoholic drink 'sodabi'	-	-	-	-	47	47	0	-
Leaves and stems ground in natural lemon juice for drinking	-	-	-	-	11	11	0	-
Entire plant ground in water for bathing	-	-	-	-	-	-	-	10
Entire plant ground and mixed with soap for bathing	-	-	-	-	-	-	-	58
*FL (%) = Fidelity Level (%). [†] Number of traders mentioning this use. Total number of traders = 36 except for <i>S. uliginosa</i> where n = 34.								

Spilanthes uliginosa

Only the spiritual use of this species for luck was considered. Seven preparations were mentioned by medicinal plant traders (Table 6). Most commonly reported was the chewing of the leaves followed by the chewing of flowers early in the morning to request for good luck in any kind of business

Momordica charantia

The three major conditions treated using this species were measles, chicken pox and diabetes (Table 6). Informants insisted that the first two diseases shared the same preparations. Seven modes of preparation were recorded for each of these diseases and the most common was grinding the plant (leaves and stems) in the traditional alcoholic drink, 'sodabi'. Regarding diabetes, similarly to the findings for *P. amarus*, with which this species was usually combined, three types of preparation were noted, the most common being the decoction of the plant (leaves and stems) with oral administration.

Acalypha ciliata

Only the magic use of this species for luck was considered and six preparations were reported (Table 6). Based on the Fidelity Level, the most common preparation, mentioned by a majority of the traders, involved grinding the plant (leaves and stems) and mixing it with soap for bathing. So the route of

administration was herbal bathing. This was said by the traders to bring good luck to business activities.

6. Traders' contribution to species conservation

The majority of the traders did not plant the four research species (Table 7). However, a low proportion of traders confirmed that they planted *S. uliginosa* and *P. amarus* for trade and personal use. *In-situ* conservation of the naturally grown populations of all species at home except *S. uliginosa* was reported by a small proportion of traders.

Table 7
Informants' contribution to species conservation

	Conserved		Not conserved
	Through planting	<i>In-situ</i> conservation at home	
	RFC (%)*	RFC (%)	RFC (%)
<i>Phyllanthus amarus</i>	11	11	78
<i>Spilanthes uliginosa</i>	22	0	72
<i>Momordica charantia</i>	0	17	83
<i>Acalypha ciliata</i>	0	17	83
*RFC (%) = Relative Frequency Citation (%). Number of traders = 36 except for <i>S. uliginosa</i> where n = 34.			

Discussion And Conclusions

1. Sources plant species traded.

All informants confirmed the trade of *P. amarus*, *M. charantia* and *A. ciliata* while 94% traded *S. uliginosa*. These findings confirmed the medico-magic importance of these four herbaceous species to indigenous people in Benin. In addition, the trade of these species may generate a considerable income to traders. There is an increasing demand for plants for herbal drugs, natural health products and secondary metabolites throughout the world [38]. The majority of traders purchased the four species in their own markets, meaning a close relationship and collaboration between medicinal plant harvesters and local traders. Elsewhere, the relationship between wholesalers and traders of medicinal plants in South Asia seemed to be exploitative [39]. There is a need to better understand this relationship in Africa, especially in Benin. In all cases, there were fewer traders reporting purchasing the four medicinal plants in distant markets. The collection from wild populations of three of the four species, *P. amarus*, *M. charantia* and *A. ciliata*, confirmed the connection of local traders with their environment. Moreover, since there is no control of herbaceous medicinal plant collection from the wild, this harvesting may threaten the conservation of the concerned species. Consequently, further investigation is needed on the harvesting and trade of herbaceous medicinal plants to ensure their long-term sustainable conservation.

2. Ranking of the four species in terms of demand and availability

The ranking of *P. amarus* as most demanded by the greatest number of traders showed the importance of this species in health care of the local population. Similarly, *M. charantia* also has a high importance. The high demand for these two species suggests that there is a likely to higher pressure on the conservation of these species than on the other two. The use of species belonging to the genus *Phyllanthus* as green medicine is becoming more popular [15]. *Momordica charantia* is widely used and in demand all over the world for its medicinal potency [40] resulting in over exploitation of its wild populations. Species belonging to the genus *Spilanthes* are widely used in traditional medicine in various cultures [41]. Knowledge related to the impact of climate change on plant species availability [42] was confirmed by local traders who perceived climate change to be a contributing factor to species scarcity. Additionally, the destruction of species habitats for logging reported by traders confirmed threats to forest biodiversity due to both habitat loss and degradation of forest ecosystems [43, 44]. Not all medicinal plant species are affected in the same way by harvesting pressure so research is needed to assess the factors affecting the scarcity of each species studied. Herbal traders who reported the planting of *S. uliginosa* in other gardens confirmed the *ex-situ* conservation of this species. As a result, further investigations should be conducted in gardens to assess the ecological patterns and horticultural practices of these plantings. This will serve to promote cultivation of the species planting throughout the country in gardens.

3. Diversity of diseases, disorders and magic utilization of species

The large number of uses recorded for *P. amarus* and *M. charantia* revealed that herbal traders hold a diversity of knowledge on these species. The medicinal potency of *M. charantia* has been widely reported [40, 45, 46] including its use to treat diabetes as reported in the present study. The use of the species to treat measles was also reported in Nigeria [16], as well as its action against inflammatory diseases [17]. The combination of *P. amarus* with *M. charantia* for the treatment of diabetes corroborates findings of Sarin et al. [15] who mentioned diabetes among ailments treated with *Phyllanthus* species. As recorded in the present research, indigenous people in Nigeria used fresh leaves of *M. charantia* in various preparations to treat measles [16]. The medicinal use of this species seems common along the West African coast. Since diabetes is mentioned among the five most lethal diseases in the world [47], further research is needed on the pharmacognosy of *P. amarus*, *M. charantia* and their combination in treating diabetes. Similarly to the present results, the use of *Phyllanthus* species in the treatment of malaria, liver disorders and constipation was also stated by Sarin et al. [15]. Malaria is

one of the most lethal diseases in tropical countries so the long-term conservation of medicinal plants, especially *P. amarus*, active in treating malaria in Benin, provides a guarantee for the treatment of this dreadful disease.

Few species of the genus *Spilanthes* have received research attention for their uses [41]. The magic utilization recorded for the species in this research was a proof of traditional belief that African populations assign to plants. *Acalypha ciliata*, similarly to *S. uliginosa*, was known as magically efficient by herbal traders. This confirmed the connection of Africans with their nature and the conservation of traditional beliefs across generations. In fact, similar to our findings, Mafimisebi and Oguntade [48] reported magico-religious practices using plant species in Nigeria. Recently, Dossou-Yovo et al. [3] reported the magico-religious practices and rituals using mangrove plant species in Benin. Since people believe that those species bring good luck, this is a strong argument to be used to promote their cultivation and conservation throughout the country.

4. Relative importance of species and their similarity in terms of uses.

Despite being the most frequently demanded, *P. amarus* did not have the highest use value. In contrast, *M. charantia* ranked second for demand had a higher use value than *P. amarus*. The relative importance and high demand confirmed the need for sustainable conservation strategies for *P. amarus* and *M. charantia* as medicinal plants. *Spilanthes uliginosa* and *A. ciliata* were the least important in terms of uses. Although there was a low similarity in terms of use between *P. amarus* and *M. charantia*, the RSI value indicated that 19% ailments and disorders could be treated using either *P. amarus* or *M. charantia*. *Spilanthes uliginosa* and *A. ciliata* with an RSI value of 9% also had a low similarity of use. However, the possible substitution of one medicinal plant for another justifies further study as it might contribute to conservation by relieving pressure of exploitation on wild populations of scarce and most threatened medicinal plant species in tropical countries.

5. Preparation and routes of administration

Similar to the present findings, aqueous extracts of *P. amarus* were reported as more efficient than ethanol extracts for the treatment of malaria by Ajala et al. [14]. The preference of traders for decoctions with an oral route of administration against malaria matches western medical knowledge and confirmed that indigenous knowledge on green medicine has a great role to play in fighting dangerous diseases worldwide. *Phyllanthus amarus* was also recorded as the most commonly used in diabetes treatment, predominantly as a decoction with oral route of administration by Thai communities [47]. Constipation is a stomach disorder very often related to dysfunctioning of the liver. Given that excessive alcohol consumption is damaging to the liver [49], the authors question the wisdom of recommending extracts of medicinal plants in alcohol for the treatment of this condition. *Spilanthes uliginosa* and *A. ciliata* were recorded mainly for their spiritual use for luck and the chewing of leaves or flowers, and the mixture of the ground plant with soap for bathing were the predominant methods of use. Elsewhere, species of the genus *Spilanthes* were reported as used for more than 60 disorders including parasitic diseases [41]. Herbal bathing as route of administration recorded in this research was also reported by Sabran et al. [50]. The harvesting of fresh flowers of *S. uliginosa* for chewing compromises the reproductive capacity of the species since flowers are reproductive organs.

6. Traders' contribution to species conservation.

There is evidence of the important role that *in-situ* and *ex-situ* conservation plays in the conservation of plant genetic resources [43]. However, the majority of traders do not plant the medicinal plant species that they sell. Therefore, there is an urgent need to promote the species plantation or the *in-situ* conservation of naturally grown populations of the study species. Traders should be trained and sensitized on tools for the planting of *P. amarus* whenever possible in order to reduce pressure on its wild populations. *Momordica charantia*, exhibiting a relative high importance in this study, should also be conserved by traders wherever it grows. Although few uses were recorded for *S. uliginosa* and *A. ciliata*, it is recommended that traders also contribute to the *in-situ* and *ex-situ* conservation of these species. Those traders who confirmed the planting and conservation of naturally grown populations of the research species should be encouraged to contribute to training and dissemination of conservation tools for these species. Herbaceous species, especially those used as medicine in Benin, are often overlooked by conservation programs. The authors strongly suggest that greater attention should be paid to herbaceous medicinal plants in Benin in order to contribute to their conservation.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Availability of data and materials

Please contact author for data requests.

Funding

No funding.

Competing interests

The authors declare that they have no competing interests.

Authors' contributions

Dossou-Yovo H. O. was the originator of the research. He wrote the first draft of the research proposal, participated in the data collection and analysis as well as manuscript writing and its submission.

Kindomihou V. participated in proposal writing, collaborated during data collection and contributed to analysis, manuscript writing and editing.

Sinsin B. as head of the laboratory, he read, edited and commented on the manuscript for its improvement. He provided valuable comments that helped improve the quality of this manuscript.

Acknowledgement

Authors are deeply grateful to Prof. Phil Harris from Coventry University (England) who read, edited the first draft of this paper and provided relevant comments for its improvement. Thanks are also due to all herbal traders who participated in this research.

References

- [1] Cunningham AB. African medicinal plants. Setting priorities at the interface between conservation and primary healthcare. People and Plants Working Paper 1. UNESCO, Paris. 1993; p. 50.
- [2] Dossou-Yovo H O, Vodouhè F G, Sinsin B. Assessment of the medicinal uses of plant species found on termitaria in the Pendjari biosphere reserve in Benin. Journal of Medicinal Plant Research 2014;8(8):368-377. DOI:[10.5897/JMPR10.124](https://doi.org/10.5897/JMPR10.124)
- [3] Dossou-Yovo H O, Vodouhè F G, Sinsin B. Ethnomedicinal survey of mangrove plant species used as medicine from Ouidah to Gand-Popo Districts, Southern Benin. American Journal of Ethnomedicine 2017;4(1):8. DOI:[10.21767/2348-9502.100008](https://doi.org/10.21767/2348-9502.100008)
- [4] Jones E T, McLain R J, Weigand J. Non-timber forest products in the United States. University Press of Kansas. Lawrence, USA. 2002; p 445.
- [5] Hamilton AC. Medicinal plants, conservation and livelihoods. Biodiversity and Conservation 2004;13:1477-1517. DOI:[10.1023/B:BIOC.0000021333.23413.42](https://doi.org/10.1023/B:BIOC.0000021333.23413.42)
- [6] Garedew B, Bizuayehu B. A Review on ethnobotanical study of traditional medicinal plants used for treatment of liver problems in Ethiopia. European Journal of Medicinal Plants 2018;26(1):1-18. DOI: [10.9734/EJMP/2018/38153](https://doi.org/10.9734/EJMP/2018/38153)
- [7] Tounekti T, Mahdhi M, Khemira H. Ethnobotanical study of Indigenous Medicinal Plants of Jazan Region, Saudi Arabia. Evidence-Based Complementary and Alternative Medicine, Hindawi. 2019; Article ID 3190670. 45p. <https://doi.org/10.1155/2019/3190670>.
- [8] Shaheen HS, Qureshi R, Qaseem, Amjad MS, Bruschi P. The cultural importance of indices: A comparative analysis based on the useful wild plants of Noorpur Thal Punjab, Pakistan. European Journal of Integrative Medicine. 2017;12:27-34.
- [9] Khan I, AbdElsalam NM, Fouad H, Tariq A, Ullah R, Adnan M. (2014). Application of Ethnomedicinal Indices on the Use of Traditional Medicines against Common diseases. Evidence-Based Complementary and Alternative Medicine. Hindawi Publishing Corporation 2014; Article ID 635371, 21p. <http://dx.doi.org/10.1155/2014/635371>
- [10] Hoffman B, Gallaher T. Importance indices in ethnobotany. Ethnobotany Research & Applications 2007;5: 201-218. DOI:[10.17348/era.5.0.201-218](https://doi.org/10.17348/era.5.0.201-218)
- [11] Prance GT, Balee W, Boom BM, Carneiro RL. Quantitative ethnobotany and the case for conservation in Amazonia. Conservation Biology 1987; 1:296-310.
DOI: [10.1111/j.1523-1739.1987.tb00050.x](https://doi.org/10.1111/j.1523-1739.1987.tb00050.x)
- [12] Phillips O, Gentry AH. The useful plants of Tambopata, Peru: I. Statistical hypotheses tests with a new quantitative technique. Economic Botany 1993; 47(1):15-32. <http://www.jstor.org/stable/4255479>
- [13] Phillips O, Gentry AH. The useful plants of Tambopata, Peru: II. Additional hypothesis testing in quantitative ethnobotany. Economic Botany 1993;47:33-43. <http://www.jstor.org/stable/4255480Acc>
- [14] Ajala T O, Igwilo C I, Oreagba IA, Odeku O A. The autiplasmodial effect of the extracts and formulated capsules of *Phyllanthus amarus* on *Plasmodium yoelii* infection in mice. Asian Pacific Journal of Tropical Medicine 2011;283-287. DOI: [10.1016/S1995-7645\(11\)60087-4](https://doi.org/10.1016/S1995-7645(11)60087-4)
- [15] Sarin B, Verma N, Martin JP, Mohanty A. An overview of important ethnomedicinal herbs of *Phyllanthus* species: Present status and future prospects. The Scientific World Journal, Hindawi. 2014;Article ID 839172: 12 pages <http://dx.doi.org/10.1155/2014/839172>

- [16] Sonibare MA, Moody JO, Adesanyo EO. Use of medicinal plants for the treatment of measles in Nigeria. *Journal of Ethnopharmacology*. 2009;122(2):268-72. doi: 10.1016/j.jep.2009.01.004.
- [17] Bartolotti M, Mercatelli D, Polito L. *Momordica charantia*, a nutraceutical approach for inflammatory related diseases. *Frontiers in Pharmacology* 2019;10:486. doi: 10.3389/fphar.2019.00486
- [18] Boko-Haya YY, Ouinsavi C, Hounbeme A, Gbaguidi F. Ethnic differences in use, phytochemical screening and non-poisonous leaves of *Phyllanthus amarus* (Schum. & Thonn.) in North of Benin. *The Journal of Ethnobiology and Traditional Medicine*. Photon 2016;126:1185-1196.
- [19] Adjobimey T, Edayé I, Lagnika L, Gbenou J, Moudachirou M, Sanni A. . *In vitro* antiplasmodial activity of some antimalarial plants of Beninese pharmacopoeia. *Comptes Rendus Chimie* 2004;7:1023-1027. doi:10.1016/j.crci.2003.10.022
- [20] Bano A, Ahmad M, Hadda TB, Saboor A, Sultana S, Zafar1 M, et al. (2014). Quantitative ethnomedicinal study of plants used in the skardu valley at high altitude of Karakoram-Himalayan range, Pakistan. *J Ethnobiology Ethnomedicine* 2014; 10:43 <https://doi.org/10.1186/1746-4269-10-43>
- [21] Amjad MS, Qaeem MF, Ahmad I, Khan SU, Chaudhan SK, Zahid Malik N. et al.. Descriptive study of plant resources in the context of the ethnomedicinal relevance of indigenous flora: A case study from Toli Peer Natonal Park, Azed Jammu and Kashmir, Pakistan. *PLoS ONE* 2017;12(2): e0171896. Doi: 10.1371/journal. Pone. 0171896
- [22] Ugulu I. Traditional ethnobotanical knowledge about medicinal plants used for external therapies, Turkey. *Int. J. Msd. Arom. Plants*. 2011; 1(2): 101-106. Available from <http://www.openaccessscience.com/>
- [23] Ugulu I, Baslar S. The determination and Fidelity Level of medicinal plants used to make traditional Turkish salves. *Journal of Alternative and complementary Medicine*. 2010; 16(3):313-322. DOI:10.1089/acm.2009.0040
- [24] Padhan B and Panda D. Wild tuber species diversity and its ethnomedicinal use by tribal people of Koraput district of Odisha, India. *Indian Journal of Natural Products and Resources* 2016;2(1):33-36.
- [25] Zenderland J, Hart R, Bussmann RW, Paniagua Z, Narel Y, Sikharulidze, S, et al. The use of "Use Value". Quantifying importance in ethnobotany. *Economic Botany*. 2019; 73:293-303. <http://dx.doi.org/10.1007/s12231-019-09480-1>
- [26] Rahman IU, Hart R, Afzal A, Iqbal Z, Ijaz F, ABD_Allah EF, et al. A new ethnobiological similarity index for the evaluation of novel use reports. *Applied Ecology and Environmental Research* 2019;17(2):2765-2777. DOI: 10.15666/aeer/1702_27652777
- [27] Rajeswara Rao BR. (2012). Cultivation, Economics and Marketing of *Phyllanthus* Species. In Kuttan R, Harikumar KB. (Eds). *Phyllanthus Species: Sceintific Evaluation and Medicinal Applications* (pp.47-70). Edition: 1 Chapter: 3. Publisher: CRC Press, Boca Raton, USA. DOI: 10.1201/b11380-4
- [28] Matou M., Bercion S, Merciris P, Meyssonier N, Fernand D, Marianne-Pepin T. Etude de la composition chimique et du potentiel pharmacologique associé de *Phyllanthus amarus* Schum et Thonn. (1827) « Grenn anba fèy ». *Colloque International des Plantes Aromatiques et Médicinales (CIPAM) - 9ème édition*, Nov 2016, Cayenne, Guyane française.(hal-01827968)
- [29] Tiwari KL, Jadhav SK, Joshi V. An updated review on medicinal herb genus *Spilanthes*. *Journal of Chinese Integrative Medicine*. 2011; 9(11):1170-1178. DOI: 10.3736/jcim20111103
- [30] Iwu MM. *Handbook of African Medicinal Plants*. Edition CRC Press. 2014; 506p. pp. 31-35.
- [31] Jia S, Shen M, Zhang F, Xie J. Recent Advances in *Momordica charantia*: Functional Components and Biological Activities. *Int J Mol Sci*. 2017;18(12): 2555. doi: 10.3390/ijms18122555.
- [32] Schaefer H, Renner SS. A three-genome phylogeny of *Momordica* (Cucurbitaceae) suggests seven returns from dioecy to monoecy and recent long-distance dispersal to Asia. *Molecular Phylogenetics and Evolution*. 2010; 54(2): 553-560. <https://doi.org/10.1016/j.ympev.2009.08.006>
- [33] Kumar KPS, Bhowmik D. *Spilanthes uliginosa* is used for dental problems and for its antiseptic, homeostatic, analgesic, insecticidal and anti-inflammatory activity. *International Journal of Pharmaceutical Sciences Review and Research*. 2010; 4(3): 23-28.
- [34] Owolade OF, Amusa AN, Osikanlu, YOK,. Efficacy of certain indigenous plant extracts against seed-borne infection of *Fusarium moniliforme* on maize (*Zea mays* L.) in south western Nigeria. *Cereal Research Communications* 2000;28(3): 323–327. DOI: 10.1007/BF03543611
- [35] Owolade OF, Alabi BS, Osikanlu YOK, Odeyemi OO, On-farm evaluation of some plant extracts as biofungicide and bioinsecticide on cowpea in Southwest Nigeria. *Journal of Food, Agriculture and Environment* 2004;2(2): 237–240. <https://worldveg.tind.io/record/37631/>
- [36] Schmelzer GH. *Acalypha ciliata* Forssk. [Internet] Record from Protabase. Schmelzer GH. & Gurib-Fakim A. (Editors). PROTA (Plant Resources of Tropical Africa / Ressources végétales de l'Afrique tropicale), Wageningen, Netherlands. 2007;< <http://database.prota.org/search.htm>>. Accessed

- [37] Tewari D, Mocan A, Parvanov ED; Sah AN, Nabavi SM, Huminiecki L, et al. "Ethnopharmacological Approaches for Therapy of Jaundice: Part I". *Frontiers in Pharmacology*. 2017; 8: 518. DOI:10.3389/fphar.2017.00518..
- [38] Chen SL, Yu H, Luo, HM, Wu Q, Li CF, Steinmetz A. Conservation and sustainable use of medicinal plants: problems, progress, and prospects. *Chinese Medicine* 2016;11:37. DOI 10.1186/s13020-016-0108-7.
- [39] Olsen CS, Helles F. Market efficiency and benefit distribution in medicinal plant market: empirical evidence from South Asia. *International Journal of Biodiversity Science & Management* 2009;5(2):53-62. DOI:10.1080/17451590903063129
- [40] Kumar DS, Sharathnath KV, Vogeswaran P, Harami A, Sudhakar K, Sudha P, Bandji D. A medical potency of *Momordica charantia*. *Int.J. Pharm. Sc. Res.* 2010;1(2):95-100.
- [41] Paulraj J, Govindarajan R, Palpu P. The genus *Spilanthes*. *Ethnopharmacology, Phytochemistry, and Pharmacological Properties: A review. Advances in Pharmacological Sciences*. 2013; 510298. DOI: 10.1155/2013/510298.
- [42] IUCN. Species and Climate Change. 2020; www.iucn.org
- [43] Rudebjer P, Eyog-Matig O, Thomson L. Biodiversity in Forestry Education: what needs to change. Bioversity International. In Temu AB; Chamshama SAO, Kung'u J; Kaboggoza J; Chikamai B; Kiwia A (eds.) 2008. *New Perspectives in Forestry Education*. Peer reviewed papers presented at the First Global Workshop on Forestry Education, September 2007. ICRAF, Nairobi, Kenya *New perspectives in Forestry Education*. 2008; pp. 270-286.. Available from https://www.bioversityinternational.org/fileadmin/_migrated/uploads/tx_news/Biodiversity_in_forestry_education_what_needs_to_change_1834_02.PDF
- [44] Javed A, Afaq AM, Leena S. Urban development: A threat to wild species of medicinal and aromatic plants. *Middle-East Journal of Scientific Research* 2013;13 (7):947-951. DOI: 10.5829/idosi.mejsr.2013.13.7.3009
- [45] Joseph B, Jini D. Insight into the hypoglycaemic effect of traditional Indian herbs used in the treatment of diabetes. *Res. J. Med Plants* 2011;5(4):352-376. DOI:10.3923/rjmp.2011.352.376
- [46] Joseph B, Jini D.. Antidiabetic effect of *Momordica charantia* (bitter melon) and its medicinal potency. *Asian Pacific Journal of Tropical Disease* 2013;3(2):93-102. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4027280/pdf/apjtd-03-02-093.pdf>
- [47] Phumthum M, Basler H. Thai ethnomedicinal plants used for diabetes treatment. *OBM Integrative and complementary Medicine* 2018;3(3):1-25.
- [48] Mafimisebi TE, Oguntade AE. Preparation and use of plant medicines for farmers' health in Southwest Nigeria: socio-cultural, magico-religious and economic aspects. *J Ethnobiol Ethnomed* 2010;6:1. DOI:10.1186/1746-4269-6-1
- [49] Osna N A, Donohue T M, Kharbanda K K. Alcoholic Liver Disease: Pathogenesis and Current Management. *Alcohol Res.* 2017;38(2):147–161. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5513682/pdf/arcr-38-2-147.pdf>
- [50] Sabran SF, Mohamed M, Bakar MFA. Ethnomedical knowledge of plants used for the treatment of tuberculosis in Johor, Malaysia. *Evidence-Based Complementary and Alternative Medicine, Hindawi*. 2016; Article ID 285084512p. <http://dx.doi.org/10.1155/2016/2850845>