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# Indigenous knowledge of *Detarium microcarpum* Guill. & Perr. (Caesalpiniaceae) and implication for conservation in Benin (West Africa)

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**Abstract**
*Detarium microcarpum* Guill. & Perr. is a priority food tree species in West Africa, but its use pattern and conservation is little known across different sociocultural areas of Benin. In this study, we analyse the determinants of *D. microcarpum* traditional uses pattern and how these determinants influence the species' conservation in Benin. Thus, 730 respondents were participated in semi-structure interview across the North and Central regions of Benin. The information related to local names, traditional uses of different plant parts, management systems and conservation of *D. microcarpum* was recorded from the respondents. Use value (UV), ethnobotanical use value (EUV) and organ use value (OUV) were calculated. These statistics were used to assess the structure and variability of traditional use categories of plant parts among the sociocultural groups, gender and age groups. Results indicated that local names were spatially structured and linked to local communities' cultural origins, according to the recent human migration roads in West Africa. In total, 42 traditional uses of seven categories were gathered. UV in relation to sociocultural groups ranges from 7.62 (Idatcha and Fon) to 16.08 (Peulh and Lokpa); within the gender, UV ranges from 9.96 (women) to 11.15 (men); and within the age groups, UV ranges from 9.37 [18–30 years old] to 14.14 [65–100]. The species' UV significantly depended on respondents' sociocultural group, age and gender. Moreover, the age, gender and sociocultural groups significantly influenced the species' use pattern. Ethnobotanical use value ranges from 0.35 (fodder) to 6.22 (traditional human medicine). OUV ranges from 2.62% (flower) to 42.38% (leaf). The various uses of the species' roots, leaves and bark in traditional pharmacology and their high-quality firewood and tasty fruits determined the various local management systems. Thus, considering the current threats (intensive use of the roots, trunk, leaves and branches, and habitat degradation) conservation measures are needed to ensure the survival, conservation of distribution pattern and sustainable use of the species.

**Keywords** Benin · Indigenous knowledge · Conservation · *Detarium microcarpum* · Ethnobotany

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**Abbreviations**

| | |
|---|---|
| UV | Use value |
| EUV | Ethnobotanical use value |
| OUV | Organ use value |
| NTFP | Non-timber forest products |
| HIV | Human immunodeficiency virus |
| ANOVA | Analysis of variance |
| PCA | Principal component analysis |
| FCA | Factorial correspondence analysis |

## 1 Introduction

Plants preserve other components of biological diversity, regulate water cycle and play significant role in soil conservation (Jesel 2005; Tchatat and Ndoye 2006). Human living conditions are tightly linked to species diversity from which food, medicine, materials for construction, etc., are harvested (Arthur-Bertrand et al. 2009; Ezebilo and Mattsson 2010). Demands for these biological products are increasing because of African population growth, thus increasing consumers across the world, as a consequence of sub-Saharan Africans migration (Tabuna 2000; Adi et al. 2013; Akouèhou et al. 2014).

Local uses of plants are culture dependent and may significantly impact species' conservation state and development strategies (Nguenang et al. 2010). *Detarium microcarpum* is a priority species, because of the diversity of its products valued across various cultural areas in sub-Saharan Africa (Adjahossou et al. 2016). This woody savannah-to-light forest species (Aubréville 1950; Arbonnier 2000) grows in the wild from Senegal to Sudan (Cavin 2007; Kouyaté et al. 2009b), where its fruits and young leaves are consumed in different forms (Kouyaté and van Damme 2006). In traditional healthcare systems, the leaves, bark, stem and roots of *D. microcarpum* are used to treat tuberculosis, meningitis, itching, syphilis, diarrhoea, etc. (Abreu and Relva 2002; Vautier et al. 2007). Nutritional and pharmacological studies revealed that the bark and roots of *D. microcarpum* contain potent antioxidants, such as flavonoids, which inhibit human immunodeficiency virus 1 or 2 infection (Mahmood et al. 1993; Doulougou 2002; Nikiema et al. 2010). Understanding the complex relationship of endogenous knowledge–use pattern–species conservation is vital for livelihood enhancement and conservation strategy design for *D. microcarpum* (Pilgrim et al. 2007).

Profound ecosystem degradation in West Africa is leading to loss of many priority plant genetic resources (Dadjo et al. 2012; USAID 2013). Moreover, overharvesting of plant parts causes low densities and occurrence probabilities, which impair species' conservation, and therefore, their related endogenous knowledge (Traoré et al. 2011; Agbo et al. 2017). Therefore, efficient conservation strategies and sustainable use programmes are needed, for *D. microcarpum* long-lasting contribution to livelihood improvement.

Sustainable forest management requires the integration of multiple nature values in management policies' design and implementation (IPBES 2014; Atakpama et al. 2015). This consideration of endogenous and local knowledge helps identify research and management priorities, and thus strengthens local management systems based on both community needs and the overall challenge of biodiversity conservation (Agbogidi 2010).

Several studies have been carried out on *D. microcarpum* in West Africa, regarding the species' systematics (Hutchinson et al. 1958), botanical description (Aubréville 1950,

Geerling 1982, Watson and Dallwitz 1993), geographical distribution in Africa (Keay 1958; Berhaut 1975), biochemistry (Anhwange et al. 2004; Kini et al. 2010; Obun et al. 2011), and pharmacognosia (Burkill 1995; Olugbuyiro et al. 2009). There is not any ethnobotanical study carried out on *D. microcarpum* in Benin. However, details on ethnobotanical knowledge in Mali by Kouyaté (2005) are still limited, while this is vital for capturing challenges for efficient biodiversity conservation and use (Albuquerque et al. 2009; Natta et al. 2010).

Today, research on traditional knowledge of species is more interested because they mostly rely on aspects such as demographic factors (including age, gender, sociocultural groups, etc.) and be internalized in sustainable management policies of plant (Ayantunde et al. 2008; Cruz et al. 2013). Moreover, ethnobotanical studies investigate local taxonomy, which provides information on species' ecology, interspecific relationship, morphological traits, main uses, etc. Thus, local taxonomy may help identify and rightly value species (Akouèhou et al. 2014; Houéhounha 2009). Ethnobotanical indices provide information on the level of knowledge and use of the species, the importance of the species in the categories of use and the frequency of use of the organs of the species. These indices reveal the importance of traditional knowledge in species conservation (Belem 2009) and help design efficient species' development and management programs, to improve livelihoods (Nguenang et al. 2010, Dossou et al. 2012). The analysis of the variation of the organs used in a plant according to human factors is an indicator of the types of pressure that can be exerted on the organs of the plant in each rural community (Gbémavo et al. 2014).

In order to promote efficient management and conservation systems of *D. microcarpum*, this study relies on ethnobotanical data to: (1) determine the local taxonomy of *D. microcarpum*, (2) evaluate the relationship traditional uses—sociocultural group, age and gender, and (3) assess differences between sociocultural groups, regarding traditional uses of the species organs in Benin.

## 2 Materials and methods

### 2.1 Study area

The study was carried out in six phytodistricts inside two climatic zones, where the species mainly occurs in Benin (Agbo et al. 2018): Mekrou-Pendjari, Atacora chain and North Borgou (Sudanian climatic zone) and South Borgou, Bassila and Zou (Sudano-Guinean zone, Fig. 1). Benin is located between 9°30′N and 2°15′E with an annual average rainfall of 1039 mm and a mean temperature of 35 °C. Data from demographical and health investigation reveal that Benin has more than 40 ethnic groups. The National Registration of Population indicated that the major ethnic groups in the Benin are: Adja (15.2%), Fon (39.2%) and Yoruba (12.3%). Bariba (9.2%), Dendi (2.5%), Ottamari (6.1%), Lokpa (4.0%) and Fulani (7.0%) are the second largest groups. There are other minor ethnic groups such as Mahi, Gun, Xueda, Xwla and Ayizo in the South and Centre and Boko, Biali, Yom, Ani, Foodo, Gulmaceba (Gourmantchés), the Wama and the Ditammari in the North (Adam and Boko 1993). In Benin, agriculture is the most important economic sector (Adohinzin et al. 2011) that employs about 48% of the population and contribution to gross domestic product (45% of the GDP structure) and provides 88% of the country's export earnings (Labintan and Ding 2012). This study area covers a diversity of ecological and sociocultural environments, where *D. microcarpum* contributes to the daily lives of locals (Table 1). In this area,

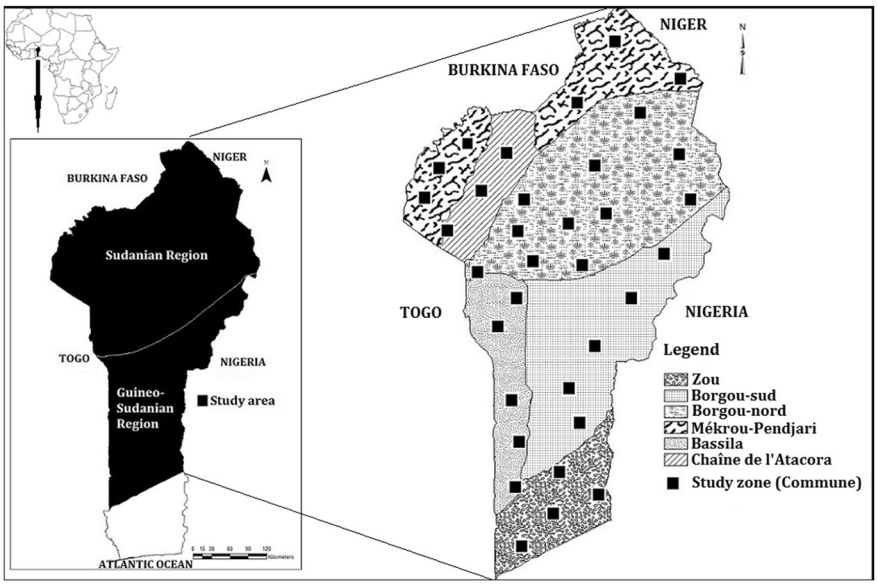


**Fig. 1** Map of Benin showing the location of surveyed townships

a great diversity of plant species for which different organs are daily exploited was identified (Eyog Matig et al. 2002; Adomou 2005).

## 2.2 Sampling and data collection

Sampling size was calculated in each phytodistrict based on exploratory study with 60 individuals randomly selected from 5 localities. This rapid appraisal helped estimate the proportion p of respondents who know and use the species. The sample size $n_i$ in the *i*th phytodistrict was computed based on the following equation (Dagnelie 2008):

$$n_i = \frac{(U_{1-\alpha/2})^2 * p_i i(1-p_i)}{d^2}, \tag{1}$$

where $n_i$ is the number of respondents surveyed in the *i*th phytodistrict, $U_{1-\alpha/2}$ the value of the normal random variable for a probability value α ($\alpha = 0.05$; $U_{1-\alpha/2} = 1.96$), $p_i$ the proportion of people who use *D. microcarpum* in this district, and $d$ the expected error of any parameter to be computed from the survey, which we fixed here at 0.05.

Using a questionnaire, semi-structured interviews were carried out with 730 respondents of 18–97 years old: 572 men and 158 women (Tables 2, 3). Respondents were mainly farmers, hunters, traditional practitioners, breeders, craftsmen and housewives. We limited the surveys to these age and socio-professional categories, because they constitute the direct users and conservationists of biodiversity (Acharya 2004). The respondents were randomly selected and interviewed, in order to assess information related to vernacular names and meaning, and different uses of any part of *D. microcarpum*, such as roots, wood, bark, stem and leaves.

**Table 1** Ecological characterization and major sociocultural groups of the phytodistricts of study areas

| Phytodistricts | Climatic zone | Rainfall regime | Rainfall (mm) | Major soil types | Major plant formation | Major sociocultural groups |
|---|---|---|---|---|---|---|
| Bassila | Guineo-Sudanian | Tendency to unimodal | Min: 1100<br>Max: 1300 | Ferralitic soils with concretions and breastplates | Semi-deciduous forest, woodland, and riparian forest | Ani, Yom, Nago, Lokpa, Itcha |
| Zou | Sudanian | Unimodal (1 rainy season) | Min: 1100<br>Max: 1200 | Ferruginous soils on crystalline rocks | Dry forest, woodland, and riparian forest | Fon, Mahi, Idatcha, Tchabè |
| South Borgou | | | | | | Mahi, Peulh, Nago, Fon |
| North Borgou | | | Min: 1100<br>Max: 1200 | | | Bo, Peulh, Bariba |
| Atacora chain | | | | Poorly evolved and mineral soils | Riparian forest, dry forest, and woodland | Natimba, Naténi, Ditamari, Berba, Waama |
| Mekrou-Pendjari | | | Min: 900<br>Max: 1000 | Ferruginous soils with concretions on sedimentary rocks | Tree and Shrub savannahs, dry forest and riparian forest | Ditamari, Berba, Waama, Gnindé, Biali, Gourmantché, M'Bèlimè |

**Table 2** Sample size per phytodistricts surveyed

| Phytodistricts | Number of people who use *D. microcarpum* in this district on the 60 pre-survey | Proportion ($p$) | Size of sample by phytodistrict ($n$) |
|---|---|---|---|
| Atacora chain | 56 | 0.933 | 96 |
| Bassila | 55 | 0.916 | 117 |
| Mekrou-Pendjari | 57 | 0.95 | 73 |
| North Borgou | 50 | 0.833 | 213 |
| South Borgou | 53 | 0.883 | 158 |
| Zou | 57 | 0.95 | 73 |
| Total | – | – | 730 |

In order to evaluate the importance of each specific use within a given use category, respondents were asked to classify and score the uses based on three pre-defined levels: high importance (3), medium importance (2) and low importance (1).

Lastly, local management and perception of the conservation state of *D. microcarpum* were recorded, combining individual and group interviews and direct field observations.

## 2.3 Data analysis

In order to determine the local taxonomy of *D. microcarpum*, the local names, used by each sociocultural group, were recorded. Moreover, the meaning of these vernacular names was recorded, in order to reconstruct similarity/dissimilarity among sociocultural groups.

The relationship between sociocultural groups, age and gender and among traditional use of *D. microcarpum* was evaluated by calculating two main ethnobotanical indices: use value (UV) and ethnobotanical use value (EUV). UV was calculated as the average number of uses reported for the species by an informant and was computed by sociocultural group, age and gender categories. This index helps to determine how uses were distributed between and within sociocultural groups, gender and age category (Philips and Gentry 1993; Rossato et al. 1999):

$$\mathrm{UV}_i = \frac{\mathrm{NU}_{ti}}{Ni}, \tag{2}$$

where $\mathrm{NU}_{ti}$ is the total number of uses reported by the $i$th sociocultural group, age or gender category (sum of all uses reported by all respondents) and $Ni$ the total number of respondents in the corresponding specific category. The calculated UVs were used in a one-factor analysis of variance (ANOVA) in Minitab 16 (Motorola Quality Companion by Minitab 2010) in order to evaluate the relationship between sociocultural group, age and gender categories.

Second, ethnobotanical use value ($\mathrm{EUV}_k$) was calculated to evaluate the importance of *D. microcarpum* in each use category within the sociocultural groups. For the $k$th category of use, $\mathrm{EUV}_k$ is the ratio of the sum of score ($S$) assigned by the $i$th respondent to the $j$th specific uses within this category to the total number ($N$) of respondents (Fandohan et al. 2010; Codjia and Yorou 2014):

$$\mathrm{EUV}_k = \frac{\sum_{j=1}^{n_k} \sum_{i=1}^{N} (S_{ijk})}{N}, \tag{3}$$

**Table 3** Sample size per sociocultural groups, gender and age

| Factors | Variables | Size |
|---|---|---|
| Sociocultural groups | Ani | 26 |
| | Bariba | 59 |
| | Biali | 21 |
| | Bo | 23 |
| | Dendi | 43 |
| | Ditamari | 26 |
| | Fon | 96 |
| | Gnidé | 18 |
| | Gourmantché | 20 |
| | Haoussa | 17 |
| | Idatcha | 26 |
| | Itcha | 34 |
| | Lokpa | 26 |
| | Mahi | 99 |
| | MBèlimè | 24 |
| | Nago | 31 |
| | Naténi | 25 |
| | Natéma | 24 |
| | Peulh | 42 |
| | Tchabè | 26 |
| | Yom | 24 |
| Gender | Men | 572 |
| | Women | 158 |
| Age categories (years old) | [18–30] | 195 |
| | [30–65] | 469 |
| | [65–99] | 66 |

where $n_k$ is the total number of specific uses recorded in the $k$th use category and $N$ the total number of respondents. We calculated the total $EUV_t$, as the sum of $EUV_k$ for all use categories. This parameter measures the overall use value for the species (Fandohan et al. 2010; Honfo et al. 2015). A principal component analysis (PCA) was performed on $EUV_k$ in Statistica 6.1 package (StatSoft 2001) in order to describe relationship between use categories and sociocultural groups.

In order to establish sociocultural groups-related differences on the traditional use of the species organs, OUV was calculated and submitted to factorial correspondence analysis (FCA) using Statistica 6.1 package (StatSoft 2001), and the impact of the use of organs on the management of the species was determined. It gives the frequency of organs use within sociocultural groups (Honfo et al. 2015):

$$\mathrm{OUV} = \frac{\mathrm{RU}_{\mathrm{org}} \times 100}{\mathrm{RU}}. \tag{4}$$

This ethnobotanical index is defined as the ratio of the total number of uses reported by all respondents in the $i$th sociocultural group for each organ of the plant ($OUV_{org}$) on the total number of uses (RU) of the species (Dossou et al. 2012).

## 3 Results

### 3.1 Local taxonomy of *D. microcarpum*

A wide range of vernacular names were locally used to identify *D. microcarpum* across the studied sociocultural areas. In general, local names were sociocultural group dependent (Table 4), and we found some similarities among sociocultural groups. This is the case of Fon and Mahi sociocultural groups that named the species "Dakpa" or "Dagpa". Likewise, the name of "Adjèkofolé" was also co-used by Idatcha and Tchabè communities, while Yoruba and Itcha people used the name of "Iyédé". Most of the local names of *D. microcarpum* are either based on the anatomy of the wood or based on its uses. For example, "Guitédékpé" in Ani language means "dry wood break in small pieces" and "Dagpa" in Fon means "great utility". *Detarium microcarpum* local names can also derive from its relation to other species: "Adjèkofolé" in Idacha language means "witch bird can never land on it'". In Nago sociocultural group, *D. microcarpum* is named "Essoékété" which means "rat food", "Oulaokoubou" in Gnindé means "rocky zone species".

### 3.2 Relationship between sociocultural group, age and gender and the diversity and level of traditional use of *D. microcarpum*

*Detarium microcarpum* was widely used by locals for many purposes. In total, *D. microcarpum* was involved in 42 different uses in seven use categories were identified: food (2), fodder (1), traditional healthcare (27), traditional veterinary medicine (2), handicraft (5), firewood (2) and medico-magic applications (3) (Fig. 2). The EUV, regarding these use categories, ranged from $0.35 \pm 0.12$ (for fodder) to $6.22 \pm 0.16$ (for traditional human medicine). Thus, the species was more intensively used in African traditional human healthcare system than in any other application. The use categories such as firewood and handicraft were fairly reported ($EUV > 1$), but food, medico-magic, traditional veterinary medicine

**Table 4** Local taxonomy of *D. microcarpum* in Benin

| Sociocultural groups | Local names |
|---|---|
| Ani | Guitédékpé; Tédékpé |
| Bariba | Béssérou; Bésségonou; Bèro; Gbèhainou |
| Biali (Berba) | Kokoakè |
| Bo (Boko) | Boussounali |
| Dendi | Faintou |
| Ditamari (Otamari) | Yamassokoua; Boumoutoubou |
| Fon | Dakpa; Dagpa |
| Gnindé | Oulaokoubou |
| Gourmantché | Téfaari |
| Haoussa | Taura |
| Idatcha | Adjèkofolé |
| Itcha | Iyédé |
| Lokpa | Kpaalè |
| Mahi | Dakpa; Dagpa |
| M'Bèlimè | M'counlè |
| Nago | Essoékélé |
| Natéma | Kankanmou |
| Naténi | Koakoakébou; Kohounkoabou |
| Peulh | Konkéyi |
| Tchabè | Adjèkofolé |
| Yom (Pila-pila) | Kpahle |
| Yoruba | Iyédé |

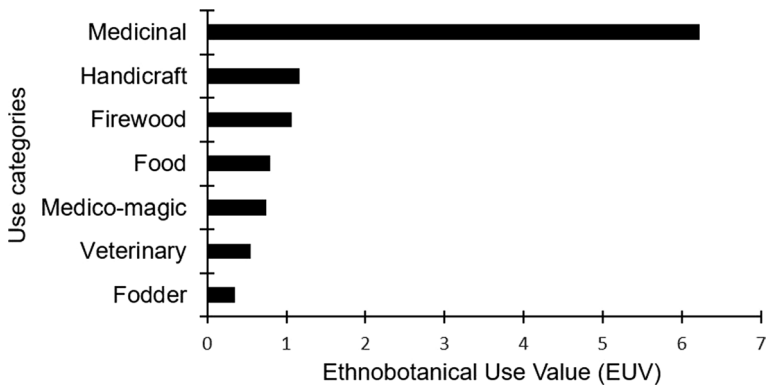


**Fig. 2** Ethnobotanical use value of *D. microcarpum*

and animal feed had low values ($EUV_k < 1$). The total ethnobotanical use value ($EUV_t$) of the species was estimated at 10.9.

The PCA showed that the first two axes explain 67.81% of the overall variance within the data matrix. The first component (37.65%) is that of food and medico-magic applications, while the second component (30.16%) expresses utilization as handicraft, fodder and

veterinary medicine applications (Table 5). Thus, Bariba, Dendi, Ditamari, Lokpa, Peulh, MBèlimè and Yom communities mostly used the species in veterinary medicine and fodder, while Fon, Idatcha, Mahi, Tchabè and Nago communities used it mostly in handicrafts. Biali, Natéma, Haoussa, Gourmantché, Gnindé, Bo and M'Bèlimè communities mostly used it in food and medico-magic applications (Fig. 3).

At maturity, *D. microcarpum* fruit pulp was consumed fresh by 92% of respondents. Respondents from the Bo community consumed the fruit of *D. microcarpum* during the post-harvest period. The young leaves are consumed as leafy vegetable by Gourmantché, Itcha, Naténi and Peulh communities. Cattle and goats (*Bos taurus* and *Capra* spp., respectively) consume the leaves of *D. microcarpum* as fodder in Bariba, Dendi, Ditamari, Lokpa, Yom and Peulh sociocultural areas, where these leaves where also used to disinfect animals. Hunters indicated that the fruits of *D. microcarpum* are consumed by wild animals such as monkeys (*Cercopithecus* spp., Cercopithecidae), rabbits (*Oryctolagus cuniculus*, Leporidae), squirrels (*Sciurus vulgaris*, Sciuridae), giant rats (*Rattus* spp., Muridae) and elephants (*Loxodonta africana*, Elephantidae).

In traditional pharmacopoeia, all plant organs (bark, leaves, flowers, fruits and roots) are involved in the composition of remedies, but generally in combination with other plants (Table 6). In medico-magic field, *D. microcarpum* flowers and roots were used by Peulh sociocultural group to protect mankind against evil occultists. In the sociocultural group of M'Bèlimè, the wood of *D. microcarpum* was used to make traditional battle rings.

In the craft, several sociocultural groups used wood, roots and flowers of the species to make statuettes, agricultural tools, incense, etc. It was also indicated that the seeds were used to make beads by Lokpa and Ditamari women.

The wood of the species was valued as good fire wood or to make charcoal in the study areas. This use category is mainly applied by Tchabè, Mahi, and Fon communities. In contrast, the M'Bèlimè community strictly forbade these applications.

The ANOVA on the UVs showed that sociocultural group, age and gender categories significantly influenced the use of *D. microcarpum* in the study areas (Table 7). The UVs ranged from $7.62 \pm 0.45$ (Idatcha) to $16.08 \pm 0.56$ (Lokpa). Thus, Lokpa and Peulh sociocultural groups had more traditional knowledge on *D. microcarpum*, in contrast to Idatcha, Fon, Mahi, Itcha, Naténi and Bariba who had relatively weak knowledge on the species ($UV < 10$, Fig. 4a). Old persons ($\geq 65$ years old) accumulated more traditional knowledge on *D. microcarpum* ($UV = 14.14 \pm 0.53$) than persons of any other age category ($UV = 9.37 \pm 0.27$–$11.07 \pm 0.18$). Men detained significantly higher level of traditional knowledge ($UV = 11.15 \pm 0.17$) than women ($UV = 9.96 \pm 0.31$) (Fig. 4b).

### 3.3 Traditional use and management of *D. microcarpum* in Benin

Organ use value (OUV) indicated that leaves, bark, roots and wood were the most exploited organs, unlike fruits, seeds and flowers (Fig. 5). The FCA showed 74.12% of total variation summarized by the first two axes (Fig. 6). Organ use varied according to social groups. Thus, the wood was more widely used by Ani, Tchabè, Fon, Idatcha, Itcha, Mahi, Nago and Biali communities, while the fruits and bark were mostly consumed by Haoussa, Gourmantché, Bo, Naténi, Yom and Natéma communities. The roots, flowers and seeds were mostly utilized by Ditamari, M'Bèlimè, Peulh, Dendi and Lokpa communities. Lastly, the leaves have the highest value in Gnindé and Bariba.

**Table 5** Principal component loads on first and second axis from PCA of *D. microcarpum* use categories

| Use categories | $PC_1$ (37.65%) | $PC_2$ (30.16%) |
|---|---|---|
| Handicrafts | − 0.23 | **0.78** |
| Firewood | − 0.38 | 0.44 |
| Food | **0.79** | − 0.34 |
| Fodder | **0.65** | 0.72 |
| Medico-magic | **0.79** | − 0.21 |
| Traditional human medicine | 0.58 | − 0.22 |
| Veterinary medicine | 0.62 | **0.74** |

Values in bold represent those with a significant positive correlation to the axis

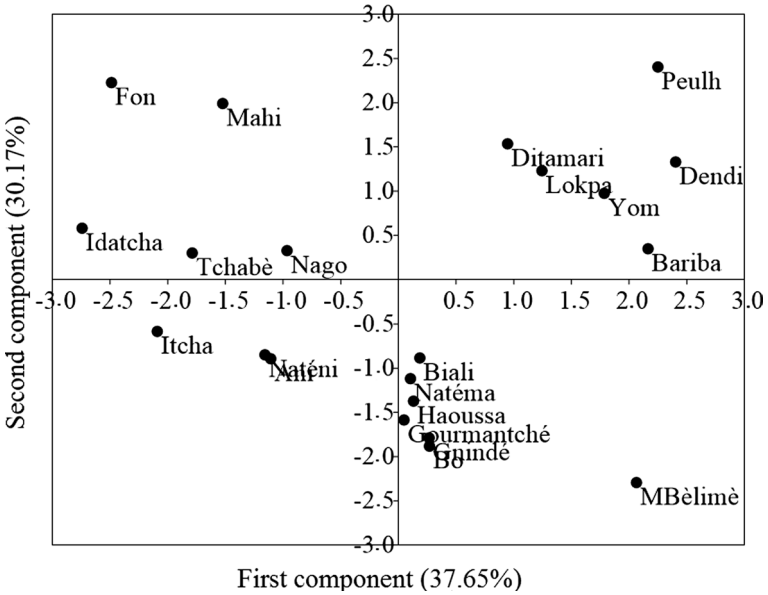


**Fig. 3** Projection of sociocultural groups in the 1 and 2 axis systems of principal component analysis

Most of the juvenile and adult trees of *D.microcarpum* grow spontaneously in wild natural ecosystems, but some trees, through the manipulation of seeds by humans, grow in cultivated agrosystems. Truly wild trees are also found in different traditional agroforestry systems, where they are protected during land preparation, as remnant of old larger populations. However, some stands are planted for familial exploitation. In Papatia (Bassila phytodistrict), *D. microcarpum* is planted on farm, in agroforestry parks and in home gardens, since wild individuals are increasingly low densities. The medical uses and consumption of fruits constitute the main reasons why the species is planted by small-scale farmers. Across Zou phytodistrict, the species is not truly planted and every individual is wild, even in traditional agroforestry systems. In the entire study areas, there is no planting initiative based on market-led selection of transplanted juveniles, seeds or mother trees.

According to local people, intensive use of root, trunk and branches of *D. microcarpum* for fire wood is the main threat that decreases adult trees' growth performances up to death in severer threat situations. In addition, shifting agriculture and fruits exploitation prevent the establishment of regenerations. Therefore, natural spatial recovery of *D. microcarpum* takes place at a patchy pattern and at low densities across the study areas, fragmenting the species distribution range. Today, this fragmentation is causing the loss of gregarious life for the species, with scattered individuals in landscape.

**Table 6** Medicinal properties of *D. microcarpum* in Benin

| Disease | Composition/preparation | Directions for use |
|---|---|---|
| 1. Amnesia | Decoction of leaves + leafy stems of *Lannea acida* (Anacardiaceae) | Drink the decoction twice a day with a small glass |
| 2. Anaemia | Decoction of leaves + wild banana root | Drink the decoction twice a day with a bamboo glass |
| 3. Vomiting | Crush the young leaves + salt | Give the mixture to the patient |
| 4. Candidiasis | Decoction of leaves and the bark | Wash with water from the decoction |
| 5. Tooth decay | Branch | Eat as a toothpick |
| 6. Healing of the burns | Pulverize the bark after drying | Put the powder in the wound |
| 7. Convulsion | Decoction of leaves + leafy branches of *Isoberlinia doka* (Caesalpiniaceae) | Drink the decoction twice a day with a small glass |
| 8. Dermatosis | Decoction of bark | Wash with water from the decoction |
| 9. Diarrhoea | Decoction of the bark of the root | Drink the decoction twice a day with a bamboo glass |
| 10. Dysentery | Decoction of bark and root | Drink the decoction twice a day with a bamboo glass |
| 11. Epilepsy/fainting | Pulverize the root | Take the powder with food |
| 12. Sexual weakness | Decoction of the root | Drink the decoction |
| 13. General fatigue | Decoction of leaves | Wash with water from the decoction |
| 14. Fever (Malaria) | Decoction of leaves + ripe fruit of *Xylopia aethiopica* (Annonaceae) + leaves of *Combretum hypopilinum* (Combretaceae) | Drink the decoction three times a day with a bamboo glass |
| 15. Haemorrhoid | Pulverize the bark + fruit of *Aframomum melegueta* (Zingiberaceae). Add warm water | Drink the mixture |
| 16. High blood pressure (hypertension) | Grind green fruits (unripe) and heat. Add water to the mix | Drink and then wash with water |
| 17. Infertility | Decoction of various organs of the plant, especially the bark of the stem or root | Drink the decoction |
| 18. Urogenital infection (gonorrhoea, syphilis, etc.). | Decoction of the root | Drink the decoction three times a day with a bamboo glass |
| 19. Liver disease (jaundice, hepatic insufficiency, hepatitis) | Decoction of root + leafy branches | Drink the decoction three times a day with a bamboo glass |

**Table 6** (continued)

| Disease | Composition/preparation | Directions for use |
|---|---|---|
| 20. Infantile diseases (mycosis, ossification, dentition) | Decoction of the bark | Wash the child with the water of the decoction |
| 21. Mental illness | Decoction of the bark of the stem + root of *Andira inermis* (Fabaceae) + the bark of the stem of *stereospermum kunthianum* (Bignoniaceae) + leaves of *Crossopteryx febrifuga* (Rubiaceae) | Drink the decoction twice a day for 12 days |
| 22. Headaches | Pulverize the bark after drying + lemon juice | Drink the mixture |
| 23. Stomach pains, gastric ulcers | Grind the root and add water | Drink water three times a day with a bamboo glass |
| 24. Meningitis | Ripe fruits | Eat |
| 25. Meteorization (paunch distending) | Collect the filtrate from crushed bark with added water | Let the animal drink |
| 26. Oedema | Decoction of leaves + bark + root | Use hot water to massage the swollen part |
| 27. Opening of the fontanel | Collect the oil from the decoction of roots | Dab the oil on the child's fontanel |
| 28. Protection against evil spirits | Grind root or flowers (dried). Put the powder on the live embers | Odorous smoke (perfumed) keeps evil spirits away |
| 29. Rheumatism | Pulverize the root after drying. Put the powder in water or in a local beverage | Drink the mixture |
| 30. Dizziness (animal) | Decoction of leafy stems | Use water to wash the face |
| 31. Intestinal worms | Triturate young leaves with water | Drink the solution |

**Table 7** Analysis of variance of use value within sociocultural groups, age and gender categories

| Factors | Degree of freedom (DF) | Sum of squares | Mean square | Fisher values (*F*) | Probability (*P*) |
|---|---|---|---|---|---|
| Sociocultural groups | 20 | 17,067.7 | 853.4 | 11.91 | 0.000*** |
| Age categories | 2 | 240,011 | 120,005 | 52.44 | 0.000*** |
| Gender | 1 | 274,743 | 274,743 | 60.60 | 0.000*** |

***Highly significant

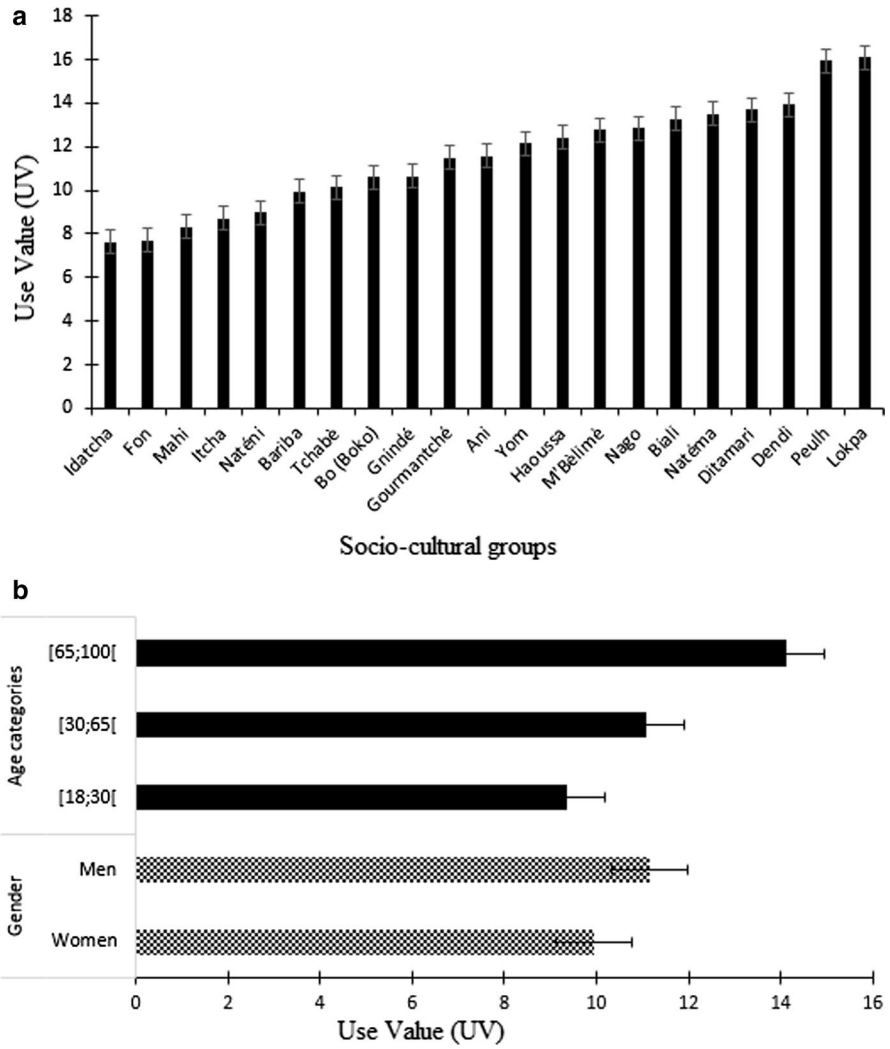


**Fig. 4** Variation of use value **a** within sociocultural groups; **b** within age and gender categories

## 4 Discussion

### 4.1 Relevance of the local taxonomy of *D. microcarpum*

Local taxonomy of *D. microcarpum* is culture dependent. It is a general situation that local taxonomy of plant species is always society and culture dependent (Öztürk et al. 2013; Akouèhou et al. 2014). The various local names of *D. microcarpum* are based on either the anatomy of the wood of the species or its uses (Dagpa in Fon language comes from Dàgba which means "Great utility"), or from its relations with other species (Adjèkofolé in Idatcha language which means "That the owl, the bird says wizards can never ask"). These often ancestral local names are based on a number of parameters related to the

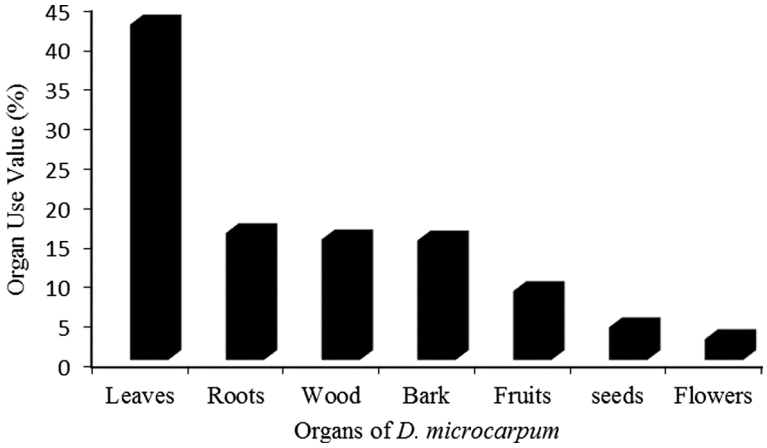


**Fig. 5** Variation of organ use value of different organs of *D. microcarpum*

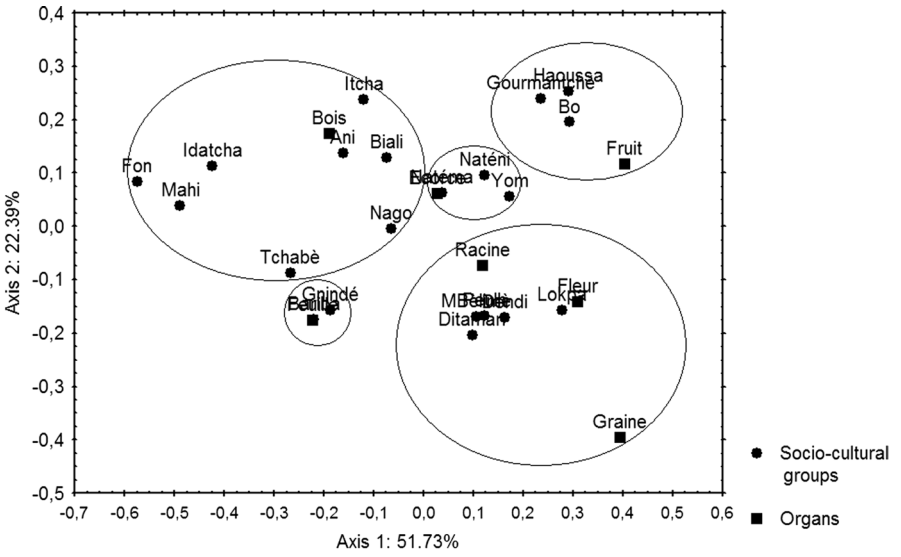


**Fig. 6** Projection of targeted sociocultural groups in the system axis of factorial correspondence analysis defined by the different organs of *D. microcarpum*

species they designate. This result is in agreement with that obtained by other authors who asserted that local names are attributed to plant species according to their habitat and their resemblance to other species (Houéhounha 2009), their morphological characteristics and their uses (Ekué et al. 2010), the sex of the tree and even the taste of the fruit of the species (Gouwakinnou et al. 2011). For example, the sociocultural group Fon, to designate *Khaya senegalensis*, places the species in its natural habitat, compares it with *Daniellia oliveri* (which takes the name of Zatin) and calls it Zoun-zatin, which means Zatin of the forest (Houéhounha 2009). The local taxonomy of plants is of vital interest that provides

information on the ecology (habitat of the species), the type of interspecific relationship (relationship with other species), the morphological characteristics of the species, the main uses, the resemblance with other species, etc. It is the address with which local people recognize and manage the genetic resources of a species.

Similarity in local names is linked to similar origin of sociocultural groups. Indeed, Fon and Mahi communities named the species Dakpa, because they both originated from the common Adja ancestor in Dahomey (old name of Benin, Anignikin 2001). It was demonstrated that the kingdom of Danxomè (Fon cultural area) comprises many other related sociocultural groups, among which is Mahi (Gayibor 1985; Anignikin 2001). Likewise, Yoruba, Nago and Itcha communities in Benin present similarities in vernacular names, because both are derived from the geographically widely established Yorubalands from Ilé-Ifè, Osun, Lagos, Ogoun, Ondo, Ekiti and Kogi states in Nigeria (Ellis 1966; Igué and Yai 1950). Idatcha and Tchabè communities call *D. microcarpum* by the same vernacular name of Adjèkofolé, because both communities are derived from a single particular Nigerian Yoruba land Oyo state, who emigrated first to South East Benin and throughout the centre of the country, where they diverged some centuries ago, to reach different places in Benin (Adam and Boko 1993; Adjatin et al. 2008). Therefore, it appears that throughout human migration origins, practices in the use of local biodiversity and local taxonomy change very slowly over the time. This was also demonstrated for *Irvingia gabonensis* and *I. wombolu* (Irvingiacea), with similar patterns between Benin and Nigeria (Vihotogbé et al. 2014).

### 4.2 Traditional knowledge of *D. microcarpum*

The ethnobotanical indices indicated that all organs of *D. microcarpum* are used by many sociocultural groups in various use categories. The importance assigned to a species depends not only on its occurrence, density or wider geographical distribution, but also on its capacity to satisfy human needs in different fields. The high total ethnobotanical use value (EUV = 10.9) of *D. microcarpum* indicated the great importance of the species according to the daily needs of local communities (Fandohan et al. 2010; Honfo et al. 2015). The various uses of *D. microcarpum* make it a truly multipurpose species, to be valued to enhance livelihood (Arbonnier 2000; Abreu and Relva 2002; Doulougou 2002; Cavin 2007; Vautier et al. 2007; Kouyaté and Lamien 2011). Unfortunately, there is no domestication/conservation programme, even locally, in order to conserve the geographical range of the species. We explain this absence of conservation decision by the informal and the local market of NTFP of the species. Moreover, *D. microcarpum* food spreading among communities (De Caluwé et al. 2009) is slow and the regional market of its NTFP does not show the significant economic importance of the species, which is supposedly abundant, unlike other priority and overexploited food tree species: *Adansonia digitata* (Bombacaceae), *Irvingia* spp. (Irvingiaceae), *Dacryodes edulis* (Burseraceae), etc. (Vihotogbé et al. 2013, 2017; Cernansky 2015).

It was demonstrated that local people use various plant organs for their food, economic, social and cultural needs (Ezebilo and Mattsson 2010). Here, organ harvested by sociocultural groups depends on endogenous knowledge. In this study, the wide utilization of leaves, bark, roots and wood is related to the important variation in OUVs. The use of *D. microcarpum* for the same purpose by different sociocultural groups can be justified by the common origin of these communities, the practice of the same activities (commercial and cultural), etc. Indeed, the use of the wood of *D. microcarpum* by Ani, Biali, Fon, Idatcha, Itcha, Mahi, Nago and Tchabè communities can be

justified by the fact that these sociocultural groups are mainly engaged in the manufacture and marketing of charcoal (Tenté 2015; Afrique Conseil 2006). The major use of the fruit of the species by Haoussa, Gourmantché and Bo communities is explained by the fact that these communities are local residents of the forests sheltering the species (Agbo et al. 2018) and are therefore accustomed to the consumption of fruit especially during the post-harvest period (Djogbénou et al. 2011). The great use of the species by Naténi, Bariba, Gnindé, Yom, M'Bèlimè, Natéma, Ditamari, Dendi, Peulh and Lokpa communities as fodder, medico-magic ingredient, and in veterinary and human medicine can be justified by their common role for the main traditional cattle and goat breeders. These ethnic groups are indeed culturally distinct from Yoruba- and Adja-derived communities, originally from Guineo-Congolian ecological regions.

The UVs showed a significant variation in the traditional knowledge of *D. microcarpum* among sociocultural groups, age and gender categories (Fandohan et al. 2010; Gouwakinnou et al. 2011; Assogbadjo et al. 2011; Atakpama et al. 2015). Also, the significant variations in local knowledge among age categories indicate knowledge erosion, subsequent to ineffective transmission of knowledge over generations. These results are consistent with other authors who have noted that older people have more knowledge about plant use than younger people (Camou-Guerrero et al. 2008; Beltrán-Rodríguez et al. 2014), but there are exceptions (Byg and Balslev 2004). Differences in the mastering of traditional knowledge between men and women were already indicated and explained by the fact that *D. microcarpum* is mostly used in therapeutic fields (EUV = 6.22), which is reserved generally to men in tropical African culture, but sometimes to old women (Camou-Guerrero et al. 2008; Souto and Ticktin 2012; Beltrán-Rodríguez et al. 2014).

### 4.3 Traditional use and management of *D. microcarpum* in Benin

Several authors confirmed the daily consumption of fruit and young leaves of *D. microcarpum* by many Africans in the Sahelian countries (Adjahossou et al. 2016). This is explained by the high concentration of vitamins, micronutrients as well as macronutriments in these organs (Anhwange et al. 2004; Kini et al. 2010). The multipurpose use of *D. microcarpum* was reported and allowed the classification of this species among the priority medicinal plant taxa in West Africa (Abreu and Relva 2002). It was demonstrated that extracts of *D. microcarpum* leaves and bark treat malaria, syncope, convulsions, yellow fever, haemorrhoid, intestinal worms, oedema, etc. (Adjanohoun et al. 1989; Kouyaté et al. 2009a; Barminas et al. 2012). We attribute this wide range of medicinal properties to the high concentration of these organs in tannins, saponins and flavonoids (Mahmood et al. 1993; Loubaki et al. 1999; Doulougou 2002; Lamien-Meda et al. 2008; Barminas et al. 2012). The intensive use (EUV > 1) of *D. microcarpum* in handicraft and as fire wood is due to the hardness of its wood, good for sustainable materials (Vautier et al. 2007; Kaboré 2005; Sawadogo 2007). These multiple usages of *D. microcarpum* indicate the need for domestication. The intensive use of *D. microcarpum* wood and seeds is the main cause of the species' increasing vulnerability (Agbo et al. 2017). However, the use of *D. microcarpum* trunk as firewood is defended to some communities as M'Bèlimè. This taboo is reported in many sociocultural areas in Mali and could be understood as a conservator measure (Kouyaté 2005; Kouyaté et al. 2009a). This conservatory taboo was recorded for *Adansonia digitata*

(Assogbadjo 2006), *Irvingia gabonensis* (Padonou et al. 2017), *Combretum molle* (Malgras 1992), *Daniellia oliveri* and *Sapium ellipticum* (Kakudidi 2004).

## 5 Conclusion and implications for the conservation of *D. microcarpum* in Benin

The present study revealed that *D. microcarpum* is a species well known and appreciated by local communities in Benin for its many uses in the traditional medicine, food, crafts, firewood and medico-magic. These numerous uses show that *D. microcarpum* is well integrated into the system of traditional use and management in Benin. The ethnobotanical indices of the species showed that use category, use frequency and organs of *D. microcarpum* vary according to sociocultural group, gender and age categories. Despite its versatility, this species remains underutilized in Benin. Considering the current threat of habitat degradation, conservation measures are needed to ensure the survival and sustainable use of the species by local communities. The major challenge is how to ensure the sustainability of *D. microcarpum* to prevent the extinction of this important species. Thus, the scientific community and the structures in charge of plants protection should carry out awareness of local population on the importance of *D. microcarpum*. They must identify areas of abundance of the species that can be used as in situ preservation areas. The introduction of the species into botanic gardens would also be an asset for its protection.

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## Compliance with ethical standards

**Conflict interest** The authors declare that they have no competing interests in this manuscript.

**Consent for publication** The respondents were informed that their opinions were to be published in a scientific paper and gave their approval.

**Ethics approval and consent to participate** No ethical approval was needed for this study. Prior to data collection, participants gave oral consent to participate in the study.

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