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Endogenous knowledge and human disturbance impact on abundance of two underutilized wild edible tree species in southern Benin

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ABSTRACT

This study assessed endogenous knowledge and impact of human disturbance on the abundance of two underutilized wild fruit tree species: *Drypetes floribunda* (Müll. Arg.) Hutch. (Euphorbiaceae) and *Mimusops andongensis* Hiern. (Sapotaceae) in the Lama Forest Reserve (LFR) in southern Benin. A survey was conducted with 145 randomly selected people amongst the surrounding communities of LFR in order to assess the endogenous knowledge of the species. One hundred square plots were established in the forest for characterizing species abundance in different habitats according to human disturbance degree. Results indicated that this species has multiple uses and either local knowledge on their uses or their organ plant uses depend on social factors. A densities assessment suggests a negative effect of human disturbance on the abundance of both species. Results support the need to envisage conservation and sustainable use strategies as perspective policies.

Keywords: Drypetes floribunda, *Mimusops andongensis*, use, abundance, Lama Forest Reserve, Benin

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1. INTRODUCTION

Numerous poor people in Africa and over the world live on forest resources, commonly called Non-Timber Forest Products. These forest resources contribute to the livelihood needs of rural people in terms of health, food and income at a local and global level.[1–3] Thus, forest areas have been severely modified by human activities in the last few decades[4] and consequently biodiversity regression followed by loss of native species, has become obvious. Biodiversity conservation is a major purpose in nature conservation[5] and the evaluation of biodiversity status and the effect of anthropogenic activities, together with ethnobotanical studies enable us to reach this objective.

Moreover, sustainable development of the last few decades has involved the promotion of use and conservation of natural forest resources for improving peoples' livelihood. Thus biodiversity conservation is generally combined with use. Such an approach is not easily implemented and knowing the human disturbance effects on resources has been used for guiding forest use and conservation of biodiversity. Additionally in developing countries, scientists are very interested in underutilized wild fruit species through research works focused on their sustainable use and conservation. In these countries there are many wild species used by local people. In Benin data reveals a richness of approximately 3000 plant species,[6] amongst which 172 species are using as food,[7] and 814 as medicinal plants.[8] Unfortunately, the use and status of most of these resources used by local people remain undocumented.

In the Lama Forest Reserve (LFR) many wild tree species are used for food and traditional medicine.[9,10] In this wide range of wild edible tree species, two that are underutilized are *Mimusops andongensis* Hiern and *Drypetes floribunda* (Müll. Arg.) A local evaluation, according to the International Union of Conservation of Nature (IUCN) criteria, classified *Mimusops andongensis* Hiern as an endangered species (EN) in Benin.[11,12] But, this species has not been described in the flora of Benin.[6] This may indicate that the species is rare and was not checked off in the inventory studies. Regarding *Drypetes floribunda*, scientific information is missing on its conservation status. Thus, both species have undergone limited study for their sustainable use and conservation.

Moreover, LFR is the main habitat where large populations of these two wild tree species occur at present in Benin.[13] This natural ecosystem is presently dominated by dense forests (typical and degraded ones) and fallows. The fallows have been subjected to historical and current human disturbances through agricultural settlings of surrounding people on the reserve. Historically degraded, dense forest has also been subjected to human disturbance, more than typical dense forest.

According to some authors,[14] indigenous knowledge is an essential component in the biodiversity conservation process; it is therefore necessary to be well informed on species that are used by people to satisfy various needs. Additionally, evaluation of endogenous knowledge may allow us to valorize the species and envisage strategies for its conservation. In Benin, many scientific studies have been carried out on various uses of edible wild fruit species such as *Adansonia digitata*,[15,16] *Tamarindus indica*,[17] or *Parkia biglobosa*.[18] Despite the availability of some studies on *M. andongensis* and *D. floribunda* in West Africa, in particular the Ivory Coast[19] and Nigeria,[20] scientific data on any indigenous knowledge is poorly documented. How human disturbance impacts their abundance has been seldom investigated. Thus, this study aims to assess: (1) local uses of those species and (2) human disturbance impact on their abundance. These objectives will provide better guidance for sustainable use and conservation of the tree species concerned.

2. MATERIALS AND METHODS

2.1. Study area

The present study was carried out in the Lama Forest Reserve (LFR) located in southern Benin, in the Guinean-Congolese zone, between 6° 55′ and 7° 00′ North latitude and 2° 04′ and 2° 12′ East longitude. The climate is sub-equatorial with a bimodal rainfall varying between 1000 mm and 1200 mm per year. The active vegetation period lasts 8 months. This vegetation is characterized by clay soil and particular microclimate. The mean daily temperature ranges from 25°C to 29°C, while the mean relative humidity is approximately 74.5%. Ethnobotanical data was collected in the villages surrounding the LFR (Figure 1).

2.2. Study species

The Mimusops genus belongs to the Sapotaceae family; it involves 45 species. *M. andongensis* is the only representative in southern Benin, especially in the LFR. The plant is a mesophanerophyte,

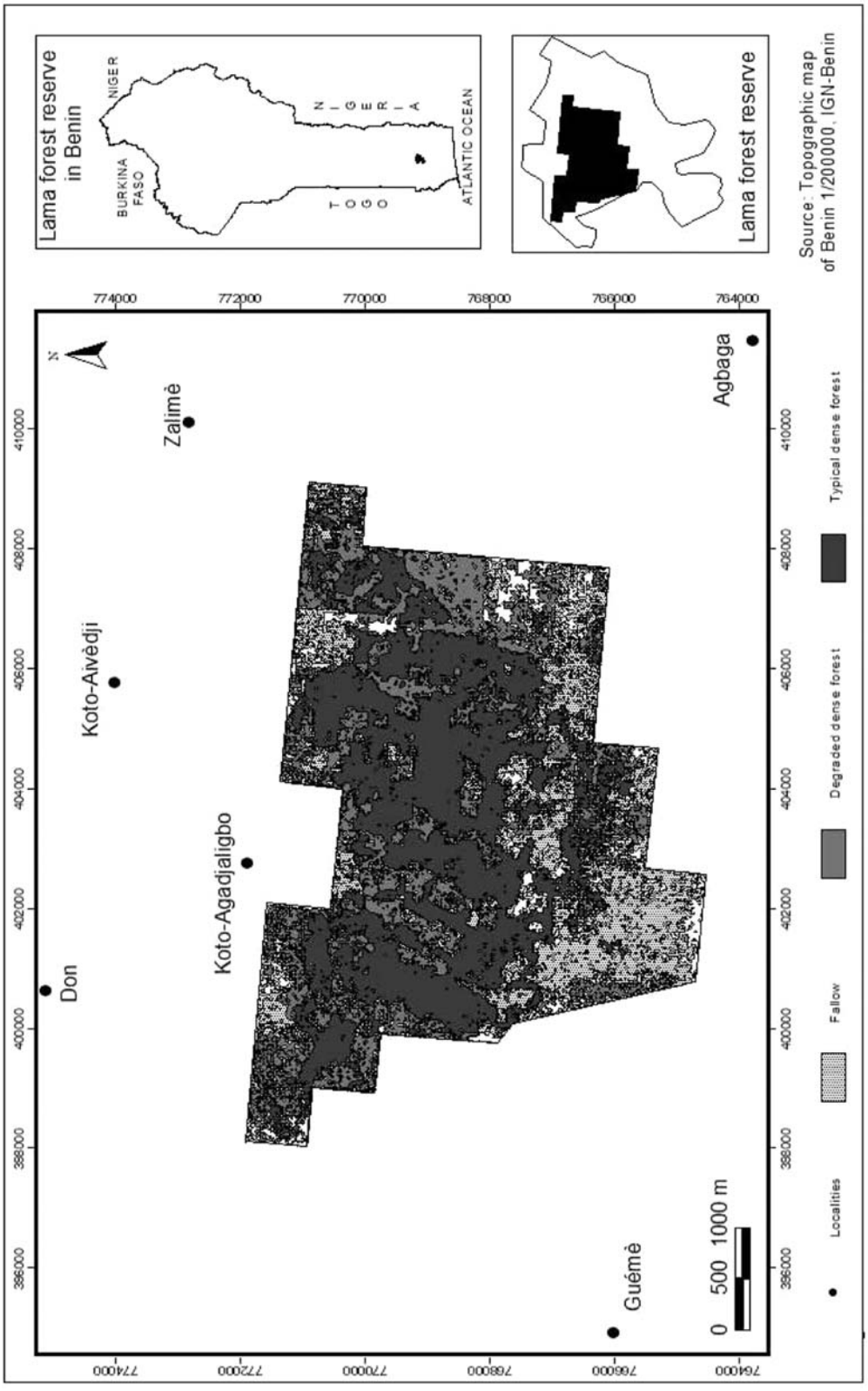

Figure 1. Lama Forest Reserve location and surrounding villages.

containing latex, with dense and very branchy leafage,[20] often grows in forest on clayey, periodically flooded substratum.[21] *Mimusops kummel* is the second species of the genus, this is found in gallery forest or tree savannah, in ferruginous and rocky soil in Benin.[6] As far as the *Drypetes* genus is concerned, it is represented by 5 species of which *D. floribunda* is the only representative in LFR in Benin. It is a cauliflower microphanerophyte, mostly found in the central Guinean phytodistrict (southern Benin), corresponding to semi-deciduous forest areas established on clay soil in the great median depression named "Lama".[6]

2.3. Sampling and data collection

2.3.1. Ethnobotanical survey

A preliminary sampling survey, on 100 persons randomly chosen among various ethnic groups was carried out. The percentage of respondents knowing at least one use of *D. floribunda* and/or *M. andongensis* was calculated at 60%. The global sample size was estimated according to the following formula[22]:

$$N = \frac{U^2_{1-\alpha/2} * p(1-p)}{d^2} \quad (1)$$

Where N is the total number of surveyed people in the study; $U^2_{1-\alpha/2}$ is the value of the normal random variable for a probability value of $\alpha = 0.05$; $U_{1-\alpha/2} = 1.96$; p is the estimated proportion of people in the village who know a use of *D. floribunda* and/or *M. andongensis* ($p = 0.6$); d is the expected error margin of any parameter to be computed from the survey, which is fixed at 0.08. The calculated global sample size N = 145, was obtained and distributed among the selected ethnic groups: Aizo, Fon and Holli. These groups have knowledge about the species and are represented in the study area. Semi-structured interviews were conducted among these three ethnic groups to collect data concerning name, sex, age, activities of people and uses of *D. floribunda* and *M. andongensis*. Overall 145 (124 men and 21 women) people composed of three socio cultural groups such as Aïzo (13), Fon (41) and Holli (91) were interviewed. Interviews were conducted with people whom ages range between 25 and 85 years old. Various socio-professional categories were also taken into account: farmers (104), healers (18), merchants (09), forest guides (08) and others (06).

2.3.2. Density survey

One hundred square plots of 1 hectare (ha) were established in different habitats according to the degree of human disturbance using information from a previous study[23] on habitat characterization in LFR. In each plot all adult individuals of *D. floribunda* and *M. andongensis* were counted. Regenerations were counted in diagonal quadrats (Figure 2). The regenerations are classified as an individual with diameter of breast height (dbh) lower than 10 cm (dbh $<$ 10 cm). But this scale was reviewed for *D. floribunda* whose dbh of adult individual is often lower than 10 cm (Table 1).

2.4. Data analysis

2.4.1. Ethnobotanical data

Various quantitative indices and distribution across ethnic groups, gender (male and female) and socio-professional categories were calculated to assess the level of knowledge. Three ethnic groups were considered: Aizo, Fon and Holli. Subgroups were formed on the basis of the combination of

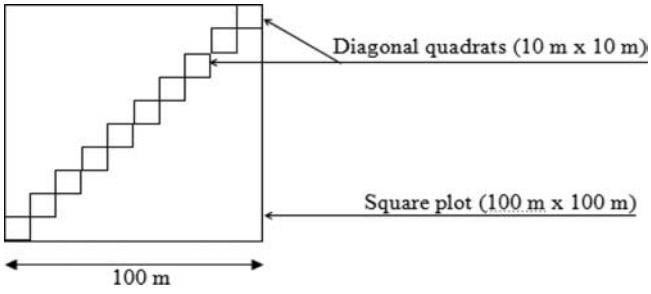

Figure 2. Sample unit of forest inventory.

Table 1. Names and dendrometrical characteristics of live stages of regeneration.

	D. floribunda		*M. andongensis*	
Name	***Height scale***	***Diameter scale***	***Height scale***	***Diameter scale***
Sub juvenile	$h < 2$ m	dbh < 2 cm	$h \leq 2$ m	–
Juvenile	$h \geq 2$ m	2 cm $\leq$ dbh < 4 cm	$h \geq 2$ m	dbh < 7 cm
Young tree	$h \geq 2$ m	4 cm $\leq$ dbh < 5 cm	$h \geq 2$ m	7 cm $\leq$ dbh < 10 cm

social factors. The diversity (DU) and equitability (EU) of use[24,25] was calculated. To assess the significance of any difference in knowledge, the non-parametric Kruskal-Wallis test was performed, at 5% with Minitab 14.[26] This test was performed taking into account non-compliance with the conditions of normality. In order to obtain a more objective index, the use value index was determined[27–29]:

$$\mathrm{UV} = \sum \frac{Ui}{\overline{Ui}} \tag{2}$$

Where Ui is the number of different uses mentioned by each informant i and N is the total number of informants interviewed. A Principal Component Analysis (PCA) based on that index value was performed with SAS 9.2, in order to assess correlations between uses and subgroups.

2.4.2. Density data

The densities were characterized by each considered habitat according to the degree of human disturbance. The average value was calculated at the plot level. The formula used to calculate the value N of the adult density is:

$$N = \frac{n}{s} \tag{3}$$

Where n is the overall number of trees in the plot, and s the area (1 ha).

The density of regeneration N_g is computed as indicated below[30]:

$$N_g = \frac{\sum_{l=1}^{k} N_l \overline{N}_{rl}}{N}; \quad \overline{N}_{rl} = \frac{1}{n_l} \sum_{i=1}^{n_l} y_{li} \tag{4}$$

N_{rl} = mean density of each species regeneration within group l ($l = 1, 2, 3, 4$); $N =$ total number of plots within the global sampling; y_{li} = regeneration density of *D. floribunda*/*M. andongensis* within the ith plot of group l of the stand.

Defined live stage classes were inspired from a previous study in the same area.[23] Height was measured with a relascope and diameter with a calliper. Table 1 shows the considered live stages for calculating regeneration densities.

Density values of each species were subjected to one-way analysis of variance (ANOVA) according to the degree of human disturbance. Densities have been compared between investigated habitats[23] and according to disturbance degree. Statistical analyses were implemented using SAS 9.2 software.

3. RESULTS

3.1. Diversity and distribution of knowledge

The total values of interviewee diversity and equitability obtained (<0.5) indicate that knowledge about the uses are distributed unequally, involving only a section of the people have knowledge on one of the two species. Indeed, for *D. floribunda*, men diversity and equitability values (ID = 0.302, IE = 0.423) were higher than the women (ID = 0.252, IE = 0.352), while an opposite scheme was observed in the case of *M. andongensis* (ID = 0.351, IE = 0.497 for men and ID = 0.374, IE = 0.524 for women). According to age, people over 40 years of age have more knowledge. But these indices values were not significantly different ($p > 0.05$). This is due to the fact that some interviewees had little knowledge of the species but almost all people interviewed knew a specific use for them, mainly the food use (fruits' consumption). As far as socio-professional categories are concerned, traditional healers showed the highest values, followed by forest guides, then farmers and traders, however these values were not significantly different. Regarding the variation between social and cultural groups,

Table 2. Correlations between organ use and ethnic group and gender.

	D. floribunda		*M. andongensis*	
Organs	***Axis 1***	***Axis 2***	***Axis1***	***Axis 2***
Leaves	0.46	− 0.32	0.43	− 0.29
Bark	0.49	− 0.22	0.48	− 0.01
Root	0.44	0.30	0.46	− 0.11
Stem	0.43	− 0.36	0.44	0.25
Fruits	0.39	0.48	0.37	0.57
Seed	0.14	0.64	− 0.21	0.73

it was observed that the Holli population hold more knowledge than the Fon and Aizo populations. This knowledge is linked to each removed organ on the plants.

3.2. Use values of organs and its relation with ethnic group and gender

Use values calculated by ethnic group and sex were subjected to Principal Component Analysis (PCA). The results indicate that 93.56% and 89.19% of ethnobotanical information are explained by the initial both axes, for *D. floribunda* and *M. andongensis* respectively. Therefore, only these axes were used to describe the relationship between ethnic groups, gender and plant organs. Organs of *D. floribunda* and *M. andongensis* were positively correlated with axis 1, except seeds that correlated with axis 2 (Table 2 (Figure 3)).

The projection of ethnic groups in the system of axes (Figure 4) indicates that Holli men (HM: 85%) and Fon men (FM:88%) have a good knowledge on the use of leaves, bark, stems, fruits and roots for both species. Moreover, among interviewed people, Holli women (HW:16%) have more knowledge of the use of seeds and fruit of both species.

As far as Aizo men (AM:69%) are concerned, they have a good knowledge on the use of *D. floribunda* stems. The other groups have little knowledge on the use of the species organs.

Thirty nine and thirty four uses were inventoried for *D. floribunda* (Table 3) and *M. andongensis* (Table 4), respectively. For both species, use values of leaves are higher than other organs.

3.3. Agreement on the types of use

The index values of use types' changed by species (Table 5). However, both species were highly appreciated for their delicious fruit and for the quality of their wood. Both species are used for medicinal purposes and a same value of consensus (CTU = 0.019) was obtained. The other uses included fertilizer and vegetable brush that were mentioned by respondents.

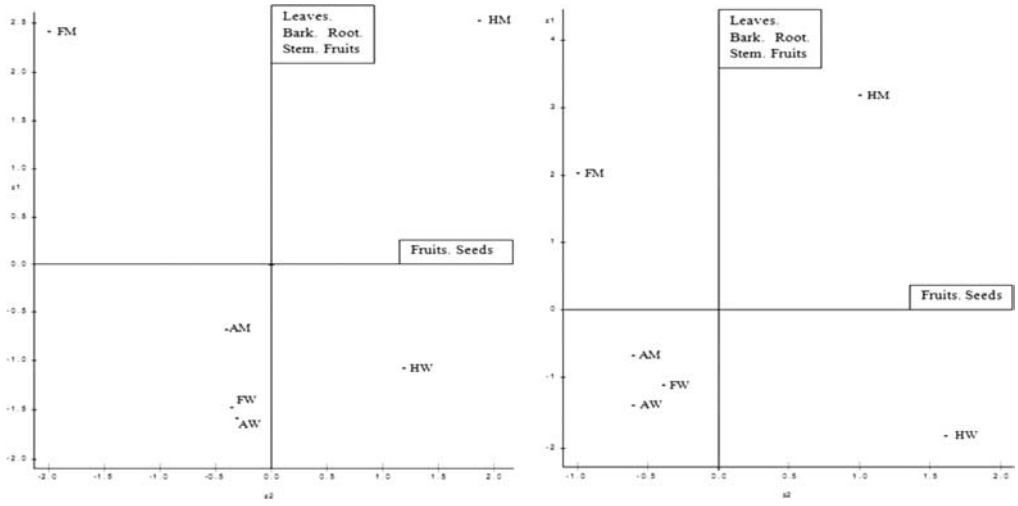

Figure 3. Representation of individuals on the initial both axes for *D. floribunda* (left) and *M. andongensis* (right). Legends FM = Fon Men. FW = Fon Women. AM = Aïzo Men. AW = Aïzo Women. HM = Holli Men. HW = Holli Women.

Figure 4. Pictures showing stem morphology: (a) stem blackish-brown with bumps and (b) reddish-brown without bumps of *M. andongensis* (c) straight or erected stem with bumps and (d) tilted/laid stem with upright branches of *D. floribunda*.

3.4. Use categories and homogeneity of knowledge on medicinal use type

Medicinal use recorded a greater number of use categories. Disease symptoms are gathered in 5 use categories, such as symptoms of asthenia (general tiredness, convalescence, sexual weakness etc.), symptoms of skin infection (scabies, itches, measles etc.), digestive system disease symptoms (constipation, stomach ache, vomiting etc.), conception (easy-pregnancy) and common diseases (malaria, fever, anemia, bellies). Asthenia diseases occupied first place among the different categories (UD = 0.36 for *D. floribunda* and UD = 0.28 for *M. andongensis*). The corresponding values of equitability index indicated a homogeneous distribution of knowledge among respondents regarding the problems of asthenia (UE = 0.99 and UE = 0.89 for *D. floribunda* and *M. andongensis* respectively). The others use categories such as skin, digestive and conception diseases have the lowest value of indexes (0.1; 0.07; 0.07) for *D. floribunda* and (0.06; 0.04; 0.02) for *M. andongensis* respectively.

Table 3. Use values (UV) of *D. floribunda* organs.

Organs	Uses	UV
Roots	Tonic, Malaria, Aphrodisiac, Headache, Osteoarthritis, Paralysis, Easy-pregnancy, To be brave (magic ritual), To be lucky (magic ritual).	0.062
Leaves	Oedema, Malaria, Convulsion, Scabies, Itches, Blood-pressure, Vertigo, Easy-pregnancy, Sterility, Cough, Measles, Urogenital depurative, Child who delay to walking, Constipation, Tonic, Ache, Pain, Magic protection.	0.124
Bark	Scabies, Itches, Stomach ulcer, Blurred vision, Urinary incontinence, Hallucinations.	0.041
Stem	Aphrodisiac, Magic protection, Tonic, Osteoarthritis, Toothpick, Tool handles, Catapult, Statuettes.	0.055
Fruit	Consummation, Tonsillitis, Tonic, Aphrodisiac, Easy-pregnancy, Farm input	0.041
Seed	Farm input	0.007

3.5. Consensus on the forms of use

Organs of these plants are used in various forms on a medicinal level (Table 6). The most common is the decoction. According to the treated affections, organs are used in decoction alone or in combination with other plant organs or ingredients. It is followed by maceration in water. Most different forms of use were observed for *D. floribunda* rather than *M. andongensis*.

3.6. Stem morphology of *D. floribunda* and *M. andongensis*

Some differences were observed on the plants stem morphology. Regarding *M. andongensis* the stem had a blackish or blackish brown color and bumps. According to interviewees, stems carrying bumps are the male, while female individuals were not bumped. As far as *D. floribunda* is concerned, the stem is brown and greenish with white marks in some places. They are erected with bumps or sometimes inclined with small upright branches emerging from representative bumps (Figure 4). However, most people interviewed have not mentioned any ethnobotanical interest in these differences. Moreover, individuals of *M. andongensis* without bumps were found on land liable to flooding or around ponds. Concerning *D. floribunda*, individuals whose stems are erected were found in fallows, while those whose stems are tilted or laid are found in forests.

3.7. Impact of human disturbance on abundance of *D. floribunda* and *M. andongensis*

Densities of adult and regeneration individuals of *D. floribunda* and *M. andongensis* across various habitats according to human disturbance degree were summarized in Table 7. Results showed that whatever the live stage, densities values were greater in least disturbed habitats (typical and degraded dense forests) compared to the most disturbed ones (young and old fallows), but the difference was not always significant. Analysis of Variance (ANOVA), indicated a high significant difference (Prob. < 0.05) between density values of some life stages between typical dense forest and degraded one. For both species, juvenile density was statistically different between typical dense forest and degraded forest, while sub juvenile density remained similar ($P > 0.05$). Young and adults tree densities showed a high significant difference ($P < 0.05$) between typical dense forest and degraded forest in the case of *D. floribunda*, while their values were similar for *M. andongensis*.

Table 4. Use values (UV) of *M. andongensis* organs.

Organs	Uses	UV
Roots	Urinary incontinence, Easy-pregnancy, Sore, hemorrhoid, Obesity, Oedema, Stomach ache, Opened fontanel, Magic protection, Tonic	0.069
Leaves	Malaria, Icterus, Tonic, Constipation (To pass a motion easily), Convulsion, Osteoarthritis, Stomach ache, Sore, Magic protection, Oedema, Scabies.	0.076
Bark	Tonic, Sanguinolent vomiting, Measles, Anemia, Magic protection, Easy-pregnancy, Malaria, Dermatosis, Stomach ache, Vermifuge	0.069
Stem	Building, Sculpture, tom-tom, Mask, Fetish ritual, Tonic (weaned child), the child who delay to walking, Easy-pregnancy	0.055
Fruit	Consummation, Convulsion, Buccal sore of child, Tonic, Easy-pregnancy	0.035

Table 5. Values of types of use (CTU).

Type of use	Food	Medicinal	Artisanal	Combustible	Ritual	Construction	Others
D. floribunda	0.045	0.019	0.038	0.008	0.004	0.022	0.006
M. andogensis	0.036	0.019	0.007	0.014	0.008	0.047	0.012

4. DISCUSSION AND CONCLUSION

4.1. Knowledge, uses and stem morphology of *D. floribunda* and *M. andongensis*

Investigations revealed that people have significant knowledge on *D. Floribunda* and *M. andongensis*. The total values of diversity and equitability indicated an inequality in the distribution of knowledge and uses according to ethnic groups. In addition, many forest guides and farmers practice traditional healing as secondary activities and harvest a relatively large part of the organs. The relative small difference observed between the values of the index reflects this situation. These results are similar to those performed on *Vitex Doniana*[31] and on *Mondia whitei*.[32] An intracultural variation on the knowledge according to gender and age was also observed. This corroborates several local[18,33,34] and international works[35–37] that have found that the level of knowledge on a species depends on age. This involves a risk of erosion of indigenous knowledge because it is held by older people.[38] Indeed, according to these authors, the stability of endogenous systems of knowledge can be affected by cultural variation of knowledge on plant species. In this study, the knowledge held by the Holli compared to others ethnic groups involved, implies that Holli people should be regarded as very important in the conservative of indigenous knowledge in Benin.[39] Consequently they should be targeted for future investigations related to local knowledge on these tree species. In addition, both species are qualified here as multipurpose species in view of the variability of their functions supplied to people: food, medicinal needs and artisanal fabrication.[7] Thus, organ harvesting appears to be linked to the needs of people and cultural differences.[40]

The medicinal virtue identified through this study was not confirmed as in the case of some species such as *Sarcocephalus latifolius*,[6,41–44] *Mondia whitei*[45–47] and *Parkia biglobosa*.[48] Biochemical studies are requisite to prove therapeutic properties of *D. floribunda* and *M. andongensis* in order to promote their use in traditional and industrial medicine.

This study also identified stem morphology of *D. floribunda* and *M. andongensis* based on the shape and color of the stem, respectively. These morphological distinctions may be related to environmental factors, such as the degree of soil hydromorphic (*M. andongensis*), forest cover (closed or opened habitat) or species density (*D. floribunda*). Indeed, some authors[34,49–51] had linked morphological changes with climatic gradients, habitat or environmental factors. It would be interesting to investigate ecological factors that are able to influence species phenotype in order to give an explanation of these morphological changes. In the case of *M. andongensis*, interviewed people distinguished the species into male and female. However these distinctions are not justified scientifically, therefore we were not able to prove them. Distinction criteria used by people could be used to choose plant organs according to the type of use and the treated disease symptoms. This highlights the necessity to investigated biochemical properties of the species. Moreover, it could be hypothesized that regeneration by layering for *D. floribunda* may involve morphological change of its stem.

4.2. Impact of human disturbance on abundance of *D. floribunda* and *M. andongensis*

It was observed that adult densities of species were lower in highly disturbed habitats (young or old fallows) than in habitats that are less disturbed (degraded or typical dense forest). Meanwhile, typical

Table 6. Forms of use and consensus values (CMU).

Forms of use	*D. floribunda*	*M. andogensis*
Decoction	0.686	0.672
Maceration	0.137	0.164
Reducing powder	0.020	0.131
Alcoholic extract	0.059	0.033
Trituration	0.059	–
Ember	0.039	–

Table 7. Density values (stems/ha) and coefficient of variation (cv) of both species.

		Sub juvenile		Juvenile		Young tree		Adult	
Species	**Habitat types**	**Average**	**cv (%)**	**Average**	**cv (%)**	**Average**	**cv (%)**	**Average**	**cv (%)**
D. floribunda	Degraded dense forest	1.00[a]	316.23	16.00[b]	200.26	10.00[b]	194.27	15.50[b]	175.88
	Typical dense forest	1.46[a]	315.97	46.25[a]	156.85	39.38[a]	121.00	35.29[a]	98.08
	Young fallow	0.00[a]	–	0.69[b]	538.52	1.03[b]	395.61	0.59[b]	221.09
	Old fallow	0.00[a]	–	1.54[b]	360.56	0.77[b]	360.56	0.62[b]	193.85
	Probability	0.243		0.001		0.000		<0.000	
M. andongensis	Degraded dense forest	1.00[a]	316.23	7.00[c]	151.34	6.00[a]	116.53	15.50[a]	74.14
	Typical dense forest	0.83[a]	335.17	15.42[a]	184.90	3.96[a]	178.56	20.60[a]	59.76
	Young fallow	0.00[a]	–	0.00[b]	–	2.07[a]	326.26	1.52[b]	238.69
	Old fallow	0.00[a]	–	0.77[b]	360.56	0.00[a]	–	0.08[b]	360.56
	Probability	0.284		0.007		0.097		<0.000	

In the same column (same live stage) of a given species, average values followed by same letter are not significantly different at probability = 0.05 (Student Newman and Keuls text).

dense forests hold great values of densities of adult individuals of *D. Floribunda* and *M. andongensis*. Indeed, fallows are exploited and degraded by the surrounding people for several years. In these habitats, inventories showed that most of the main forest species are rare. The impact of human activity is harmful globally on wild species and in particular on both the studied species. These results corroborate a study that showed the negative impact of human disturbance on adult densities of some valuable tree species such as *Afzelia africana*, *Pterocarpus erinaceus* and *Khaya senegalensis*.[52] However, according to other study,[53] tree abundance is not only the result of human disturbance but several others factors, such as climate or microclimate, soil properties, fire regimes and herbivory all have an effect. According to regeneration density, the same trend was found. High values of regeneration densities were observed in degraded and typical dense forests. These results may suggest that habitat type with adult individuals should be able to accommodate juveniles. Consequently sexual reproduction should be appropriated for these species. Previous works have shown that the recruitment rate would be limited by several factors such as seed and light availability. Indeed, the weak recruitment rate of these species could be due to old age that affects the regeneration potential of seeds of species individuals.[23,54] Moreover, these species are heliophilous and their growth could be influenced by canopy cover. Also, the presence of invasive plants such as *Chromolaena odorata*, an herbaceous plant could hinder seed germination.[55] On the other hand, the fruits of these species are very palatable by animals; so it is possible that the seeds are damaged and cannot regenerate when they fall.

4.3. Implication for sustainable use and conservation

The consequences of human activities remain visible especially on the abundance of these tree species. Although, protective measures have existed, unlawful use is indicating the dependence of surrounding people on forest resources for their livelihood. But interviewees are not totally aware of the disturbance effect on these species. Thus, protection strategies need to be popularized among the surrounding people of LFR. According to some authors,[56] human activities, in particular unlawful use, are considered a major threat to the future of the tropical forest reserve. Therefore, sustainable use strategies are required to help surrounding people sustain their livelihood. This ecosystem appears to be the only one in Benin that contains great populations of *D. floribunda* and *M. andongensis*. Specific studies on threat factors and the impact of harvesting are necessary in this area to help future viability.

In Benin and other West African countries, there is a cultural practice existing to preserve useful wild fruit species on farmed land.[57] However, studied species are not yet preserved on the surrounding farmed land of the Lama Forest Reserve. Indeed, in these surrounding agroforestry parklands, individual *D. floribunda* and *M. andongensis* have not been observed during field investigation. Some interviewees reported that these species have disappeared from agricultural lands due to increasing human pressure. Therefore, local conservation strategy, for example their introduction in home gardens or in agricultural land, could be promoted for their sustainable use. Complementary research work on the reproduction biology, as in the case of several valuable tree species: *Blighia sapida*,[58–60] *Adansonia digitata*,[16,49,61] *Vittelaria paradoxa*,[62] *Milicia excelsa*,[63] *Tamarindus indica*,[17,34,50] *Vitex doniana*,[31] *Parkia biglobosa*[18] should be encouraged for enhancing domestication and conservation of these tree species.

5. CONCLUSION

Finally, both studied species are multipurpose wild edible plants used by local people on various levels. The knowledge of these plant species are diverse, but unevenly distributed within ethnic groups, with the majority of knowledge held by older people. This knowledge also depends on gender. The Holli ethnic group had the highest level of knowledge on the different uses of these species. All organs of the species are harvested generally for food and medicinal needs. These tree species are underutilized. Their uses are well known at local levels. Exploited habitats for various needs are unable to hold more individuals of *M. andongensis* and *D. floribunda*. Some conservation policies integrating these species have been discussed for their sustainable use.

AUTHORS' CONTRIBUTION

All authors have made an intellectual contribution towards each step of this research.

ETV has made acquisition, interpretation and analysis of data, designed and performed fieldwork, and drafted the manuscript.

TDH has been involved in manuscript drafting and revising it for important intellectual content.

AEA has made substantial contributions to conception, design of work and involvement in data collection.

JD, RGK and BK gave conceptual advice, read and corrected the drafted manuscript.

BS supervised the work and improved the manuscript.

All authors have read and approved the final manuscript.

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