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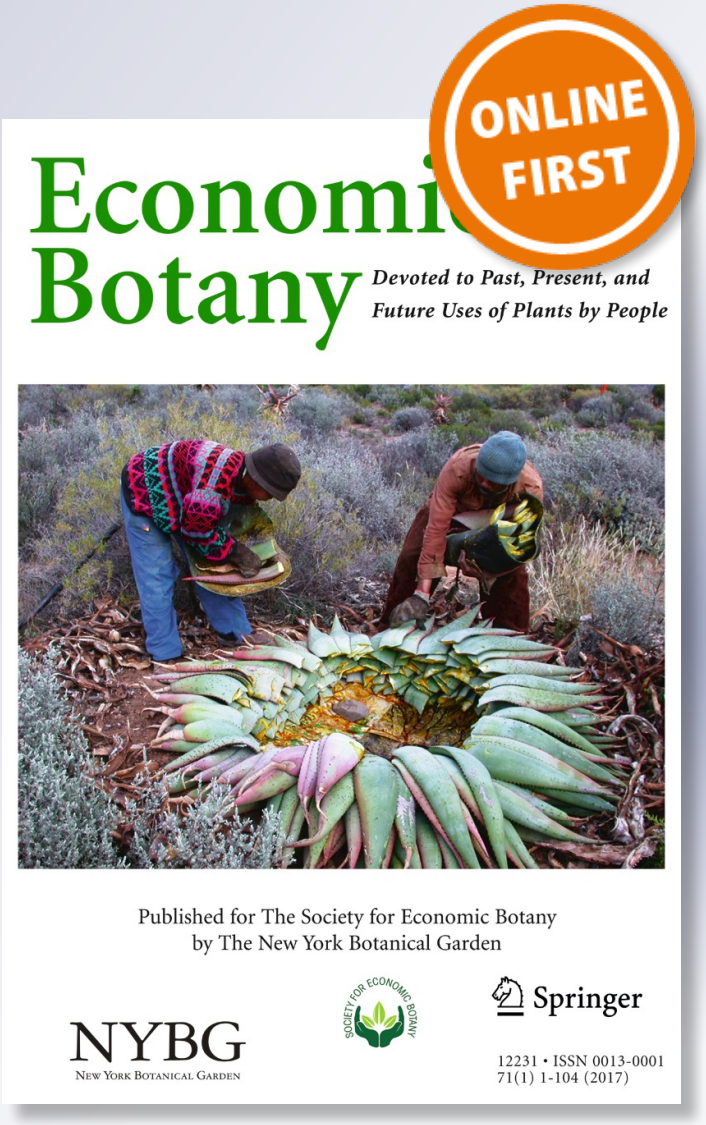
Economic Botany

ISSN 0013-0001

Econ Bot
DOI 10.1007/s12231-017-9370-6



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Local Knowledge on the Uses, Habitat, and Change in Abundance of Multipurpose *Mimusops* Species in Benin

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Multipurpose NTFP species typically experience higher harvest demand because of their multiple uses, which, when combined with unsustainable land use practices, may threaten population viability. We assessed local knowledge on the uses, habitat, and population status of *Mimusops andongensis* and *Mimusops kummel*, both multipurpose NTFP species in Benin, to promote their valorization and conservation and thus sustain local knowledge on their uses for domestication issues. One hundred households were randomly selected for structured interviews for *M. andongensis* and 500 for *M. kummel*. The relationship between age, sex, and ethnic groups and the species uses was assessed using comparison and correspondence analyses. Nearly all organs of the species were used. Both species were mainly exploited for medicinal purposes but also in construction and as firewood. We found similarities in some uses of the species organs, although the species occur in different ecological zones and are used by different ethnic groups. This result should be considered for the valorization of the species. Most informants reported that populations of *M. andongensis* were decreasing, although some felt that they were increasing, whereas less than one-third said that *M. kummel* was decreasing. There were strong relationships between gender, age, and ethnic affiliation of the users and the exploited organs of both species. Potential uses exist based on both the past and current uses of the species and in comparison to other countries where they are exploited. Local ethnoecological knowledge and practices will help to valorize and conserve the species. However, further research on the species' seed germination and propagation ability are also necessary.

Les espèces de PFNL à usage multiple font particulièrement face à une demande plus élevée qui, combinée avec les pratiques destructrices d'utilisation des terres, peut constituer une menace pour la viabilité des populations. Cette étude vise à identifier les connaissances locales sur les usages, habitats et le statut de la population de 2 espèces de PFNL à usage multiple au Bénin, *Mimusops andongensis* et *Mimusops kummel*, afin de promouvoir leur valorisation et conservation et ainsi maintenir les connaissances endogènes sur leurs utilisations à des fins de domestication. Cent ménages ont été aléatoirement interviewés pour *M. andongensis* et 500 pour *M. Kummel*. La variation des usages des 2 espèces entre les groupes d'age, de sexe et ethniques a été évaluée aux moyens des analyses de comparaison et de l'analyse factorielle des correspondances. Presque tous les organes des espèces sont exploités, principalement à des fins médicinaux, mais aussi pour la construction et comme bois de feu. Il existe de similarité dans certains usages des organes des 2 espèces, bien qu'elles soient exploitées dans différentes zones écologiques par différentes ethnies. La majorité des

[1] Received 17 March 2016; accepted 27 February 2017; published online ——————

Economic Botany, XX(X), 2017, pp. 1–18

Published online: 25 April 2017

interviewés a rapporté une décroissance des populations de *M. andongensis* bien que pour certains elles auraient augmenté, tandis que environ 1/3 ont rapporté une décroissance des populations de *M. kummel*. Il y a une différence significative dans l'usage des organes des 2 espèces par les groups d'âge, de sexe et ethniques. Compte tenu de leurs usages passés et actuelles et en comparaison à d'autres pays où elles sont exploitées, il existe du potentiel d'utilisation des espèces. Les connaissances endogènes, ainsi que des essaies de germination et de propagation aideront à leur valorisation et conservation.

Key Words: Non-timber forest products, local knowledge, ethnobotany, ethnoecology, medicinal plants, *Mimusops andongensis*, *Mimusops kummel*.

Introduction

Worldwide, people harvest a wide range of forest products (non-timber forest products; NTFPs) which greatly contribute to their diet, health, energy, and other aspects of their welfare (Shackleton and Pandey 2014). Although a recent meta-analysis concluded that in most cases, the harvesting of NTFPs is ecologically sustainable (Stanley et al. 2012), the threat or reality of overharvesting is real for many NTFP species, particularly multipurpose ones, and contexts (Shackleton et al. 2009; Ticktin et al. 2012; Gaoue et al. 2013). For example, the concurrent harvesting of leaves and bark can negatively impact the population viability of tree species more than the harvesting of leaves only (Ticktin and Shackleton 2011). Also, the exploitation of trees for both timber and NTFPs may present a high potential of conflict of use for either product (Herrero-Jáuregui et al., 2013). However, the impact of multiple uses on species population can be location specific depending on the biology, level of use, geographical distribution, and ecological resilience of the species in question. Moreover, NTFP species face threats from conversion of forest lands to non-forest lands and shifts in ecological processes coupled with invasion by alien species (e.g., Rist et al. 2008; Sinasson et al. 2016). Therefore, it is vital to understand local peoples' uses and dependency on NTFPs and threats to natural habitats, which will allow for development of policies and strategies to promote sustainable use and conservation at species, community, and landscape scales. This will also help to maintain local knowledge related to the uses of indigenous species, which are highly pertinent for domestication strategies (Chekole et al. 2015).

Mimusops andongensis Hiern and *Mimusops kummel* Bruce ex A. DC (Sapotaceae) are two multipurpose NTFP species widely used in many African countries (Lemmens et al. 2010). Their wood is used to produce charcoal and firewood, as well as for construction and timber (Lemmens 2005; Bekele-Tesemma 2007; Lemmens et al. 2010). The fruits, seeds, bark, roots, and leaves are used for local healthcare needs and the fruit and bark for alimentary uses. For example, the fresh, tasty fruits of *M. kummel* are used to supplement the diet, especially during food shortage seasons (Teketay et al. 2010). When dried, the ripe fruits are pounded and the powder is used to make juice or a local brew (Ruffo et al. 2002). *M. kummel* is a nationally marketable fruit tree in Ethiopia and has been chosen as a priority species for the development of indigenous fruit trees in Eastern Africa. In traditional medicine, the seeds are used to cure ascariasis and the roots as a laxative and galactagogue. The leaves of *M. andongensis* are used to treat skin infections (Soro et al. 2010). The fruits are also consumed by monkeys and birds in forests (e.g., Nombimè and Sinsin 2003; Moscovice et al. 2007).

Until recently, there was limited knowledge on the uses and conservation status of both species in West Africa. In Benin, studies have investigated *M. andongensis* uses and population profile in Lama Forest reserve (Lokonon 2008), but not further afield. Despite its possible widespread local use, nothing is formally documented on the use or ecology of *M. kummel* in Benin. Such information will help to assess the value of the species and guide effective actions concerning their valorization and conservation, if needed. However, Benin is facing severe pressures on indigenous forests, including overexploitation, changing land use, grazing and bushfires, invasive species, and variation in climatic conditions. For example, Benin has lost 50,000 ha of forest annually between 2000 and 2010 (FAO 2011). Consequently, many indigenous species are threatened, including *Adansonia digitata* L. (Assogbadjo et al. 2005), *Pentadesma butyracea* Sabine (Avocèvou-Ayisso et al. 2009),

Sclerocarya birrea (A. Rich.) Hochst. (Gouwakinnou et al. 2009), and *Tamarindus indica* L. (Fandohan et al. 2010a). Under such circumstances, multipurpose species are particularly at risk of both overharvesting and loss through forest conversion (e.g., Thompson et al. 2013; Sinasson et al. 2016), potentially undermining the well-being of user households and communities. Thus, diminished stocks or loss is not just about conservation but also of social and development concern.

Within the content of the above, this study aimed to (1) assess the proportion of local households who use or used *M. andongensis* and *M. kummel* in Benin, which parts and for what purposes; (2) analyze how the species knowledge and uses vary among sex, age, and ethnic groups; (3) analyze if there is any similarity in the uses of the two species; and (4) assess local knowledge on the occurrence habitat and change in abundance of the species. The hypotheses underlying this study are that (1) *M. andongensis* and *M. kummel* organs are exploited in Benin for multiple purposes; (2) local knowledge on and uses of both species vary according to sex, age, and ethnic groups; (3) both species' organs can have similar uses while exploited by different ethnic groups; and (4) local people are aware of the threats faced by the species in forest.

Methods

Study Area

We conducted a survey in Benin, in Zalimey and Koto villages for *M. andongensis* and in Akpassi, Djagbalo, Banon, Manigri, Wari-Maro, Igbèrè, Pénéssoulou, Bakou, Idadjo, and Aklamkpa for *M. kummel* (Fig. 1). Zalimey and Koto are in the southern part of the country which is characterized by a subequatorial climate with a bimodal rainfall regime, i.e., two rainy seasons alternating with two dry seasons. The mean annual rainfall is 1200 mm, the mean annual temperature varies from 25 to 29 °C, and the relative humidity between 69 and 97%. The villages for *M. kummel* are located in the Sudano-Guinean zone characterized by a transition towards a unimodal rainfall regime. Annual rainfall varies between 1100 and 1300 mm and evapotranspiration between 1400 and 1500 mm. The annual temperature range is 25 to 40 °C, and the relative humidity varies between 31 and 98%. The original vegetation in the southern part was dense semi-deciduous forests and Guinean savannas whereas the vegetation in the Sudano-Guinean zone is characterized by a mosaic of woodlands, dry dense forests, tree and shrub savannas, and gallery forests (Adomou 2005). Zalimey and Koto are inhabited mainly by Holli and Fon ethnic groups, and the villages for *M. kummel* are mostly of Nagot, Mahi, and Anii. Generally, the survey communities are characterized by low levels of formal education and are highly reliant on land-based livelihood strategies such as farming and NTFP collection.

Data Collection

Before collecting data, we obtained permission from heads of villages and heads of traditional healers who informed people about our work and to welcome and help us. Pictures of leaves, trunk, and fruits of both species (Fig. 2) were also shown to them and to some people in the villages to get local names of the species. *M. andongensis* is well-known (even the scientific name) by some young people who used to work as forest guides or helpers during various research activities in Lama forest reserve. *M. kummel* organs were sometimes confused with those of *Vitellaria paradoxa* C. F. Gaertn. or sometimes those of *Manilkara* sp. Forest managers were also contacted and pictures of leaves, trunk, and fruits were shown to them. This was to get local names of the species and permission to enter the forests to identify species locations. However, several of current forest managers did not know the species and they put us in contact with local people who used to work in the forest and knew the different species. To avoid any confusion, we accompanied these local people into the forest to help differentiate *M. kummel* from both *V. paradoxa* and *Manilkara* sp.

We conducted a structured household survey using questionnaires spanning 3 months. Fifty households were randomly selected in each sampled village, giving a total of 100 households for *M. andongensis* and 500 for *M. kummel*. Interviews were with heads of households. Information gathered included (i) socio-economic characteristics of households (Table 1), (ii) species knowledge and the exploited plant parts and their uses (both past and current, when applicable), and (iii) the habitat of occurrence and change in species abundance.

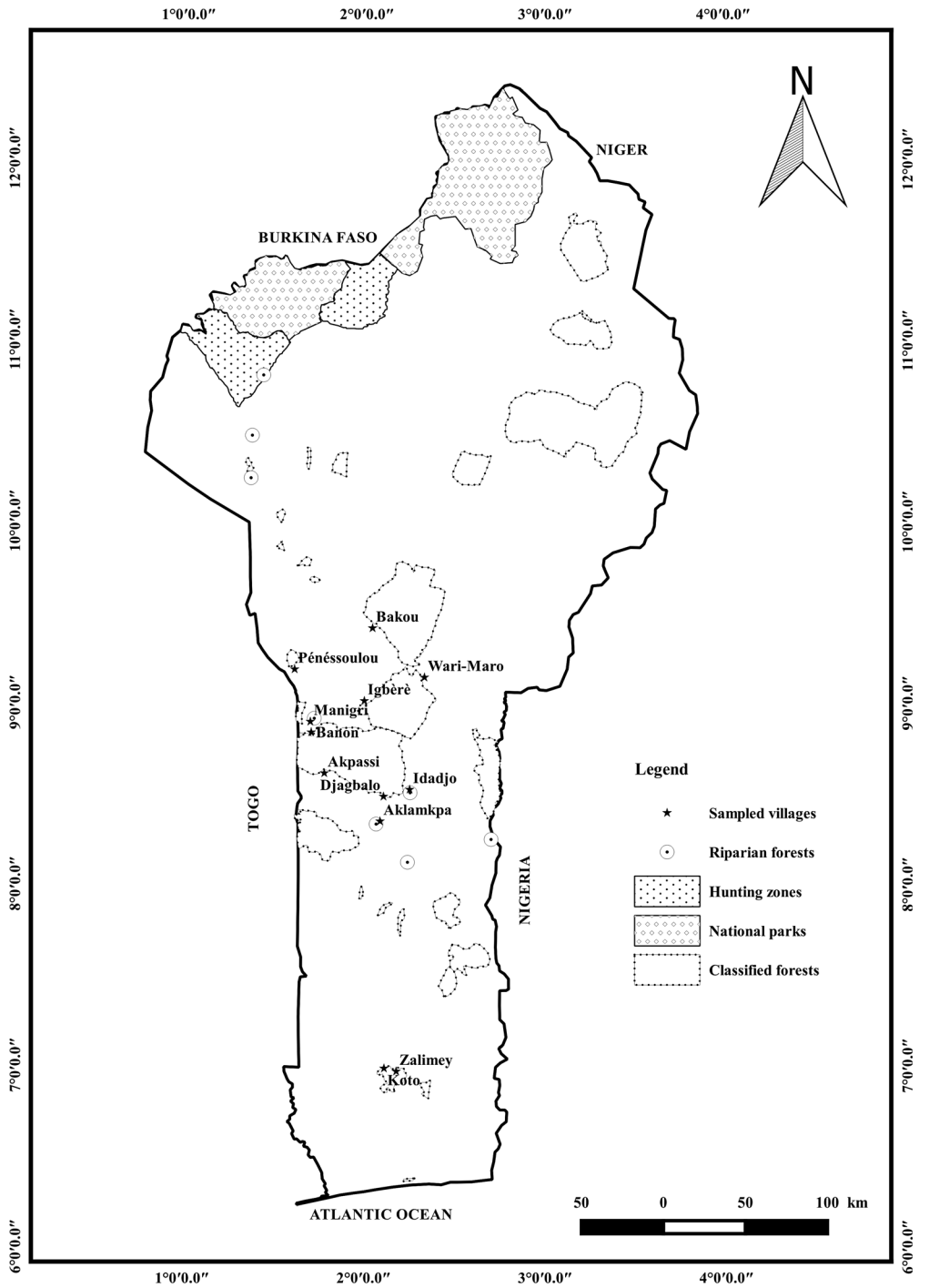

Fig. 1. Location of the study area and sampled villages.

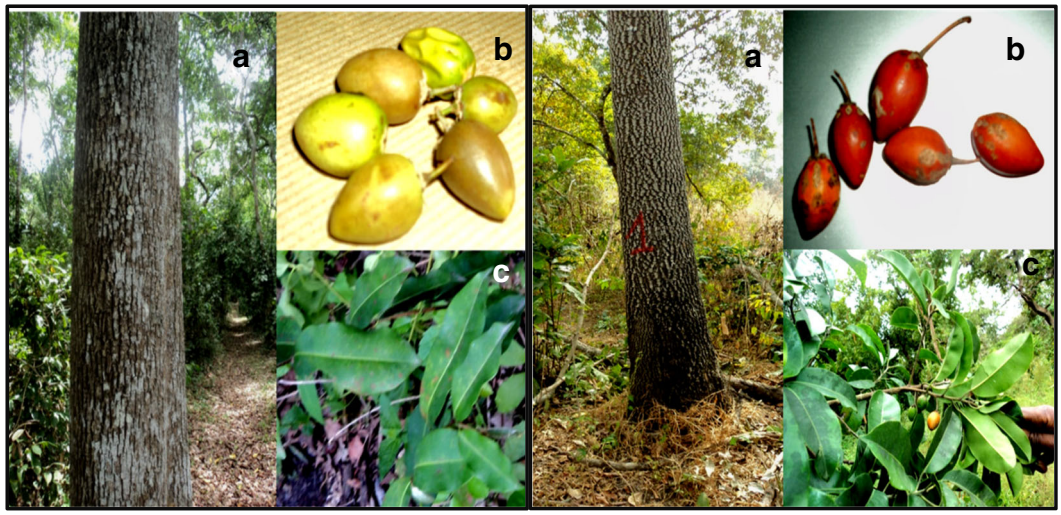

Fig. 2. *Mimusops andongensis* (*left*) and *Mimusops kummel* (*right*) trunk (*a*), fruits (*b*), and leaves (*c*).

Data Analysis

The different uses were grouped into categories. We determined the overall use importance of both species using the use value (Phillips and Gentry 1993) computed as:

$$UV = \frac{\sum UVi}{N}$$

UVi is the sum of all uses reported by the informant *i* and *N* the total number of informants.

Use value was also determined for each category of use and comparison was made between studied species, using a non-parametric Mann-Whitney *U* test. For comparison reasons, only past uses (had been used at least 5 years ago) were considered because the forest where we were able to carry out the survey for *M. andongensis* has been fully protected since 1988 and the species is no longer exploited. Additionally, use values were calculated and compared between sex, age, and ethnic groups for each species by means of Mann-Whitney *U* (between sex groups) and Kruskal-Wallis (between age/ethnic groups) tests. Simple correspondence analysis was performed on the frequencies of citation of the use categories to describe how the uses of both species are related to sex, age, and ethnic groups of users. The first two dimensions explained more than 80% of total variance of the data and therefore we used them to display the relation.

Results

Local Uses of *Mimusops* Species

About 68% of the interviewees knew *M. andongensis*, locally known as afoutin (Fon) and égui-oché (Holli). Of these, 69% made use of the species. Seventeen uses were recorded grouped into five use categories, namely medicinal, construction, energy, food, and social uses (Table 2). The species were mainly used as medicine to treat malaria, mouth infections, and scabies and to strengthen newborns. Other important uses of *M. andongensis* included the construction of houses and attics with the wood, exploitation of young stems/branches and wood as firewood, consumption of fruits to relieve hunger, and the use of young stems/branches as a toothbrush (Table 2). The most widely used parts of the species were the wood, young stems/branches, and bark (Fig. 3). The Holli were aware of all the uses whereas the Fon reported only two uses. Fifty-nine percent of the informants preferred to use *M. andongensis* mainly because of its effectiveness in the treatment of ailments and because the wood is hard, resistant to termites, and does not deteriorate quickly like other species. Another reason was that the wood maintained roofs even during heavy rains and tornados. Although *M. andongensis* is no longer exploited in the Lama forest reserve, the species is still used mainly as medicine elsewhere where it occurs (Fig. 4b, d, and e) but where we were not able to carry out the survey due to political reasons.

TABLE 1. SOCIO-ECONOMIC PROFILE OF THE SAMPLED POPULATION.

Characteristics		*M. andongensis*	*M. kummel*
Sex	Male	97	458
	Female	3	42
Age groups (years)	≤30	28	57
	31–60	53	345
	60	19	98
Educational levels	None	66	278
	Primary	22	162
	Secondary/more	12	60
Mean size of households (SD)		9.3 (5.0)	8.3 (4.5)
Main activities	Farmer	89	341
	Traditional healer	0	15
	Sawyer	2	35
	Others	9	109
Ethnic groups	Holli	70	–
	Fon	30	–
	Nagot	–	44
	Mahi	–	68
	Anii	–	362
	Adja	–	8
	Bariba	–	5
	Yom	–	13

Most (79%) interviewees knew *M. kummel*, locally named èmèdo (Nagot), tohoukoho (Mahi), and alan (Yom). The species was used by 31% of those of knew it. A total of 69 uses were reported and grouped into eight use categories, namely medicinal, construction, furniture, tool, energy, food, commercial, and social uses (Table 3). *M. kummel* was mostly used to treat (currently by traditional healers) malaria, stomachache, intestinal worms, chickenpox, and mouth infections and to strengthen newborns. The species was mainly used in construction of houses and classrooms to make roofs and doors. It was also exploited for the manufacture of household furniture (mainly beds, chairs, and tables) and tools (mainly mortars, pestles, and arrow shafts). Wood and young stems/branches served also for domestic energy mainly as firewood and fruits to relieve hunger and as a trap for animals in the forest. Young stems/branches were socially appreciated for toothbrushes while the wood was sold as timber (Table 3). *M. kummel* wood, young stems/branches, and bark were the most widely used part. The Nagot were aware of 97% of the recorded uses while the other ethnic groups reported 22% or less. Thirty-seven percent of the informants preferred to use the species mainly because (i) of the effectiveness in the treatment of ailments and (ii) the wood is hard and resistant (maintained roofs even during heavy rains and tornados). Five percent of the informants preferred to exploit the young stems/branches as toothbrush because they are tender and effective. Figure 4 (**a**, **c**) presents some uses of *M. kummel*.

Although the two species were used by different ethnic groups in different zones of the country, there were similarities in some uses of their leaves (against malaria, headache), bark (against malaria, stomachache, skin infections, for newborns growth), young stems/branches (mouth infections, toothbrush, fire), wood (construction), and fruits (relieve hunger).

USE VALUES AND USE PATTERNS ACCORDING TO GENDER, AGE, AND ETHNIC GROUPS

There were significant differences between the two species regarding the overall and the medicinal use values as well as the energy and the construction use values ($p < 0.05$). The highest overall use value was obtained for *M. kummel* which also had the highest medicinal value but the lowest construction and energy use values (Table 4).

Although there were no significant gender, age, and ethnic group-based differences in the use value per category for *M. andongensis* ($p > 0.05$), our results showed that only Holli informants mentioned the medicinal, energy, and social use of the species and only men revealed its use in construction (Table 5).

TABLE 2. CATEGORIES OF USE, EXPLOITED ORGANS OF *MIMUSOPS ANDONGENSIS*, PROCESSING METHODS, PERCENTAGE OF RESPONDENTS, AND ETHNIC GROUPS USING THEM (ALL USES MENTIONED BY RESPONDENTS ARE DISPLAYED).

Plant part	Use category	Purpose of use	Processing method	Form of use	Respondents (%)	Ethnic groups
Leaves	Medicinal	Malaria	Boil in water with leaves of lemongrass and skin of pineapple	Drink the liquid	6.3	Holli
		Headache	Boil in water with leaves of *Citrus* sp. and *Ocimum gratissimum* L.	Drink the liquid	4.2	Holli
Fruits	Food	Satisfy hunger	Clean the fruits	Eat raw fruits	10.6	Holli, Fon
Bark	Medicinal	Malaria	Boil in water	Drink the liquid	6.4	Holli
		Child growth	Boil in water or soak in cold water	Wash the child	8.5	Holli
		Stomachache	Boil in water	Drink the liquid	2.1	Holli
		Scabies	Soak in hot water with bark of *A. digitata*	Drink the liquid	4.3	Holli
Roots	Social	Curse	Associated elements forgotten		2.1	Holli
		Protection against sorcerers	Associated elements forgotten		2.1	Holli
Young stems	Medicinal	Mouth infections	Use as a toothbrush	Keep the saliva for few minutes	17.0	Holli
		Sexual weakness	Use as a toothbrush	Swallow the saliva	4.3	Holli
	Energy	Firewood	NA	NA	12.8	Holli
	Social	Toothbrush	NA	NA	21.3	Holli
Wood	Construction	Houses	NA	NA	78.7	Fon, Holli
		Attics	NA	NA	31.9	Holli
	Energy	Charcoal	NA	NA	2.1	Holli
		Firewood	NA	NA	4.3	Holli

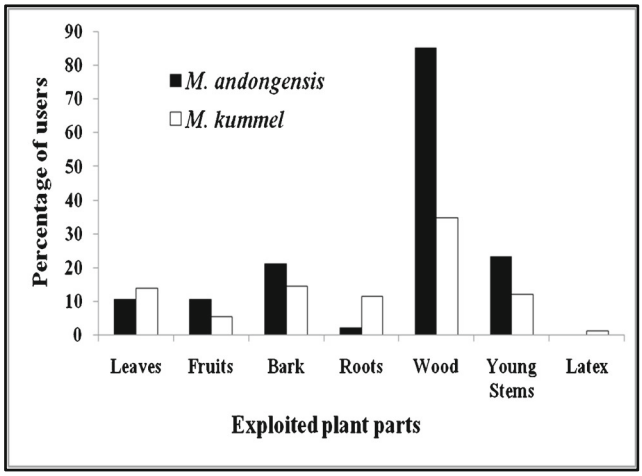

Fig. 3. Exploited organs of *Mimusops andongensis* and *Mimusops kummel*.

We found some significant differences in the use value of *M. kummel* according to sex, age, and ethnic affiliation of the informants ($p < 0.05$; Table 6). The highest mean social use value was

Fig. 4. Arrow's shafts (**a**), debarking damage on *Mimusops andongensis* (**b**) and *Mimusops kummel* (**c**) and young stems regrowing after exploitation (**d**, **e**).

TABLE 3. CATEGORIES OF USE, EXPLOITED ORGANS OF *MIMUSOPS KUMMEL*, PROCESSING METHODS, PERCENTAGE OF RESPONDENTS, AND ETHNIC GROUPS USING THEM (USES MENTIONED BY AT LEAST THREE RESPONDENTS EXCEPT DIZZINESS AND SOCIAL USES OF LEAVES, ROOTS, FRUITS, AND BARK ARE DISPLAYED).

Plant part	Use category	Purpose of use	Processing method	Form of use	Respondents (%)	Ethnic groups
Leaves	Medicinal	Malaria	Boil in water or soak in hot water with leaves of *Mangifera indica* L., *Carica papaya* L., and lemongrass	Drink the liquid	7.0	Nagot, Anii
		Strengthen newborns	Boil in water or soak in hot water	Drink the liquid and wash	2.5	Nagot, Anii
		Stomachache	Soak in hot or cold water (roots or bark of the species)	Drink the liquid	3.3	Nagot
		Chickenpox	Boil in water or soak in cold water	Drink the liquid or wash	1.2	Nagot
		Headache	Boil in water or soak in hot water	Drink the liquid	1.2	Nagot
		Body/muscular pains	Soak in hot or cold water with roots of the species and guinea pepper	Drink the liquid	1.2	Nagot
	Social	Bad spirits	Cook as sauce with seasoning	Eat	0.4	Nagot
Fruits	Medicinal	Dizziness	Crush with guinea pepper	Eat	0.4	Nagot
	Food	Relieve hunger	Wash raw fruits	Eat	2.9	Mahi, Nagot
Bark	Medicinal	Stomachache	Boil in water or soak in hot water or crush with bark of *Kigelia africana* (Lam.) Benth. and red potash	Drink the liquid	4.1	Yom, Nagot
		High blood pressure	Soak in hot water or crush with salt	Drink the liquid	1.2	Yom, Nagot
		Strengthen newborns	Soak in cold water (or in hot water)	Wash (put the liquid in porridge)	2.5	Nagot, Anii
		Malaria	Boil in water or soak in hot water	Wash	2.1	Nagot
		Headache	Soak in hot water	Drink	1.2	Nagot
		Dysentery	Soak in hot water with potash or make sauce with the powder with seasoning	Drink the liquid or the sauce	1.2	Nagot
		Intestinal worms	Soak in hot water with leaves or roots of the species	Drink the liquid	2.1	Nagot
		Chickenpox	Soak in hot water with bark of *Anacardium occidentalis* L. and *Khaya senegalensis* (Desr.) A. Juss.	Drink the liquid	2.1	Nagot
		Facilitate teeth	Boil in water	Drink the liquid	1.2	Nagot
		Prevent miscarriage	Soak in hot water or crush	Drink the liquid/product	1.2	Nagot, Anii
	Social	Madness	Make sauce with the powder and small green pepper	Drink the sauce	0.4	Nagot
Roots	Medicinal	Stomachache	Soak in hot or cold water with the leaves of the species	Drink the liquid	2.9	Nagot

(Continued)

TABLE 3. (CONTINUED).

Plant part	Use category	Purpose of use	Processing method	Form of use	Respondents (%)	Ethnic groups
		Microbial infections	Soak in hot water	Drink the liquid	1.2	Nagot
		Fatigue	Boil in water with leaves of the species	Drink the liquid	1.6	Nagot
		Strengthen newborns	Boil in water or soak in hot water	Drink the liquid (or put in porridge) or wash	2.5	Nagot, Anii
		Malaria	Soak in hot water with leaves of the species	Drink the liquid and wash	1.6	Bariba, Nagot
		Constipation	Soak in hot water and broil	Drink the liquid	1.2	Nagot, Yom
		Muscular pains	Soak in hot water or crush with leaves of the species and guinea pepper	Drink the liquid or put in porridge	1.2	Nagot
		Intestinal worms	Soak in hot water with leaves of the species	Drink the liquid	1.2	Nagot
	Social	Bad spirits	Broil with guinea pepper and head of viper	Put in porridge	0.4	Anii
		Incurable illnesses	Boil in water or mix the powder with butter of *V. paradoxa*	Wash or lap up	0.8	Nagot
Young stems	Medicinal	Mouth infections, wounds, and sores	Use as a toothbrush	Keep the saliva for few minutes	3.7	Nagot
	Tool	Arrow shafts	NA	For hunting	10.7	Nagot
	Energy	Firewood	NA	NA	1.2	Nagot
	Social	Toothbrush	NA	NA	7.4	Nagot, Anii, Adja
Wood	Construction	Houses, classroom roofs, and doors	NA	NA	29.1	Anii, Nagot, Mahi, Bariba
		Bridges	NA	NA	1.2	Nagot
	Furniture	Beds, chairs, furniture, wardrobe, tables, benches			18.4	Nagot,Bariba, Anii
	Tool	Mortars, pestles	NA	NA	20.1	Mahi, Nagot
		Hoe handles	NA	NA	2.1	Nagot
	Energy	Firewood, charcoal	NA	NA	1.2	Nagot
	Commercial	Sold as timber	NA	NA	11.5	Nagot, Mahi, Anii

TABLE 4. USE VALUE (MEAN ± SD) OF *MIMUSOPS ANDONGENSIS* AND *MIMUSOPS KUMMEL* IN BENIN.

	Use value		Mann-Whitney	
Use category	*M. andongensis*	*M. kummel*	*U*	*p*
Medicinal	0.47 ± 0.8	0.88 ± 1.1	5699	0.008
Construction	0.98 ± 0.6	0.36 ± 0.5	9728	<0.001
Furniture	NA	0.32 ± 0.7	NA	NA
Tool	NA	0.54 ± 0.8	NA	NA
Energy	0.26 ± 0.7	0.02 ± 0.1	7529	<0.001
Food and trap	0.11 ± 0.3	0.12 ± 0.4	7022	0.500
Commercial	NA	0.12 ± 0.3	NA	NA
Social	0.23 ± 0.4	0.18 ± 0.4	7266	0.240
Overall	2.04 ± 1.2	2.53 ± 1.6	5826	0.020

found for women, while only men reported that the species was used for energy, as food, and for commercial use. However, men were aware of more social uses (as a toothbrush, to treat madness, and to protect against bad spirits and sorcerers) of the species than women, who only knew its use as a toothbrush. The highest overall, construction, and tool use values were found for old people and the lowest values for young people meaning that old people reported more uses of these use categories than young people did. Our results also revealed significant variations in the medicinal, tool, and social uses of *M. kummel* among ethnic groups (Table 6).

Results from the correspondence analysis showed, for *M. andongensis*, that most of the men, adults, old, and Holli reported the medicinal and construction uses whereas food and social uses were less cited by the younger respondents. For women and Fon, no use was reported by more respondents than the others (Fig. 5). For *M. kummel*, most of adults, old, men, and Nagot reported the medicinal, construction, furniture, tool, and social uses while respondents from the other groups did not mention any use more than others (Fig. 5).

LOCAL KNOWLEDGE ON *MIMUSOPS* SPECIES HABITAT AND CHANGE IN ABUNDANCE

M. andongensis is found in the Lama forest reserve and according to local populations, it can be found throughout the forest but mostly in the dense parts. *M. kummel* prefers to be near water and specifically along watercourses (93% of the informants). It could also be found in the humid and dense parts of forests.

Figure 6 summarizes the perception of informants on change in abundance and factors responsible of the decrease in abundance of *Mimusops* species. Sixty and thirty-one percent of the respondents for *M. andongensis* and *M. kummel*, respectively, reported that the population abundance of the species had decreased. The factors responsible for this decrease were attributed to the conversion of forest for agricultural lands, the exploitation of the species for local consumptive use, limited regeneration, and bushfires. In contrast, some informants (24 and 10% for *M. andongensis* and *M. kummel*, respectively) stated the population abundance had increased. The reasons reported for this supposed increase were (i)

TABLE 5. SEX, AGE, AND ETHNIC GROUP VARIATION IN THE USE VALUE (MEAN ± SD) OF M. *ANDONGENSIS*.

	Sex			Age groups				Ethnic groups		
Use category	F	M	*p*	Young	Adults	Old	*p*	Fon	Holli	*p*
Medicinal	1.50 ± 2.1	0.42 ± 0.7	0.3	0.64 ± 1.0	0.39 ± 0.8	0.36 ± 0.8	0.7	0.00 ± 0.0	0.55 ± 0.9	NA
Construction	0.00 ± 0.0	1.02 ± 0.6	NA	0.82 ± 0.6	1.13 ± 0.6	1.00 ± 0.6	0.4	0.86 ± 0.4	1.00 ± 0.7	0.6
Energy	0.00 ± 0.0	0.30 ± 0.7	NA	0.00 ± 0.0	0.35 ± 0.8	0.18 ± 0.6	0.3	0.00 ± 0.0	0.30 ± 0.6	NA
Food	0.50 ± 0.7	0.09 ± 0.3	0.08	0.18 ± 0.4	0.09 ± 0.3	0.09 ± 0.3	0.7	0.14 ± 0.4	0.10 ± 0.3	0.8
Social	0.50 ± 0.7	0.22 ± 0.4	0.4	0.36 ± 0.5	0.13 ± 0.3	0.27 ± 0.5	0.3	0.00 ± 0.0	0.28 ± 0.4	NA
Overall	2.50 ± 2.1	2.02 ± 1.2	0.7	2.00 ± 1.2	2.1 ± 1.2	1.9 ± 1.1	0.9	1.00 ± 0.0	2.23 ± 1.2	NA

TABLE 6. SEX, AGE AND ETHNIC GROUP VARIATION IN THE USE VALUE (MEAN ± SD) OF *M. KUMMEL*.

Use category	Sex			Age groups				Ethnic groups						
	F	M	*p*	Young	Adults	Old	*p*	Adja	Bariba	Yom	Mahi	Nagot	Anii	*p*
Medicinal	1.00 ± 1.2	0.88 ± 1.1	0.6	0.54 ± 0.6	0.95 ± 1.2	0.85 ± 1.2	0.5	1.00 ± 1.4	1.00 ± 1.4	3.00 ± 1.6	0.11 ± 0.3	0.86 ± 1.1	1.58 ± 1.2	0.03
Construction	0.08 ± 0.3	0.37 ± 0.7	0.07	0.09 ± 0.3	0.35 ± 0.5	0.46 ± 0.6	0.04	0.00 ± 0.0	0.50 ± 0.7	0.00 ± 0.0	0.67 ± 0.5	0.36 ± 0.6	0.08 ± 0.3	0.1
Furniture	0.08 ± 0.3	0.33 ± 0.8	0.3	0.18 ± 0.7	0.33 ± 0.8	0.33 ± 0.7	0.6	0.00 ± 0.0	0.50 ± 0.7	0.00 ± 0.0	0.00 ± 0.0	0.35 ± 0.8	0.08 ± 0.3	0.5
Tool	0.33 ± 0.6	0.55 ± 0.8	0.4	0.23 ± 0.5	0.50 ± 0.8	0.80 ± 0.9	0.003	0.00 ± 0.0	0.00 ± 0.0	0.00 ± 0.0	1.00 ± 0.7	0.56 ± 0.8	0.00 ± 0.0	0.01
Energy	0.00 ± 0.0	0.20 ± 0.2	NA	0.05 ± 0.2	0.01 ± 0.2	0.02 ± 0.1	0.3	0.00 ± 0.0	0.00 ± 0.0	0.00 ± 0.0	0.00 ± 0.0	0.02 ± 0.2	0.00 ± 0.0	0.99
Food	0.00 ± 0.0	0.13 ± 0.5	NA	0.05 ± 0.2	0.16 ± 0.5	0.08 ± 0.3	0.7	0.00 ± 0.0	0.00 ± 0.0	0.00 ± 0.0	0.11 ± 0.3	0.13 ± 0.5	0.00 ± 0.0	0.9
Commercial	0.00 ± 0.0	0.13 ± 0.3	NA	0.23 ± 0.4	0.12 ± 0.3	0.07 ± 0.2	0.1	0.00 ± 0.0	0.00 ± 0.0	0.00 ± 0.0	0.22 ± 0.4	0.11 ± 0.3	0.25 ± 0.4	0.6
Social	0.50 ± 0.5	0.16 ± 0.4	0.001	0.23 ± 0.4	0.22 ± 0.5	0.07 ± 0.2	0.047	1.00 ± 0.0	0.00 ± 0.0	0.00 ± 0.0	0.11 ± 0.3	0.17 ± 0.4	0.33 ± 0.5	0.02
Overall	2.00 ± 0.9	2.56 ± 1.6	0.3	1.60 ± 0.8	2.63 ± 1.7	2.66 ± 1.5	0.003	3.00 ± 1.4	1.50 ± 0.7	2.00 ± 1.2	4.00 ± 3.5	2.50 ± 1.4	2.25 ± 1.8	0.3

prohibition of access to Lama forest reserve, in the case of *M. andongensis*, and (ii) no impact of fire on plants in humid parts of the forest and species no longer exploited like others (or it is sometimes cut only under order), in the case of *M. kummel*. For other respondents (20%), the population abundance of *M. kummel* is stable because it is not only exploited like other species but also does not regenerate as readily as other species.

Discussion

Uses of *Mimusops* Species

This study investigated local knowledge of the use of *M. andongensis* and *M. kummel*. Our results showed that nearly all organs of both species were exploited, from leaves to the roots. This corroborated similar results on the importance and uses of *M. andongensis* and *M. kummel* as NTFP species elsewhere (e.g., Lemmens 2005; Chekole et al. 2015 in Ethiopia). Leaves, bark, and roots of the species were used not only to treat different ailments but also as magic. Leaves of both species were used against malaria and headaches; bark in the treatment of malaria, stomachache, skin infections, and for the growth of newborns; and roots to protect against bad spirits or sorcerers. Previous studies have shown the potential of the bark, leaves, and roots in traditional medicine. For example, *M. andongensis* leaves are used to treat skin infections in Ivory Coast (Soro et al. 2010); the bark of *M. kummel* is exploited in Tanzania for anemia, asthma, and malaria (Ruffo 2002); and its roots are used as a laxative and galactagogue (Lemmens 2005). Young stems are used in the study area for oral and dental care, echoing the findings of Odugbemi (2008) in Nigeria. Nonetheless, the uses of the species against miscarriage and to strengthen newborns are new findings in this study. However, nothing is known on the bioactive components in the species organs that confer these medicinal properties.

The wood of both species is exploited for construction of houses and attics and for charcoal production, and wood and young stems for cooking fires (Lemmens 2005; Bekele-Tesemma 2007). Although not frequently, wood of *M. kummel* was exploited to make furniture such as beds, chairs, benches, wardrobes, and tools (mortars, pestles, TV poles, hoes, and utensils) as well as in the construction of bridges and classroom roofs. Previous inves-

tigations have already mentioned the use of the wood of *M. kummel* for tool handles, local utensils, and as timber for heavy and local construction (e.g., Bein et al. 1996 in Eritrea; Bekele-Tesemma 2007 in Ethiopia). Young stems were used to make arrow shafts. Studies showed that fruits of *M. kummel* are used to supplement diets, during food shortage seasons, and to treat diseases such as high blood pressure (Teketay et al. 2010), amoeba (Teklehaymanot and Giday 2010), and asthma (Chekole et al. 2015). Contrary to those studies, fruits of *M. kummel* were used in Benin to relieve hunger especially by children and during hunting.

Our results revealed fewer uses for *M. andongensis* than *M. kummel*; this might be due to the full protection status of the forest where *M. andongensis* was found and its use by fewer ethnic groups. *M. kummel* is locally called Èmèdo in the Nagot ethnic group, which means "*V. paradoxa* of the river" and thus it is not surprising that some respondents confused the pictures as those of *V. paradoxa*. Similarly, the species is called Emido in the *Yoruba* ethnic group in Nigeria, which has the same meaning (Odugbemi 2008).

We found gender, age, and ethnic variation in the knowledge and use of the species. For instance, women only reported the social use of *M. kummel* as a toothbrush, and men were also aware of its use for magic. Similarly, elderly people knew the use of the species for the manufacturing of more tools than young people did. Moreover, the Holli knew more about the medicinal, fire, and social uses of *M. andongensis* than the Fon. The observed variation between ethnic groups in the use of both species was mainly linked to their status in the locality (native vs. immigrant). The gender, age, and ethnic variation revealed by this study in the use of the species should be integrated into planning actions for their valorization and conservation (Fandohan et al. 2010b; Gouwakinnou et al. 2011; Chekole et al. 2015). For instance, the Nagot and old people knew more about the medicinal uses of *M. kummel* and should be involved in planning actions for its medicinal valorization.

Local Knowledge on the Ecology and Population Status

Local communities reported *M. andongensis* to be present largely in the dense parts of Lama semi-deciduous forest, characterized by periodically flooded, clayey soils. *M. kummel* can be found not only near water, specifically along watercourses, but also in the humid and dense parts of forests. Similar habitats have been recognized as preferential for the species in different countries. Indeed, humid habitats where water is retained in the soil along or during rainy periods of the year such as dense humid forests and riparian forests have been shown as the preferential habitats of both species, with some variation between countries. For instance, in the Ivory Coast, both *M. andongensis* and *M. kummel* have been found in gallery forests and along watercourses (Ake-Assi 2001) while in Nigeria they have been found in lowland rain forests. *M. andongensis* is present in humid forest, riparian forest, and mangrove borders in Guinea-Bissau (Catarino et al. 2008) and *M. kummel* on riverbanks in Eritrea (Bein et al. 1996). However, the species can also be found in other habitat types such as woodland forest and savanna, forest-savanna transition zones, and fallows in the last stages of succession. This might be a result of disturbances of original forests (Adeola 1987).

Some respondents recognized that populations of both species have declined in forests, which they attributed to farm establishment, and exploitation for both timber and NTFPs. Forest clearing and species exploitation for timber and NTFPs are well-known to be common pressures on many forest species (WWF 2015; Sinasson et al. 2016). The impacts of these threats are reinforced by difficulty in regeneration, bushfires, and other pressures on forests which might prevent many forest species from recolonizing natural habitats after disturbances (e.g., Sinasson et al. 2016). Our results confirm how important local knowledge is in designing research or considering actions for useful species conservation.

Potential Uses and Similarity in the Use of the Species: Implications for Their Valorization and Conservation

Although there were differences in the number of ailments treated, our results showed the medicinal use of these two species to be an important and widespread. In many countries around the world, traditional medicine is and continues to be the basis of healthcare delivery, especially in rural areas (WHO 2013). Although widely recognized, the importance of traditional medicine is underestimated and its integration into national health services underdeveloped. Therefore, research and political actions related to health delivery should promote the identification and valorization

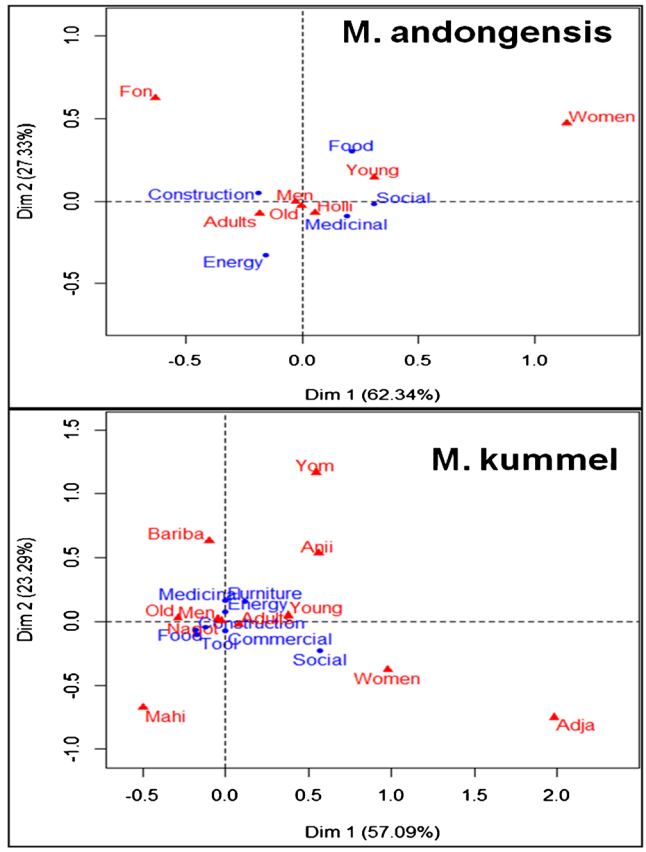

Fig. 5. Correspondence analysis results for *Mimusops andongensis* and *Mimusops kummel*.

of indigenous medicinal plants, their management and sustainable use. Both *M. andongensis* and *M. kummel* plant parts are used against malaria, headache, stomachache, and skin and mouth infections and for the growth of newborns. Furthermore, as previously shown in Ethiopia (Teketay et al. 2010), this study found that *M. kummel* was used to treat high blood pressure which along with malaria and other infections are increasing chronic disease across the world (WHO 2015).

In the study area, *M. kummel* fruits were consumed by children and by hunters when hungry. They were not exploited for economic purposes, unlike in other countries (e.g., Ethiopia) (Teketay et al. 2010). Fruits of *M. andongensis* are also consumed by children. Sufficient consumption of fruits can facilitate digestion and be helpful in the absorption and use of food nutrients because of their high concentrations of minerals and vitamins (Banwat et al. 2012) and hence prevent many diseases (Kehlenbeck et al. 2013). Many underutilized indigenous fruit species are richer in vitamin C and pro-vitamin A than the most widely valorized and commercialized species (IPGRI 2002). Moreover, *M. kummel* fruits have been shown to be an excellent source of vitamin C and contain good levels of carbohydrate, fat, and proteins (Fentahun 2008) and this could be the case for *M. andongensis*. The fruits could be further valorized, as currently only a small proportion of fruit is consumed, the remainder being left to rot and the seeds destroyed by insects and other parasites. Several studies have indicated that the sustainable offtake of similarly large-fruited species is high, over 80% (e.g., Bernal 1998; Emanuel et al. 2005). This could in principle help to improve both diets and revenues of local people (Kalaba et al. 2009; Jamnadass et al. 2011).

Currently, the two species are neglected by governments and development agencies (like many other useful indigenous species) and as a

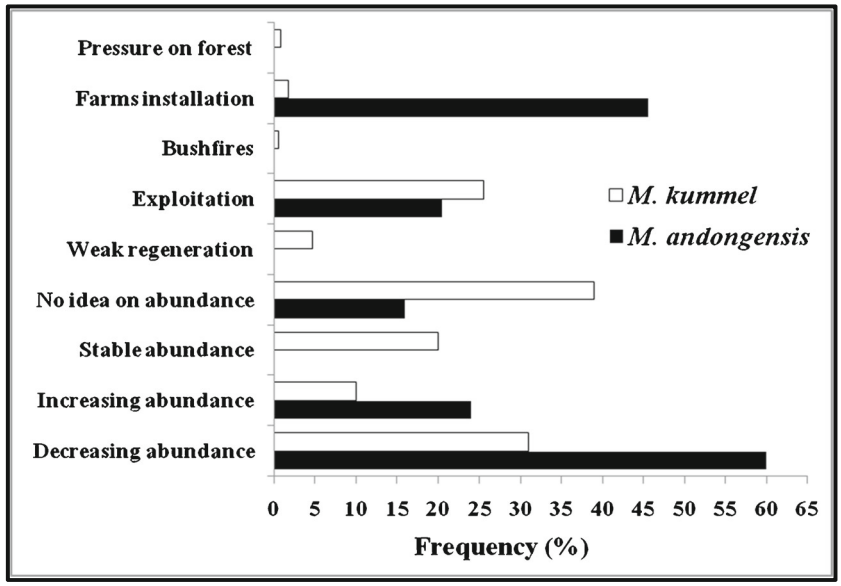

Fig. 6. Change in abundance and factors responsible of the decrease in abundance of *Mimusops* species according to local people.

consequence, indigenous knowledge and practices related to their uses could be in the process of ethnobotanical erosion (Wondimu et al. 2006). Both species also face or have been confronted by threats from forest conversion, habitat fragmentation, and exploitation for both timber and NTFPs (Tebkew et al. 2014), as reported by the informants. The valorization of the species could incite, under the right circumstances, effective actions for their sustainable use, marketing, and conservation, which are potentially mutually reinforcing strategies (Gouwakinnou et al. 2011). However, prohibitions of access to forests by forest-dependent peoples by local politics might hamper the sustainable harvesting of NTFPs and their continued contribution to local livelihoods (Ruwanza and Shackleton 2015).

Conclusions

Our results revealed a wide range of uses of *M. andongensis* and *M. kummel* among which the most important is their use as medicine. Further research on their bioactive components is needed to elucidate their medicinal properties. However, neither of species has widely recognized use/economic value. Although potential commercial uses exist, in Benin the species remain underutilized in comparison to other countries. For example, fruits of *M. kummel* are prepared and sold in open markets in different regions of Ethiopia (Wondimu et al. 2006). Its inner bark is used for tea in Kenya and the ripe fruits are sundried and pounded and the powder used to make juice or local beverage in Tanzania (Ruffo 2002). Furthermore, raw fruits of *M. kummel* have local and national market prospects and prospects for agro-industrialization as jams and jellies (Teketay et al. 2010). This could also be applied for *M. andongensis*.

As revealed by the surveys and mentioned in the literature, forest conversion to non-forest lands as well as timber and NTFP exploitation are potentially significant contributors to the perceived decline in their abundance. Loss of such multipurpose use species may well result in the loss of traditional ecological knowledge. Some strategies to promote the species valorization and conservation should include (i) sharing knowledge and practices on the uses of the species with other countries where the species (or species from the same genus) are better valued (e.g., Ethiopia, India, Tanzania, South Africa), (ii) valorization of the fruits and creating added value, (iii) collaboration with local people for knowledge sharing on the species and conservation actions, and (iv) promotion of local and perhaps national markets if population densities are sufficient. Sex, age, and ethnic variation in the species uses should also be

considered while planning actions for their management. Further research on the species ecology, especially seed viability, germination, and propagation ability would help to valorize them and sustain their uses by local people and their conservation.

Acknowledgements

This work was financially supported by International Foundation for Science grant D/5467-1 to KGSS for data collection and data analysis, and OWSD (Organization for Women in Science for the Developing World) and SIDA (Swedish International Development Cooperation Agency) through a Postgraduate Fellowship to KGSS for literature review and manuscript writing. We are also grateful to Christian Affoukou, Hervé Kanlissou, Cyrus Binassoua, and local communities for their help during surveys.

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