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Uses of *Haematostaphis barteri* Hook.f. among the Waaba and Bètammaribè in North-Benin and impact on the species vulnerability

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Haematostaphis barteri Hook.f. **is an endemic plant species with a high economic potential that mostly grows on rocky soils in the Sudanian zone from Ghana to Sudan. In Bénin, the species is found only around the commune of Natitingou, but there is little knowledge on its uses by the local populations and how these uses potentially affect its conservation status. This study aimed to evaluate the vulnerability of *H. barteri* in its natural range in Benin, based on the assessment of its indigenous uses and its population inventory. An ethnobotanical survey was conducted in eight villages of the commune of Natitingou from eighty people belonging to the Bètammaribè and Waaba ethnic groups, to identify their knowledge and usage of the species. The species population inventory was also carried out to estimate the frequency and density of *H. barteri* populations. The species' vulnerability score was determined using results from the ethnobotanical survey, population inventory and information in the literature. Rural populations in Natitingou use *H. barteri* mainly for food (100% of interviewees), traditional medicine (76.3%) and wood fuel (37.5%). Most of the respondents (91.3%) usually harvest immature fruits so as to preserve them, both for their consumption and for commercialization. Twenty-nine populations of *H. barteri* were identified with densities averaging 46.6 adult individuals per hectare and a regeneration of 9.7 individuals per hectare. The average vulnerability score for *H. barteri* was estimated at 2.4 on a scale of 1 (not vulnerable) to 3 (highly vulnerable). *H. barteri* is thus a vulnerable species that deserves to be included in Benin's list of endangered species.**

Key words: West Africa, Atacora mountains, ethnobotany, endemic species, exploitation, vulnerability, non timber forest products (NTFP).

INTRODUCTION

Non timber forest products (NTFP) are a potential source of income that allows human communities to meet several of their socio-economic needs (Laird and Pierce, 2002; Vodouhê et al., 2009; Moupela et al., 2011).

NTFP constitute a set of various products including fruits, nuts, seeds, latex, resin, gum, medicinal herbs, spices, dyes, decorative plants, firewood and bamboos (Sodhi, 2010) to name a few. In south Saharan Africa, several and well-diversified wild plants have been identified as contributing significantly to the diet balance and improvement of rural population health (Eyog Matig et al., 2002). This crucial importance prompted reflections on the possibility of domesticating multi-purpose species to ensure their sustainable conservation (Assogbadjo et al., 2002; Codjia et al., 2003; Dossou et al., 2004).

Haematostaphis barteri Hook.f. (Anacardiaceae) is a woody plant species typical of tropical Africa and which distribution spans from Ghana to Sudan (Arbonnier, 2002). The species is endemic to the Sudanian zone and mostly grows on rocky soils (Adomou, 2005). In Benin, it is specifically found around the commune of Natitingou (Adomou, 2005; Akoègninou et al., 2006). The species limited geographic range and its high socio-economic importance for human communities, particularly the high consumption of its fruits (Umaru et al., 2007; Atato et al., 2010), might be prejudicial to its survival. Indeed, several studies showed that harvesting of organs or parts of plants can compromise species dissemination and reproduction (Betti, 2001; Gaoué and Ticktin, 2007; Krishnamurthy et al., 2013) and then increase their vulnerability (Betti, 2001; Dibong et al., 2011). Multiple uses, in particular, create many stresses to the plant that can affect the overall population dynamics (Gaoué and Ticktin, 2007; Hawkes and Sullivan, 2010; Allred et al., 2012).

Uncontrolled harvesting of NTFP can even sometimes give rise to the disappearance of species, especially when such species are not abundant (Akpagana and Bouchet, 1995). Apart from the direct damages to the integrity of the plant and its vital functions, the exploitation of NTFP could also contribute to the loss of diversity by altering the abundance and distribution of species as well as reduce their genetic base (Papy and Goldringer, 2011). This applies in particular where farmers select and conserve a small number of species to maintain the functions they deem useful in their agro-ecosystems such as soil fertility, production of firewood, leaves, fruits or other products. Hence, biodiversity conservation involves the identification of species sensitive to exploitation and anthropization of ecosystems, and which require conservation actions. This study aimed to evaluate the vulnerability of *H. barteri* based on the assessment of its indigenous uses and its population inventory in the natural range of the species in Northern Benin.

MATERIALS AND METHODS

Study area

The study was conducted in the commune of Natitingou (10°19' North and 1°29' East), in northwestern Benin (Figure 1). Natitingou is located in the vicinity of the Atacora mountain chain and is characterized by an accidental relief, with altitudes ranging from 400 to 650 m. The climate is of the sudanian type with a rainfall between 1,000 and 1,400 mm, and two seasons: the rainy season from April to October and the dry season from November to March. The dry season is marked by the harmattan, a cold-dry and dusty northeast wind which blows from the Sahara desert. The average temperature is 27°C but can reach 37°C in March and April. Soils are of the tropical ferruginous type and mostly rocky and shallow throughout the mountain chain (Azontondé, 1991). The vegetation is dominated by tree and shrub savannah. The dominant woody species are *Parkia biglobosa, Vitellaria paradoxa, Adansonia digitata, Bligia sapida, Tamarindus indica, Bombax costatum* and *Khaya senegalensis* (Wala, 2005).

The commune of Natitingou covers an area of 3,045 km^2 and counts nine arrondissements (four urban and five rural), which contain 39 villages and 26 urban districts. The population was estimated at 103,843 inhabitants in 2013 (INSAE, 2013) and is dominated by the Waaba (or Yoabou) and Bètammaribè ethnic groups which live around the Atacora mountain chain (Biaou, 2006). Other ethnic groups in the commune include the Dendi, Batombou, Peuhl, Yoruba, Fon and Natimba. The majority of the population, including the Bètammaribè and Waaba, believe in animist practices and worship divinities represented by physical elements such as clumps of natural stones, large sized trees or other specific constructions. Agriculture is the principal economic activity in the commune and farmers produce mostly maize, sorghum, millet and yam (Biaou, 2006).

Study species

Haematostaphis barteri Hook.f. (Anacardiaceae) is a shrub up to 8 m tall and can reach 35 cm in diameter (Kpemissi Amana, 2007). It is found in the Guinean and Sudanian savannas on rocky soils, in tropical Africa. It has been observed in Ivory Coast, Ghana, Togo, Nigeria, Benin, Gabon, D.R. Congo (Zaire) and Cameroon (GBIF Secretariat, 2016) but the populations are mostly scarce and isolated. The crown is spread out and open (Figure 2A), and the leaves are grouped at the ends of the branches. The leaves are alternate, imparipinnate, glabrous and 20-35 cm long, with 17 to 25 alternate or subopposed leaflets, narrowly elliptic or oblong. The bark is scaly and brown - gray. *H. barteri* is a dioecious species with a glabrous pendant inflorescence in the terminal panicle, and up to 30 cm long. The infructescence is made of long hanging clusters composed of glabrous ellipsoid drupes, purple at maturity and 2 cm long (Figure 2B). Flowering and fruiting occur at the end of the dry season, generally before the first leaves appear.

Overview of the study method

To assess the uses and the vulnerability of *H. barteri* in North-Benin, four complementary approaches were combined:

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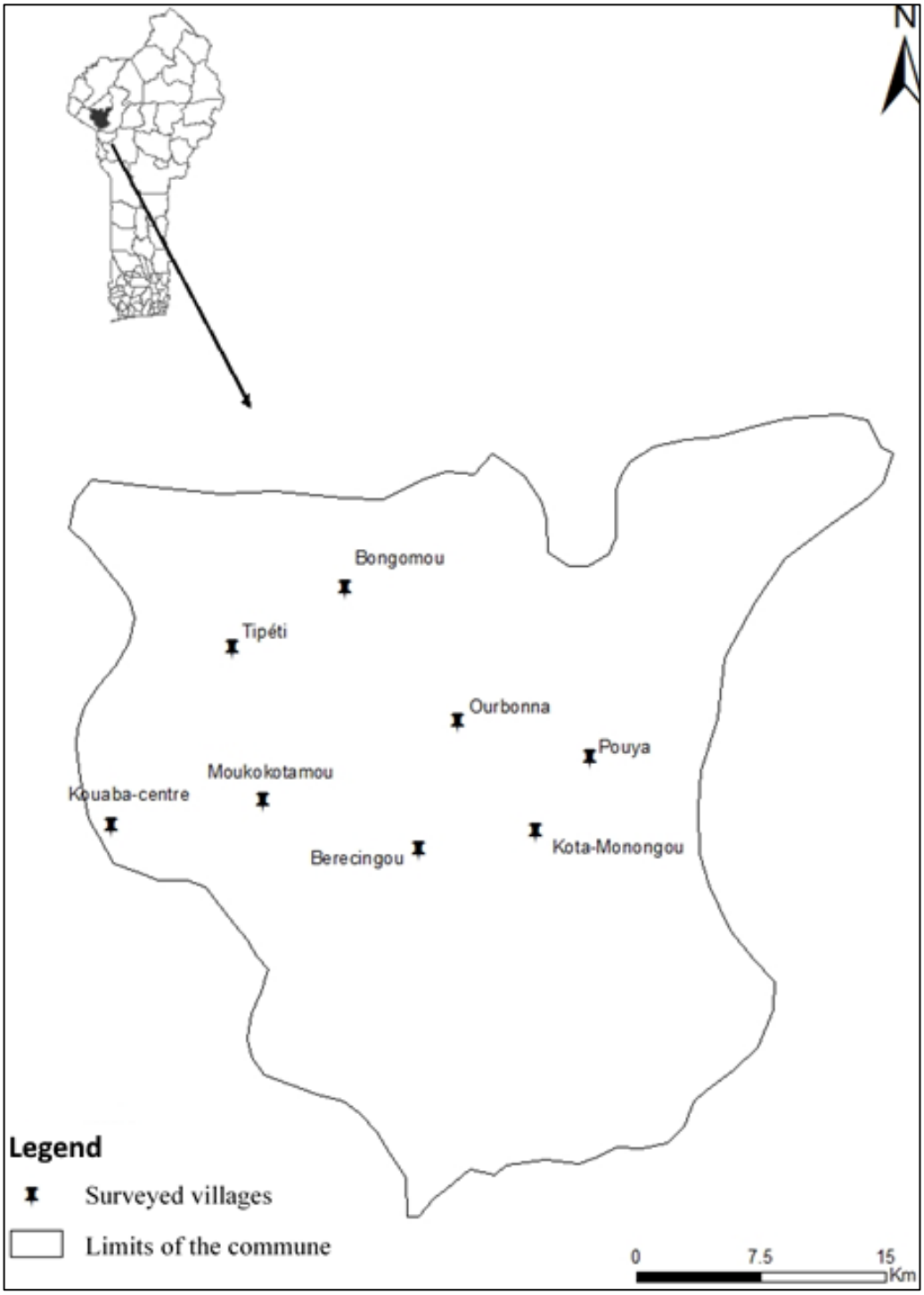

Figure 1. Location of the commune of Natitingou in Benin and the surveyed villages for the ethnobotanical study of *H. barteri.*

1. Exploratory survey to identify and select localities where *H. barteri* is present for further characterization of the species population and ethnobotanical surveys;
2. Detailed inventory of the selected *H. barteri* populations to estimate the density and frequency of the species populations;
3. Ethnobotanical study of *H. barteri* in the selected localities to identify current uses of the species in the study area; and
4. Assessment of *H. barteri* vulnerability through the calculation of a

Figure 2. *H. barteri* shrub on a rocky outcrop (A) and mature fruits (B) in the commune of Natitingou (Benin). Photo credit: Moutouama (2011).

vulnerability score derived from the information gathered during both the species population inventory and the ethnobotanical survey.

Exploratory survey and localization of *H. barteri* populations

An exhaustive list of localities where *H. barteri* is present was established in July 2011 through an exploratory survey combined with road transects across the commune of Natitingou and two neighboring communes (Boukombé and Toucountouna). The populations of the species were identified with the aid of agents from the local forestry and agriculture departments, as well as traditional health practitioners and farmers, by showing them a fresh specimen collected in the wild. Based on this exploratory survey, *H. barteri* presence was confirmed in 25 villages, including 20 in the commune of Natitingou, 3 in the commune of Boukombé and 2 in the commune of Toucountouna. The commune of Natitingou was eventually maintained for the ethnobotanical survey since the species was more abundant and more frequent in this area.

Characterization of *H. barteri* populations

Individuals of *H. barteri* were counted systematically within all the populations identified, including the neighboring communes of Boukombé and Toucountouna, so as to estimate the density and frequency of *H. barteri* populations. The species sometimes grows in clumps because it resprouts after periodic fires or other wounds. In these cases, each clump was counted as one individual. The environmental characteristics of each site were also noted for each population. These included the type of vegetation, type of soil, presence of rocky outcrop and presence of streams. All the surveyed populations were georeferenced using a Garmin 60 GPS to establish the distribution map of the species populations using the software Quantum GIS.

Ethnobotanical study of *H. barteri*

Ethnobotanical surveys were conducted in eight villages (Table 1) randomly sampled out of twenty where the species was recorded in the commune of Natitingou. A total of 80 people (40 men and 40 women) were interviewed based on five men and five women per village. Interviewees are individuals aged between 36 and 80 years and belonging to the two dominant ethnic groups (Bètammaribè and Waaba) in the study area. Interviewees also belong to socio-professional groups that may be familiar with the species, including farmers, NTFP sellers, quarrymen and traditional health practitioners (Table 1).

Based on a semi-structured questionnaire, the indigenous names of the species, its potential uses (food, medicine, construction, art and wood energy) as well as the most used organs and diseases treated were collected. Fisher's exact test in R.3.2.2 software (R Core Team, 2015) was used to evaluate the relation between the ethnic groups and the use categories of *H. barteri*, organs used or diseases treated. Fisher exact test was preferred because some of the expected frequencies were less than five (Crawley, 2007).

Assessment of the species vulnerability

H. barteri vulnerability was assessed based on nine parameters (Betti, 2001). These include the popularity of the species, the organs harvested, the stage of development of these organs, the mode of collection of the organs, the pharmaceutical forms used, the plant biotope, the mode of seed dissemination, the plant morphological type and the species frequency in the area. For each of these parameters, a vulnerability score (V_i) was assigned a scale from 1 (species not vulnerable for the parameter considered) to 3 (highly vulnerable), with 2 corresponding to a moderate vulnerability. These scores were deduced from:

1. The ethnobotanical study (popularity of the species, organs harvested, stage of development of these organs, mode of collection of the organs and pharmaceutical forms used)
2. *H. barteri* populations inventory (plant biotope and frequency in the area)
3. Information from the literature (mode of seed dissemination and plant morphological type).

By combining the vulnerability scores of all the parameters, an average index of vulnerability (V) was calculated using the equation:

Table 1. Number of people interviewed in the ethnobotanical study of *H. barteri* in the commune of Natitingou and characteristics of the species local populations.

Localities	Number of interviewees	Ethnic groups		Age		Socio-professional groups				Characteristics of *H. barteri* populations	
		Be	Wa	30 to 49	≥ 50	F	H	M	O	Number of populations recorded (and ID)	Density /ha (dbh ≥ 5 cm)
Berecingou	10	10		3	7	9		1		1 (P11)	120
Bongomou	10		10	4	6	2	2	5	1	1 (P02)	40
Kotamonongou	10		10	4	6	7		2	1	1 (P12)	20
Kouaba-Centre	10	10		8	2	6	3	1		1 (P17)	20
Moukokotamou	10	10		5	5	8		2		2 (P05 & P06)	50 30
Ourbonna	10		10	4	6	6	1		3	1 (P08)	20
Pouya	10		10	5	5	7	3			1 (P13)	20
Tipeti	10	10		5	5	5	4		1	1 (P29)	20
Total	80	40	40	38	42	50	13	11	6	9	

Be (Bètammaribè); Wa (Waaba); (F) farmer; (H) housewife; M (merchant of NTFP), O (other); ID (population identification number "Pxx", used also in Figure 3); dbh (diameter at breast height).

$V=\sum Vi \times 1/n$

where V_i is the vulnerability score for the parameter i, and n is the total number of parameters.

RESULTS

Localization and characterization of *H. barteri* populations

29 populations of *H. barteri* were identified, of which 22 were in the commune of Natitingou and the remaining in the communes of Boukombé and Toucountouna (Figure 3A). The density of *H. barteri* was in average 46.6 stems/ha for adults (dbh ≥5 cm) and 9.7 stems/ha for the regeneration (dbh <5 cm). The regeneration was inexistent in 19 (65.5%) of these populations, for example at Kounitchankou (P03), Katagnika (P19), Koussantikou (P07), Kotamonongou (P12), Pouya (P13), Moukokotamou (P05) and Ourbouga (P26) in the commune of Natitingou, and Peperkou (P20) and Takissari (P14 and P15) in the commune of Toucountouna (Figure 3B).

Also, there is no significant plantation of the species in the surveyed area, and only two (2.5%) of the interviewees stated they have once planted a few individuals of the species.

Indigenous names of *H. barteri*

The language spoken by the Waaba is called Waama, while the language of the Bètammaribè is called Tammari or Ditammari. All (100%) the interviewees know *H. barteri*. Only one name is used in each of the two ethnic groups surveyed to designate the tree and its fruit indiscriminately. *H. barteri* is locally named "Yinrinyinrinbou" (singular) or "Yinrinyinrina" (plural) by the Waaba and "Mouyinyinrinmou " (singular) or "Deyinrinyinride" (plural) by the Bètammaribè, thereby indicating similarities in the consonances between the two languages.

Uses of *H. barteri* and most sought plant parts

The Waaba and Bètammaribè of Natitingou use *H. barteri* primarily for food (100% of the interviewees), traditional medicine (76.25%) and wood fuel (37.5%) (Figure 4A). The proportion of the respondents using the species for food (fruits) is the same among the Waaba (100%) and Bètammaribè (100%). However, its use in traditional medicine is more important among the Bètammaribè (87.5%) than the Waaba

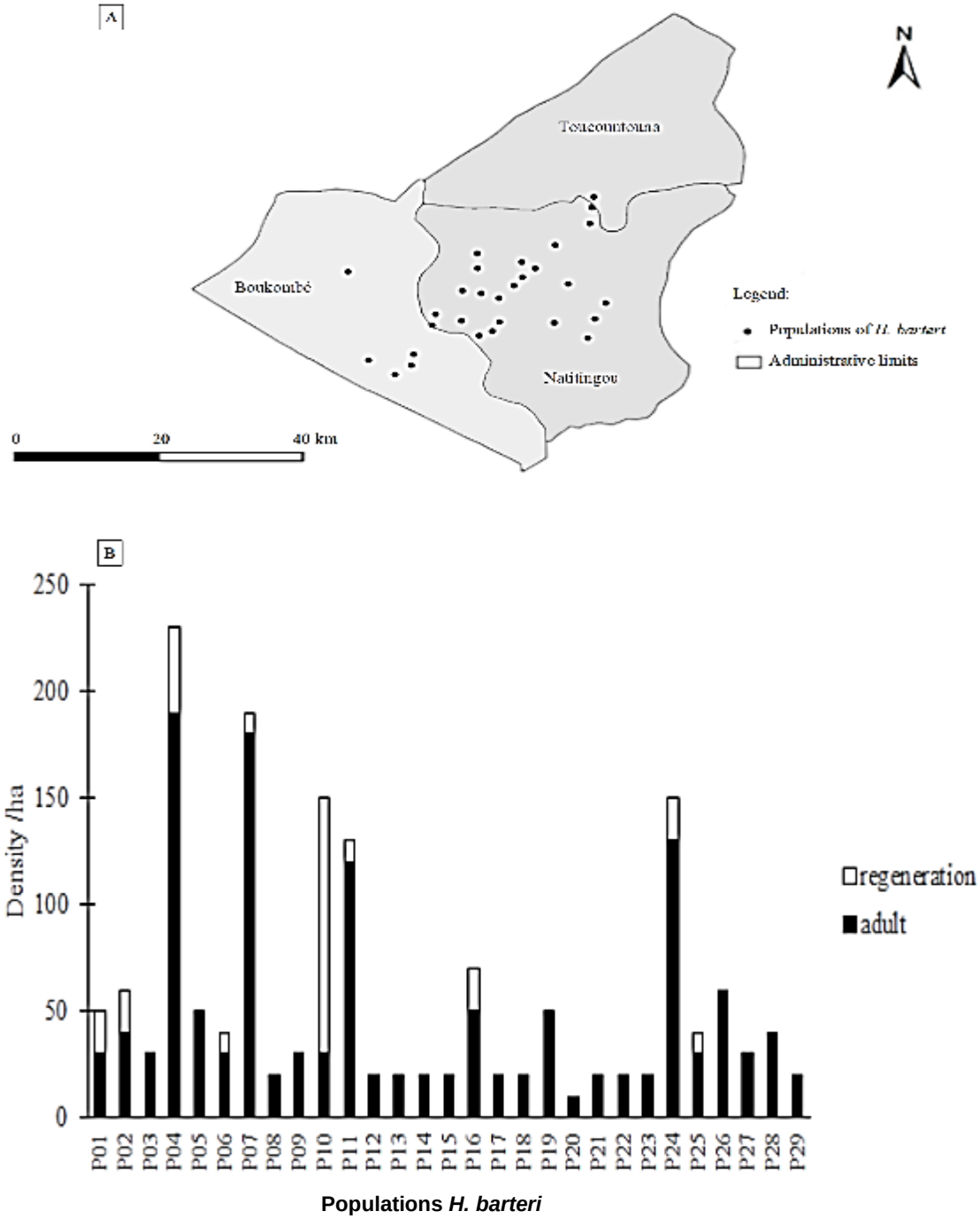

Figure 3. Characteristics of *H. barteri* populations inventoried in North Benin: (A) localization in the communes of Natitingou, Boukombé and Toucountouna; and (B) Density of the regeneration and adult trees.

(65%). Also, ritual use is limited (1.25%) and was noted only among the Waaba. The species is not used at all as craft wood, timber or construction wood.

The most sought parts of *H. barteri* in both ethnic groups are fruits (100% of interviewees), stems (98.75%) and leaves (82.5%) (Figure 4B). Most of the respondents (91.3%) usually harvest immature fruits to preserve them, both for their consumption and for commercialization. On the contrary, both ethnic groups rarely use barks (22.5%), roots (20%) and flowers (12.5%). Still, the Waaba use more, the flowers (25%), barks (27.5%) and roots (27.5%) of the species than Bètammaribè (0, 17.5 and

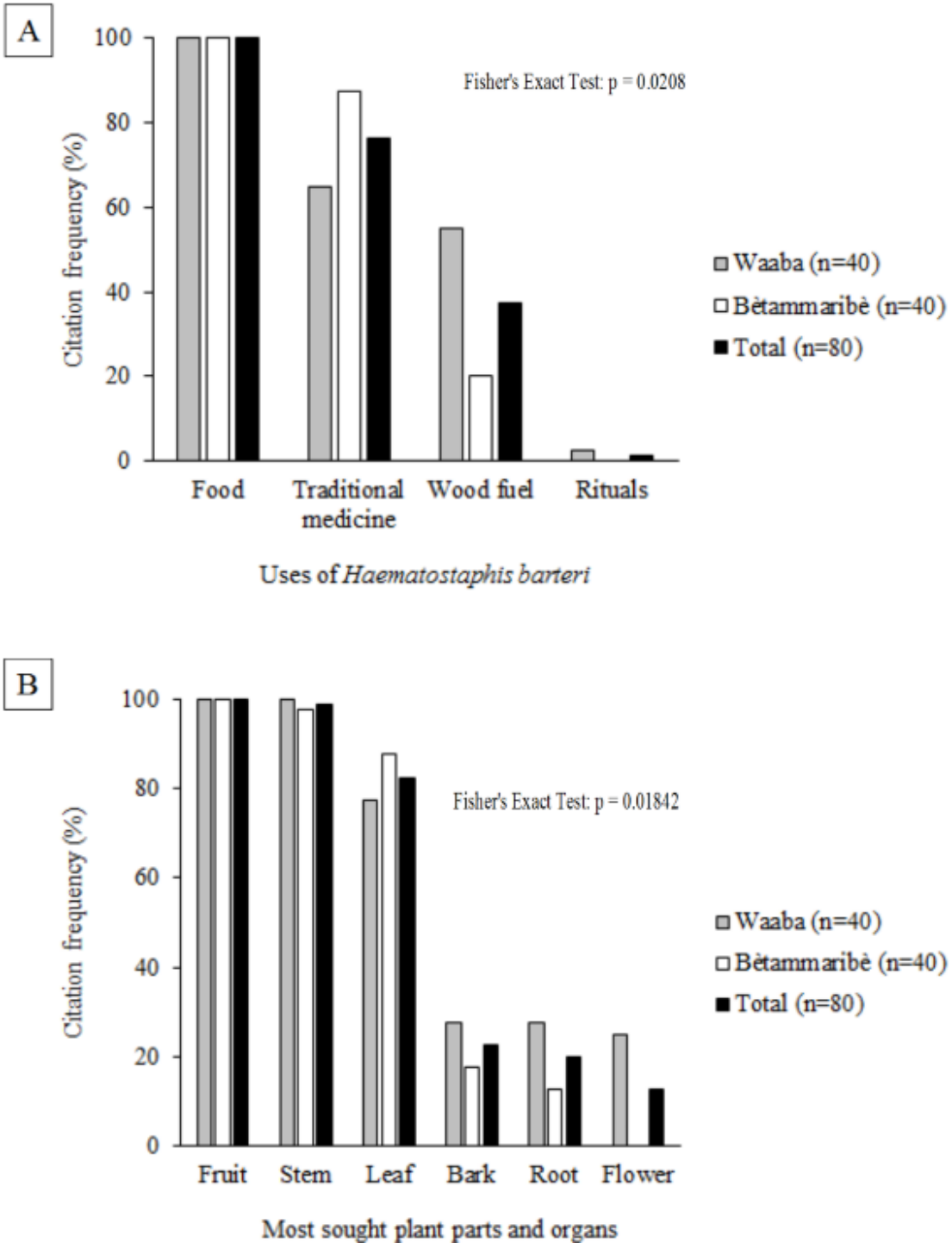

Figure 4. Uses of *H. barteri* by the Waaba and Bètammaribè of the commune of Natitingou: (A) most common uses and (B) most sought plant parts and organs.

12.5%, respectively). In contrast, the Bètammaribè (87.5%) use more, the leaves of the species than Waaba (77.5%).

There were significant differences between the Waaba and Bètammaribè for both the uses of *H. barteri* (Fisher's Exact Test, p = 0.0208) and the plant parts collected

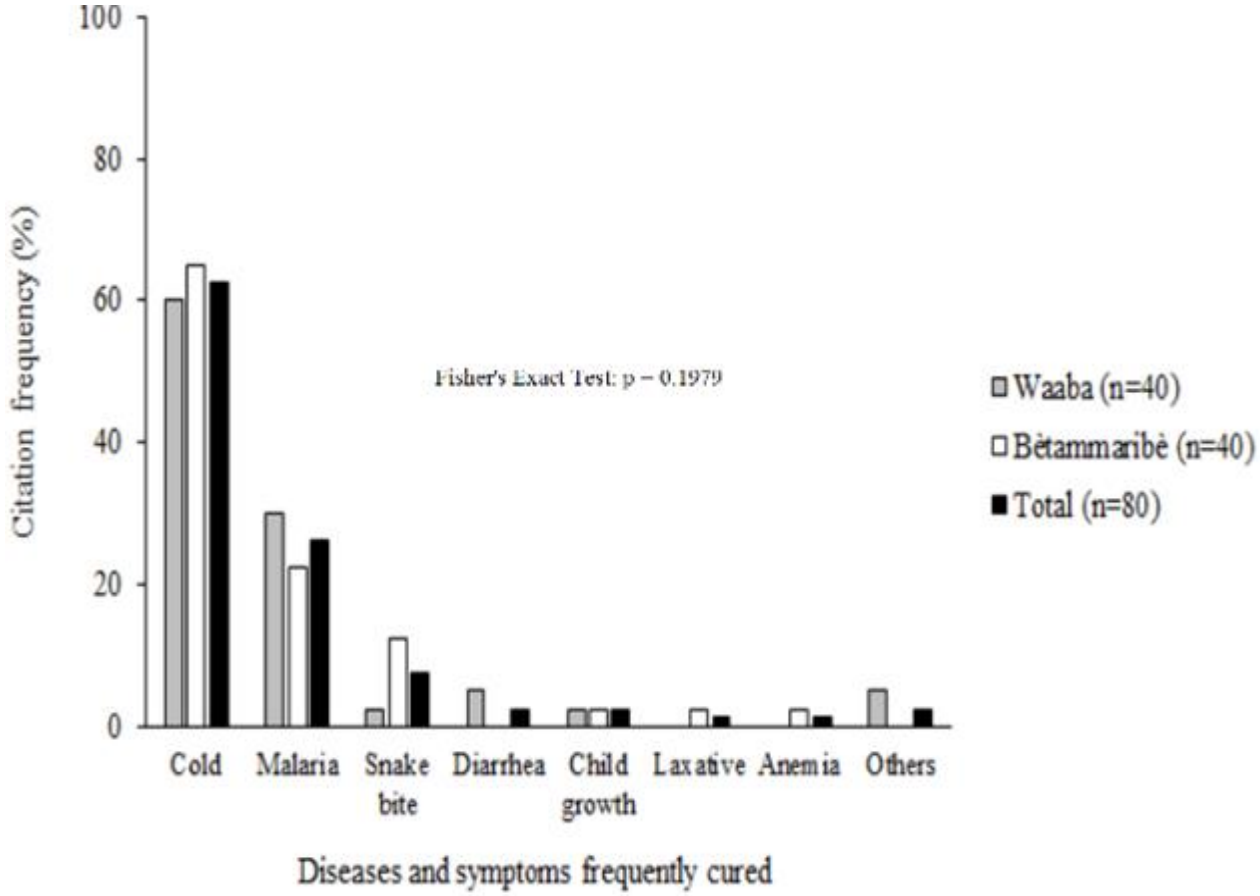

Figure 5. Diseases and symptoms frequently cured with *H. barteri* organs.

(Fisher's Exact Test, p = 0.01842).

Diseases and symptoms treated with *H. barteri* organs

There was no difference between the Waaba and Bètammaribè regarding the use of *H. barteri* in traditional medicine (Fisher's Exact Test, p = 0.1979). The majority (86.75%) of the interviewees quoted at least one disease or symptom treated with *H. barteri* organs. The plant can be used solely or in combination with other plants for the treatment of more than seven diseases or symptoms (Figure 5). Diseases treated with *H. barteri* include cold (62.5% of the interviewees), malaria (26.25%), snake bite (7.5%), diarrhea (2.5%) and child growth (2.5%). It is used to a smaller extent as laxative (1.25%) or to treat anemia (1.25%). Also, the cooking of the wild yam (*Dioscorea* sp.) in combination with the leaves of *H. barteri* makes it more pleasant to eat, thus enabling poor households to survive during the lean season with this occasional meal.

Vulnerability of *H. barteri*

The average vulnerability score for *H. barteri* was estimated at 2.4, thus indicating that the species is vulnerable (Table 2 and Figure 6). Factors contributing to the species vulnerability include its popularity, the harvesting of its immature fruits by locals, its biotope restricted to rocky soils on the Atacora mountain chain, the scarcity of its populations, and its dependence on external factors (animals and human) for seed dissemination.

DISCUSSION

The understanding of local populations needs in term of NTFP is essential for establishing sustainable conservation policies and for biodiversity conservation (Vodouhê et al., 2009). Also, to be effective, efforts to conserve biodiversity must ideally be based on endogenous knowledge and local mechanisms of resource management (Camou-Guerrero et al., 2008).

Table 2. *H. barteri* vulnerability score established for nine ecological and ethnobotanical parameters.

Vulnerability parameters assessed	Score	Score justification
Popularity of the species	3	100% of the interviewees (Waaba and Bètammaribè) know *H. barteri*, and 100% use either its fruits or other plant parts.
Organs harvested	2	The mostly used organs by locals are fruits (93% of citation) and leaves (83%). The harvesting of these organs does not necessarily lead to the death of the plant individuals.
Development stage of organs harvested	3	91.3% of the interviewees harvest fruits of *H. barteri* before maturation while leaves, roots, and barks are harvested at a mature stage. Harvesting of immature fruits can compromise the species regeneration.
Mode of collection of the organs	2	The majority of the interviewees (87.5%) rely on the harvesting of *H. barteri* fruits while 12.5% combine collecting fallen fruits and harvesting.
Pharmaceutical forms used	2	Roots and barks are dried for their conservation. However, fruits are directly consumed.
Biotope	3	*H. barteri* is restricted to rocky soils on the Atacora mountain chain
Morphological type	1	*H. barteri* is a woody plant species with many stems and is then less vulnerable than species with single stem
Seed dissemination mode	3	Seeds of *H. barteri* are disseminated by animals and human, making the species dependent on external factors and thus vulnerable
Frequency/abundance of the plant in the area	3	*H. barteri* is an endemic and uncommon species which distribution is restricted to the commune of Natitingou. Its populations are presently isolated
Average vulnerability score (V)	2.4	Vulnerable species

Vulnerability score = 1 (not vulnerable); = 2 (moderately vulnerable); = 3 (highly vulnerable).

This study enabled understanding the importance of *H. barteri* for the human communities living along Atacora chain and to assess the species status of conservation which was found critical in Benin.

Uses and importance of *H. barteri*

Significant differences were found between the Waaba and Bètammaribè for both the uses of *H. barteri* and the collected plant parts. Although, the two ethnic groups have been living closely for a long time and could consequently share similar knowledge, only the diseases and symptoms cured with the species in traditional medicine were similar in the two ethnic groups. There are indeed cultural connections between the Waaba and Bètammaribè, and both of their spoken languages (Waama and Tammari) belong to the Oti-Volta languages, a subgroup of the Gur languages spoken in northern Ghana, Benin and Burkina Faso (Williamson and Blench, 2000). This is also evidenced by the similarities in the consonances of the species local names between the two languages. Still, it seems that there have been some differentiations between the two groups about the use of the plant in traditional medicine, in rituals or as wood fuel. This differentiated uses could also explain the differences between the two groups concerning the most sought plant parts.

The fruits and leaves of *H. barteri* are widely used by the communities living in the vicinity of the Atacora mountain chain. On the other hand, the roots and the bark are less used. The same findings regarding food and therapeutic uses of *H. barteri* by local populations were made in Nigeria (Eromosele and Eromosele, 2002; Umaru et al., 2007; Kubmarawa et al., 2009) and Togo (Kpemissi Amana, 2007). However, it is only in Benin that the species is reported as wood fuel. The contribution of *H. barteri's* wood to domestic energy in the survey area increases its socio-economic interest but might also pose serious problems for its conservation.

Besides, *H. barteri* bear fruits at the end of the dry season (Arbonnier, 2002), which corresponds to the lean period in the study area, and makes the species a subsistence food of high importance for local poor communities. Indeed, the commune of Natitingou, where the species is found, belongs to the Benin communes having the highest food insecurity rates. In this commune, the proportion of households with poor or limited food consumption was estimated at 50% (PAM, 2014). Their poorly diversified diet is characterized by major deficiencies (lack of foods rich in animal proteins, fruits, milk and dairy products), as cereals (millet, sorghum, and maize) and yam form the basis of the diets. In this context, NTFP and fruit trees like *H. barteri* can contribute significantly to the diet balance of poor households.

Also, the level of poverty of the population greatly

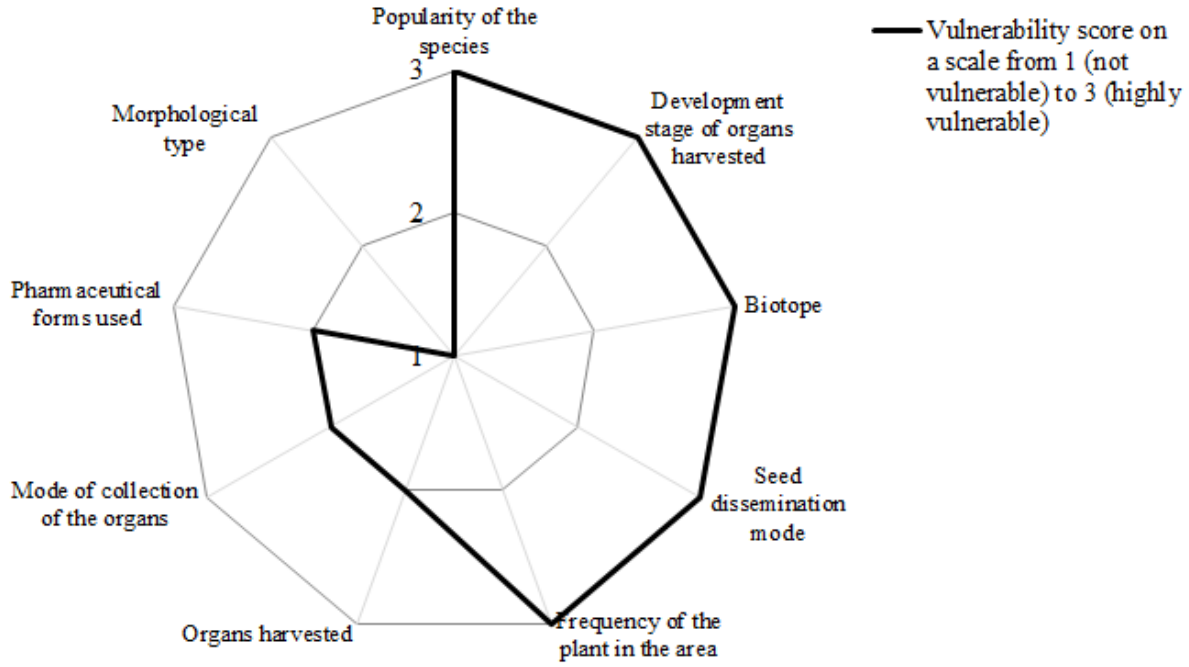

Figure 6. Vulnerability indicators for *H. barteri.*

reduces its accessibility to modern health facilities and increases the use of flora and fauna species for health care. The leaves, roots and barks of *H. barteri* contain substances like tannins, saponins and flavonoids (Eromosele and Eromosele, 2002; Kpemissi Amana, 2007; Umaru et al., 2007; Kubmarawa et al., 2009) and explains the interest of traditional healers in using *H. barteri* for treating several diseases. These chemical substances have anti-inflammatory and analgesic properties and could account for the fact that *H. barteri* is used for treating snakes bites and attenuating headaches. Tannins favor the inhibition of intestinal motility and justify the utilization of the species as anti-diarrheic (Djemai, 2009). Likewise, *H. barteri* leaves are known to be excellent sources of nutrients for human, and its organs contain proteins such as leucine, tyrosine and phenylalanine at a higher rate than WHO's recommended standards for human (Kubmarawa et al., 2009) with potentially interesting effects on child growth.

Vulnerability of *H. barteri*

In this study, *H. barteri* was found vulnerable due to its popularity, the harvesting of its immature fruits by locals, its uncommon biotope, the scarcity of its populations, and its dependence on external factors for seed dissemination. *H. barteri* is well known and widely used in the commune of Natitingou for multiple purposes such as food, traditional medicine and wood fuel. Locals often harvest immature fruits so as to be among the first to collect them, and for preserving them long enough. This practice demonstrates a high demand for the species as compared to the relatively low availability of the resource, and one potential consequence could be the lack of regeneration we observed within the majority of the species populations, as also noted in Togo (Agbogan et al., 2015). The availability of a resource and types of use are important criteria for assessing the vulnerability of a species (Dibong et al., 2011). Indeed, a strong pressure on a species can increase its vulnerability (Traoré et al., 2011) and the irrational harvest of certain parts can negatively affect the survival of the species (Gaoué and Ticktin, 2007). In the actual context of the commune of Natitingou, which is mostly composed of poor populations (PAM, 2014), the high dependence of the population on flora and fauna species for food and health care suggests that the level of *H. barteri* vulnerability is likely to increase (Betti, 2001; Dassou et al., 2014). The results of this study thus call for more attention regarding the conservation status of *H. barteri* in Benin and particularly its inclusion in the Benin's list of threatened species.

Conclusion

H. barteri is a multi-purpose use plant species of high importance for the populations living along the Atacora mountain chain in Benin. It contributes significantly to food subsistence and health care for the local people. It

also provides wood energy which is a vector for the socio-economic development in rural areas. However, the current uses of the species make it vulnerable and can compromise its persistence in Benin. Consequently, there is a need to include *H. barteri* in the local list of threatened species, and to develop methods for the species conservation and sustainable management, such as artificial regeneration and plantation techniques. Also, future studies need to assess and monitor the dynamics of this restricted-range and highly demanded species in the context of climate change.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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