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# Usages and cultural significance of *Hura crepitans* L. (Euphorbiaceae) in local communities of ouémè and plateau departments (South Benin)

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**Key words:** *Hura crepitans*, Ethnobotany, Knowledge transmission, Communities' perceived threats, Cultural importance

**Abstract**

*Hura crepitans* L., commonly referred to as the "sandbox tree," is a tree species widely distributed across tropical regions. Despite its ecological and socio-economic significance, limited research has been conducted on its traditional utilization and perception by local communities in West Africa, particularly in Benin. This investigation aims to address this knowledge gap by examining the ethnobotanical importance of this species in southern Benin. Ethnobotanical surveys were conducted with 357 respondents across nine (09) Communes in the Ouémè and Plateau departments. Data concerning socio-demographic characteristics, usages made from species, modes of knowledge transmission, and threats were collected and analyzed using Microsoft Excel and R studio. Twenty-eight (28) distinct uses categorized into eight (08) use categories were identified. The "Holli" sociolinguistic group primarily employs species for medicinal, construction, and artisanal purposes, while the "Nago" focuses on construction, medicinal, and cosmetic applications, and the "Wémè" on agricultural, cultural, and religious uses. Knowledge transmission is predominantly oral, passed from father to son, with significant variations among ethnic groups ($p < 0.0001$), age categories ($p = 0.002$), religious affiliations ($p < 0.0001$), and education levels ($p = 0.045$). The species demonstrates high cultural importance for construction (0.60), agricultural (0.47), artisanal (0.31), and medicinal (0.30) applications. Deforestation and excessive harvesting were identified as primary threats to the species' survival. These findings enhance our understanding of the relationship between people and the species for sustainable management and conservation strategies.

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## Introduction

The field of ethnobotany has been established to document, analyze, and understand the multidimensional relationships between human societies and plants (Martin *et al.*, 2010) through an interdisciplinary investigation approach of the uses of plants in traditional pharmacopoeias, food systems, rituals, and daily life (Siraj, 2022). This includes the botanical, anthropological, ecological, and linguistic disciplines used to unravel this framework of interdependent human-plant relationships (Martin *et al.*, 2010). This respect for the past is revealed in human history, with evidence of systematic documentation of herbal knowledge by humans going back millennia to antiquity. Medicinal plants are the most important source of life-saving drugs for 75–80% of the population in developing countries. They have also been a valuable resource for scholars throughout recorded history, documenting information on plant identification, uses (e.g., as drugs), and preparation methods through pharmacopoeia (Favi *et al.*, 2022; Rahman *et al.*, 2022).

Traditional medicine is still a key pillar of the health system in Benin and many other parts of Africa, with households depending largely on plant-based treatment as first-line healthcare (Dossou-Yovo *et al.*, 2022; Dougnon *et al.*, 2023).

Furthermore, habitat fragmentation, overexploitation of natural resources, and climate change contribute to biodiversity loss, threatening traditional ecological knowledge (TEK) systems (Assogbadjo *et al.*, 2012; Fandohan *et al.*, 2017). This biodiversity loss affects people who depend on these ecosystems for their livelihoods and cultural practices (Agoyi *et al.*, 2015).

Therefore, documenting and integrating TEK into conservation is beneficial for scholarly research, as well as for resource management practices dealing with ecosystem resilience (Avakoudjo *et al.*, 2020).

The purpose of this study is to investigate the ethnobotanical significance of *Hura crepitans* L., commonly known as the sandbox tree, a species widely distributed across Benin mainly in two specific departments: Ouémè and Plateau (Montcho, 2016; Sidohounde *et al.*, 2019). By employing a qualitative and quantitative approach, this research contributes valuable insights into the diverse ways in which *H. crepitans* is integrated into the cultural beliefs and daily lives of communities in Southern Benin. This study aims to address the following key questions: (i) What are the traditional uses, use diversity, and socio-cultural importance of *H. crepitans* in the Ouémè and Plateau departments of Southern Benin, (ii) How do sociodemographic factors attributes influence the usage patterns and cultural significance of *H. crepitans* in the study area? (iii) What are the primary modes of knowledge transmission regarding *H. crepitans* among local communities? (iv) What are abundance overtime and main threats faced by this plant in these two departments?

## Materials and methods

### *Study area*

The research was carried out in the southeastern region of Benin, West Africa, specifically in the Ouémè and Plateau departments located between 6°22'–7°41'North latitude and 2°28'–2°47'East longitude (Fig. 1). Ouémè is bordered by the Atlantic Ocean to the south and shares boundaries with Plateau and Zou departments. Plateau department shares an international border with Nigeria to the east while internally bordering Ouémè to the west and Collines department to the north. The Ouémè department is subdivided into 52 arrondissements, totaling 437 villages and city quarters, while Plateau is split into 29 arrondissements and 218 villages (Adomou, 2005). The climate is essentially Sudano-Guinean, with two rainy seasons with annual rainfall ranging from 800-1,200 mm in the west to 1,000-1,400 mm in the east. The soil profile is more diverse, including ferralitic, alluvial, and colluvial soils near rivers and floodplains. Vegetation in Ouémè mirrors Plateau's, with shrubland, dense forests, oil palm groves, and some relic forests. Despite their proximity, the two departments differ ethnically. Ouémè is mainly inhabited by Fon and related groups (78.7%), followed by Yoruba (10.1%) and Adja (8.1%), while Plateau is predominantly Yoruba (68.7%), with a smaller Fon population (29.0%) (Mehinto-Dovonou *et al.*, 2018).

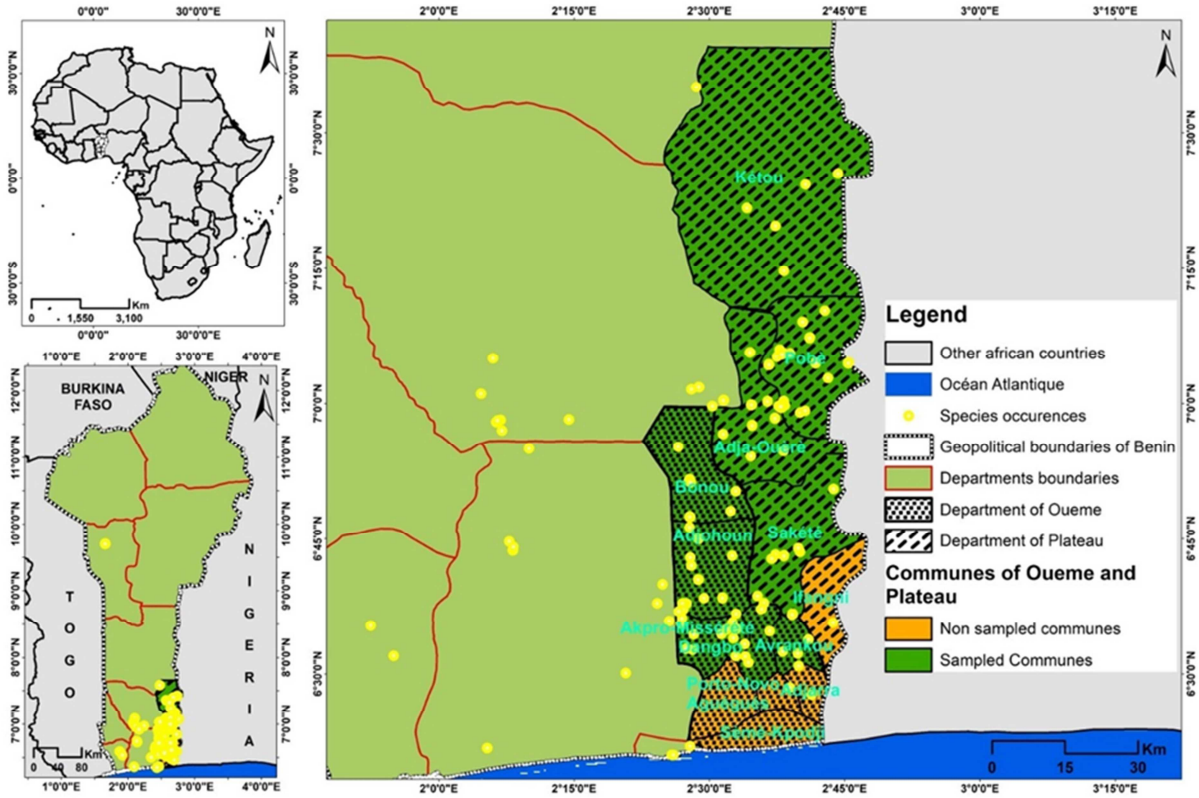


**Fig. 1.** Geographic location of study areas and sampled communes overlaid with the species occurrence data for Benin

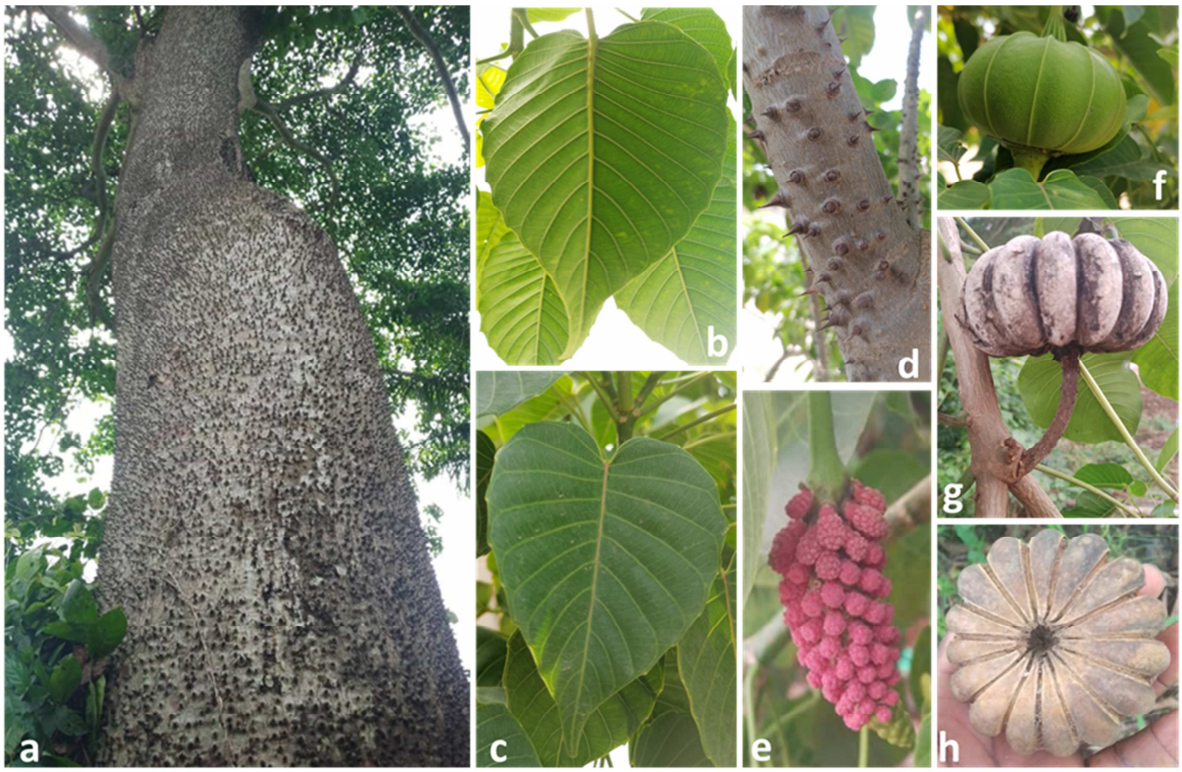


**Fig. 2.** Standing adult tree of *H. crepitans* (a), its leaf seen from back (b) and from front (c), its spines on the branches (d), its male inflorescence (e), its fruit unripe (f), ripe seen from side (g) and from above (h)

**Table 1.** Preliminary survey outcomes and planned and actual informants' sizes at the selected communes level

| Selected communes | Proportion (p) | Sample size (Planned) | Actual informant (Total) | Actual informants (Knowledgeable users) |
|---|---|---|---|---|
| Adjohoun | 0.080 | 114 | 104 | 102 |
| Akpro-Missérété | 0.007 | 11 | 26 | 10 |
| Avrankou | 0.021 | 30 | 28 | 27 |
| Bonou | 0.021 | 30 | 27 | 27 |
| Dangbo | 0.012 | 18 | 15 | 16 |
| Adja-Quèrè | 0.031 | 44 | 41 | 39 |
| Kétou | 0.007 | 11 | 11 | 10 |
| Pobè | 0.089 | 126 | 130 | 112 |
| Sakété | 0.011 | 16 | 18 | 14 |
| Total | - | 400 | 400 | 357 |

*Studied plant species*

*Hura crepitans* L., 1753, known as "sandbox tree" or "huru" in English and "Bombardier" or "Sablier des Antilles"; "bois du diable"; "crepiton", "sablier" in French. In Benin, it is called "wuntin" in Fon and "kekefotin" or "kekefootin" in other vernacular languages (Akouègninou *et al.*, 2006). The tree can reach 40 m in height in the wild with a stem and main branches densely spiny (Fig. 2). The bark is generally grey with black, conical spines (Ajani *et al.*, 2019). The leaf has a broadly ovate blade of 5 to 29 cm in length and 5 to 17 cm in width attached to a 4 to 20 cm long petiole. The leaf blade is papery, abaxially pilose along the midrib, and elevated on both surfaces, with 10 to 16 lateral veins on each side (Owojuyigbe *et al.*, 2020). The male flowers are ovoid-conical inflorescence, mostly dark red. The female flower is often solitary, with a cup-shaped calyx terminating in a thick apical disc of 1 cm in diameter and 5 to 20 radiating lobes of 5 to 10 mm. The fruiting pedicel is pendent to 6 cm, holding an oblate fruit of 3 to 5 × 8 to 9 cm in diameter, concave at its apex and base, and longitudinally grooved, becoming reddish brown.

*Data collection*

Prior to field data collection, the species' distribution was accessed using 668 occurrence data of *H. crepitans* downloaded from the Global Biodiversity Information Facility (GBIF) and mapped using RStudio (Fig. 1).

A preliminary survey was conducted from June 1-10, 2024, involving 100 individuals across nine (09) communes in Ouémè and Plateau departments. This approach, consistent with established ethnobotanical methodologies (Albuquerque *et al.*, 2014) helped gauge local awareness and use of *H. crepitans*. The final sample size was determined using Dagnelie's formula (Dagnelie, 2000) $n = (U_{1-\alpha/2})^2 * p * (1 - p) / d^2$, where n is the sample size, $U_{1-\alpha/2}$ is the value of the normal distribution at probability $1-\alpha/2$ (1.96 for $\alpha = 5\%$), p is the estimated proportion of individuals familiar with at least one use of *H. crepitans,* and d is the margin of error (5%). Based on these hypotheses, for the commune of Adjohoun, the obtained value of n was equal to 112.54, rounded up to 114. The same approach was used for the remaining selected communes and led to the planned size of 400 persons (Table 1). The surveyed participants were randomly selected from the arrondissements of each selected commune and included people who have knowledge of the species.

Survey forms were designed using the Kobotoolbox platform, and data collection was primarily conducted through individual semi-structured interviews, each lasting 30-60 minutes, a method widely used in ethnobotanical research (Albuquerque *et al.*, 2014). A total of 400 informants were interviewed across the study area, with 357 identified as knowledgeable users of *H. crepitans* (Table 1). Data collected concerned (i) the socio-demographic characteristics of respondents, (ii) the uses made from each organ, including traditional knowledge, variety of uses, modes of uses, frequency of usage, (iii) the modes of knowledge transmission about the plant, and (iv) people's perception about the threats on the species (Avakoudjo *et al.*, 2020; Gbesso *et al.*, 2021). Within sociodemographic attributes, we have also defined a

category of age as variable. Three age categories were considered (age < 30 years for young; 30 ≤ age < 60 years for adults; age ≥ 60 years for old persons (Salako *et al.*, 2018).

*Data processing and analysis*

To assess the diverse usages of *H. crepitans* across different sociolinguistic groups in both the Ouémè and Plateau departments, descriptive statistics were first used to characterize the sample across sociodemographic variables (age, gender, education, ethnicity, marital status, Age category) and their knowledge and use of the species. That provided a basic understanding of the study population and their relationship with the species (Gbesso *et al.*, 2021). After the descriptive statistics, ethnobotanical indexes including frequency of citation (F), use value (VUo and VUT), the cultural importance index (IP) and the informant consensus factor (ICF) were calculated. Furthermore, correspondence analysis (CA) was performed to better describe the links between sociolinguistic groups and use categories (Avakoudjo *et al.*, 2020). Knowledge transmission on *H. crepitans* was accessed by forecasting the percentage of respondents who identify each mode of transmission as primary. The potential relationships between knowledge transmission modes and other variables like age, gender, etc. (Gbesso *et al.*, 2021) was explored by using chi-square test at 5% of the error margin confirmed by the Fisher exact test.

*Frequency of citation (F)*

For each use report of *H. crepitans*, the relative frequency of citation, defined as how often a use report was mentioned, was calculated using the formula F =n/N*100 where n is the number of informants who mentioned a specific use, and N is a total number of informants. Only the significant uses (F > 5%) were reported (Salako *et al.*, 2018).

*Ethnobotanical use value*

A usage score assigned by respondents according to each category of usage were included in the formula $VUo = \frac{\sum_i^n \alpha}{n}$ where: VUo = use value of the organ for a given category; α = usage score assigned by respondents; n = number of positive responses (yes) for the organ in each usage category (Lykke *et al.*, 2004, Salako *et al.*, 2019). The rating scale used were: *3 = frequently used; 2 = moderately used; 1 = weakly used*. The total ethnobotanical use value (VUT) is calculated by summing the use values of the organ within the different usage categories. It is given by the formula $\boldsymbol{VUT} = \sum_{cl}^{cn} VUo$ where VUT = total ethnobotanical use value of the organ; VUo = ethnobotanical use value of a given organ for a usage category.

*Cultural importance index*

This index highlighted the relative importance of specific *H. crepitans* uses for each informant within a sociolinguistic group (Houehanou *et al.*, 2011; Salako *et al.*, 2019). It was calculated using the following formula $IP = \sum_{uc=1}^{nuc} IPuc = \sum_{uc=1}^{nuc} \sum_{i=1}^{n} \frac{Suc,i}{n}$ where: Suc,i is the score of importance (1 = weakly used, 2 = meanly used and 3 = highly used) attributed by informant i (i = 1,..., n) for the use-category uc; nuc is the number of use-categories. IP is the overall importance value of *H. crepitans* and IPuc, the importance value of the use-category uc of *H. crepitans*.

*Informant consensus factor*

This measured the agreement among respondents about the use of *H. crepitans* for specific purposes (Hadonou-Yovo *et al.*, 2019).

ICF = (Nuc - Ns) / (Nuc - 1) where: Nuc = Number of use citations for a specific use category and Ns = Number of *Hura crepitans* used by informants for that use category.

**Results**

*Sociodemographic profile of informants and traditional names of the species*

The socioprofessional and sociodemographic attributes analysis of informants revealed that, in both the Ouémè and Plateau departments, the socioprofessional status of respondents is dominated by farmers and handcrafters, who constitute a significant portion of the surveyed population,

particularly among adults (Table 2). Farmers and handcrafters account for 13.17% and 17.65% in Ouémè, and 17.37% and 16.81% in Plateau, respectively. In both departments, male respondents dominated the sample and represented 88.51% globally regardless of the department. Female representation is low, concentrated in roles such as traders and civil servants. The Plateau department shows slightly more professional diversity, with contributions from traders, breeders, and traditional healers, suggesting a more varied economic landscape.

**Table 2.** Distribution of informants by age group, gender, and profession across the study areas

| Socioprofessional groups | Young | | Adult | | Elder | | Male | | Female | | Percentage (%) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | OU | PL | OU | PL | OU | PL | OU | PL | OU | PL | OU | PL |
| Farmer | 0 | 7 | 41 | 53 | 6 | 2 | 44 | 60 | 3 | 2 | 13.17 | 17.37 |
| Students | 4 | 9 | 4 | 0 | 0 | 0 | 7 | 9 | 1 | 0 | 2.24 | 2.52 |
| Handcrafter | 4 | 28 | 59 | 32 | 0 | 0 | 61 | 43 | 2 | 17 | 17.65 | 16.81 |
| Musician | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0.28 |
| Hunter | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 1.12 |
| Trader | 0 | 3 | 3 | 10 | 0 | 0 | 3 | 4 | 0 | 9 | 0.84 | 3.64 |
| Breeder | 0 | 2 | 3 | 5 | 0 | 0 | 3 | 7 | 0 | 0 | 0.84 | 1.96 |
| Civil servant | 0 | 0 | 25 | 3 | 2 | 1 | 23 | 4 | 4 | 0 | 7.56 | 1.12 |
| Carpenter | 0 | 1 | 5 | 3 | 0 | 0 | 4 | 4 | 1 | 0 | 1.4 | 1.12 |
| Fisher | 0 | 0 | 3 | 1 | 0 | 0 | 3 | 1 | 0 | 0 | 0.84 | 0.28 |
| Nurseryman | 0 | 1 | 8 | 1 | 1 | 0 | 9 | 2 | 0 | 0 | 2.52 | 0.56 |
| Farmer facilitator | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0.28 | 0 |
| Veterinarian facilitator | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0.28 | 0 |
| Traditional healer | 0 | 0 | 8 | 8 | 4 | 0 | 10 | 8 | 2 | 0 | 3.36 | 2.24 |
| Percentage (%) | 17.1 | | 78.4 | | 4.47 | | 88.51 | | 11.49 | | 100 | |

NB: Caption: OU = Department of Ouémè; PL = Department of Plateau

**Table 3.** Sociodemographic attributes distribution through sociolinguistic groups

| Sociocultural groups | Age | | | Gender | | Proportion (%) on all surveyed informants |
|---|---|---|---|---|---|---|
| | Young | Adult | Elder | M | F | |
| Adja | 0 | 4 | 0 | 4 | 0 | 1.12 |
| Aizo | 0 | 1 | 0 | 1 | 0 | 0.29 |
| Fon | 1 | 13 | 0 | 10 | 4 | 3.92 |
| Goun | 3 | 24 | 3 | 28 | 2 | 8.4 |
| Holli | 38 | 62 | 2 | 83 | 19 | 28.57 |
| Mahi | 0 | 5 | 0 | 5 | 0 | 1.4 |
| Mina | 0 | 1 | 0 | 1 | 0 | 0.28 |
| Nago | 11 | 50 | 1 | 55 | 7 | 17.37 |
| Tofin | 1 | 0 | 0 | 1 | 0 | 0.28 |
| Tori | 1 | 8 | 0 | 8 | 1 | 2.52 |
| Wémè | 6 | 112 | 10 | 120 | 8 | 35.85 |
| Total | 17.09 | 78.43 | 4.48 | 88.51 | 11.49 | 100 |

**Table 4.** Local names of *Hura crepitans* and their significance according to sociolinguistic groups

| Sociolinguistic groups | Vernacular name | Significance in English |
|---|---|---|
| Holli | Egui aba yimbo | The shade tree |
| Adja | Kéké tchi; Hounsou kèkè | Motorcycle tree |
| Aizo | Hountin | Canoe tree |
| Fon | Danmalia | The snake cannot climb up there |
| Goun | Kèkèti | Motorcycle tree |
| | Danmahloui | Snake cannot catch it |
| | Hountin | Canoe tree |
| Nago | Egui Kêkê. Egui Aba tyrè | Fruits like wheels |
| Mahi | Guédéhoussou | Because of its gigantic size |
| Mina | Wunti vegon | The second of bombax |
| Wémè | Kèkèti. Hounsou kèkè | Motorcycle tree |

Regarding sociolinguistic groups (Table 3), the Wémè represents the largest segment of Ouémè department, accounting for 35.85% of the total population, with a considerable number of both adults and elders. Young individuals made up 17.09% of the surveyed population, primarily found within the Holli group (38 youth). Elderly respondents are the least represented, constituting only 4.48%, with the highest number coming from the Wémè (10 elders). Holli group stands out with the highest number of young individuals (38 youth), representing 28.57% of the total population. Elders constitute 4.48% of the surveyed individuals, with the Wémè and Goun groups having the most elders. Female representation is slightly more visible compared to Ouémè, but still limited, with the Holli group having the highest number of females (19).

*Hura crepitans* is called by several names in the two studied departments (Table 4). Even though among the eleven sociolinguistic groups informants belong to, two groups the Tofin and the Tori did not provide information about the local name of the species, all the other groups have provided names having all together seven different meanings including the "Motorcycle tree", the "Canoe tree" and tree that "snake cannot climb" or "snake cannot catch". The sociolinguistic group Goun has three different ways of calling the species having all the above-mentioned meanings. Globally, people of the studied departments know the species by a name which is linked to the wheel-like appearance of its fruits or its thorny stem which makes the tree almost impossible to climb. The other names emphasized on its large size.

**Table 5.** Reported uses of *Hura crepitans* in two studied departments

| Usage category | Organs | Specific usage/Disease | Sociolinguistic groups | |
|---|---|---|---|---|
| | | | Ouémé | Plateau |
| Medicinal | Leaves | Leprosy/ Skin wound | Goun | - |
| | | Difficult childbirth | - | Holli/Nagot |
| | | Lack of breast milk production | - | Holli |
| | | Headache | - | Nagot/Holli |
| | | Stomachache | - | Nagot/Holli |
| | Roots/Leaves | Snake bite | Wémè | - |
| | Leaves/Bark | Swellings | - | Nagot/Holli |
| | Leaves, roots | Cancer | - | Nagot/Holli |
| Construction | Wood | Carpentry (tables, desks, plywood, chevrons, slats, formwork) | Wémè, Goun | Holli, Nago, Fon, Mahi |
| Handcraft | Wood | Cabinetmaking | Goun | Holli |
| | | Art Objects (decorative paintings, statuettes) | Wémè | - |
| | | Agriculture handle tools | Wémè, Goun | Holli, Nago |
| Agriculture | Entire tree | Shade | Nago, Goun, Wémè, Torri | - |
| | | Pest control in crops | Nago, Goun, Wémè, Torri | - |
| | | Support for crops (peeper) | Nago, Goun, Wémè, Torri | - |
| | Latex | Paralyze fish in water | Wémè | - |
| Cultural | Seeds/Fruits | Traditional games & toys | Wémè/Goun | - |
| | Wood | Mask making | Wémè | - |
| | Wood | Musical instruments | Wémè/Mahi | Wémè/Mahi |
| | Whole tree (flowers, fruits, leaves) | Decorative objects in the home garden | Wémè | - |
| Religious | Bark | Protection rituals | Wémè/Goun | - |
| | Bark, leaves | Purification ceremonies | Wémè/Goun | - |
| | Bark, leaves | Fertility ritual | Wémè | - |
| | Whole tree | Amplification of ORO fetish cries | - | Holli |
| | Wood | Guèlèdè mask making | - | Holli |
| Ecologic | Whole tree | Biodiversity improvement | Fon | - |
| | | Erosion control/soil restauration | Fon/Goun/Wémè | - |
| Cosmetic | Seed oil | Skin cream | Wémè | Holli |

**Table 6.** Consensus value of respondents in use categories

| Sociodemographic characteristics | Construction | Agricultural | Medicinal | Handcraft | Cultural | Religious | Ecological | Cosmetics |
|---|---|---|---|---|---|---|---|---|
| Socioprofessional groups | | | | | | | | |
| Farmer | -0.32 | -0.51 | -0.84 | -0.71 | -0.79 | -0.84 | -0.95 | -1 |
| Student | -0.37 | -0.75 | -0.62 | -0.37 | -0.75 | -1 | -0.87 | -1 |
| Artisan | -0.5 | -0.5 | -0.7 | -0.69 | -0.72 | -0.95 | -0.93 | -0.98 |
| Musician | 0 | 0 | -1 | 0 | -1 | 0 | -1 | -1 |
| Hunter | 0.6 | -0.6 | -1 | -1 | -1 | -1 | -1 | -1 |
| Trader | -0.45 | -0.63 | -0.63 | -0.63 | -1 | -0.9 | -0.81 | -0.9 |
| Breeder | 0 | -1 | -0.8 | -0.6 | -0.8 | -1 | -0.8 | -1 |
| Civil servant | -0.72 | -0.33 | -0.88 | -0.88 | -0.55 | -0.88 | -0.77 | -0.94 |
| Carpenter | 0.6 | -1 | -0.8 | -0.8 | -1 | -1 | -1 | -1 |
| Fisherman | -1 | -1 | -1 | 0 | -1 | -1 | 0 | -1 |
| Nurseryman | -0.45 | -0.09 | -0.81 | -0.81 | -0.81 | -1 | -1 | -1 |
| Agricultural technician | -1 | 1 | -1 | -1 | -1 | -1 | -1 | -1 |
| Veterinary technician | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Traditional healer | -0.6 | -0.86 | 0.06 | -1 | -0.46 | 0.06 | -1 | -1 |
| Socio-cultural groups | | | | | | | | |
| Adja | -0.2 | -0.2 | -1 | -1 | -1 | -0.6 | -1 | -1 |
| Aizo | 0 | -1 | 0 | -1 | -1 | -1 | -1 | -1 |
| Fon | -0.42 | -0.42 | -0.9 | -0.61 | -1 | -0.9 | -0.71 | -1 |
| Goun | -0.87 | -0.18 | -0.93 | -0.75 | -0.56 | -0.87 | -0.81 | -1 |
| Holli | -0.11 | -0.91 | -0.61 | -0.59 | -0.91 | -0.89 | -1 | -0.96 |
| Mahi | -0.09 | -0.81 | -0.81 | -0.63 | -1 | -0.63 | -1 | -1 |
| Mina | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Nago | 0 | -0.91 | -0.45 | -0.75 | -0.91 | -0.97 | -0.97 | -1 |
| Tofin | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tori | -0.46 | -0.06 | -1 | -0.73 | -0.73 | -1 | -1 | -1 |
| Wémè | -0.88 | -0.14 | -0.96 | -0.83 | -0.52 | -0.8 | -0.85 | -0.98 |
| Gender | | | | | | | | |
| Young | -0.13 | -0.85 | -0.56 | -0.68 | -0.82 | -1 | -0.97 | -0.97 |
| Adults | -0.47 | -0.45 | -0.8 | -0.72 | -0.77 | -0.87 | -0.91 | -0.98 |
| Elder | -0.75 | -1 | -0.75 | -1 | -0.37 | -0.37 | -0.75 | -1 |
| Age | | | | | | | | |
| Men | -0.41 | -0.53 | -0.78 | -0.72 | -0.77 | -0.86 | -0.9 | -0.99 |
| Women | -0.46 | -0.68 | -0.55 | -0.73 | -0.73 | -0.91 | -1 | -0.91 |

*Usage patterns of the species and ethnobotanical indexes*

Based on the frequency of citation, a total of 28 distinct and significant uses for *H. crepitans* were identified in the two studied departments. These uses are organized into 08 usage categories with 08 medicinal, 01 construction, 03 handcrafts, 04 agricultural, 04 cultural, 05 magical-religious, 02 ecological, and 01 cosmetic (Table 5). The species leaves and wood were the most used organs regardless of the usage categories, while the seed was the least used organ and mainly as oil in cosmetics.

The Plateau department showed greater diversity for usage, with 28 distinct uses reported compared to 24 in Ouémè. However, despite the fewer reported uses, higher citation frequency was seen in Ouémè (89.5% vs 87.5%) indicating that the uses of *H. crepitans* may be more commonly recognized in this area. Regarding the consensual value of respondents in use categories (Table 6), the carpenters and hunters strongly agree on the use of *H. crepitans* in the construction domain. Traditional healers weakly agree on the use of the species in the medicinal and religious domains. In contrast, all others very weakly agree or do not agree on the uses of *H. crepitans* at all.

Considering the overall cultural importance index value, though globally weakly used, the species has greater importance for the sociocultural groups of Wémè, Holli, Nago and Goun but is less important for the Adja (Fig. 3a). The species is highly important for male adult people (Fig. 3d) who are either farmers or handcrafters (Fig. 3c) involved in construction or agriculture (Fig. 2b).

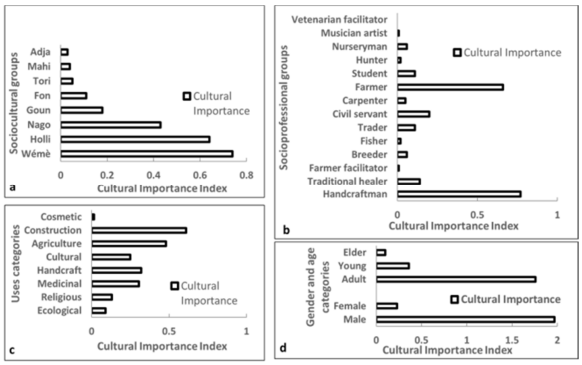


**Fig. 3.** Figure showing the cultural importance index for sociocultural groups (a) and the cultural importance index for socioprofessional groups (b), for uses categories (c), for gender and age categories (d)

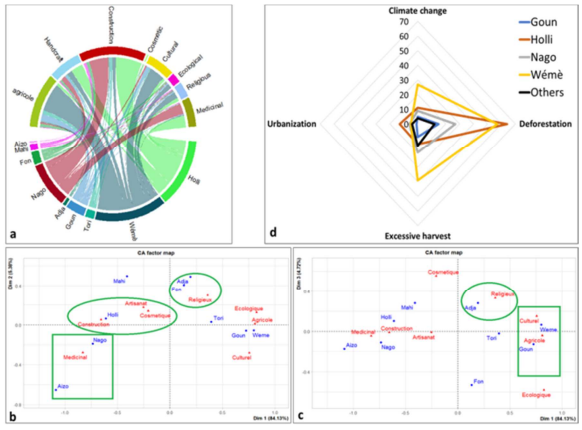


**Fig. 4.** Chord plots showing uses of *H. crepitans* in divers usages categories by sociolinguistics group (a), graph of the AFC on the plane of axes F1 and F2 (b), on the plane of axes F1 and F3 (c) of usage categories of *H. crepitans* and socio-cultural groups, graph of the main threats regarding sociolinguistic groups (d)

The linkage between the sociolinguistic groups and the use categories was analyzed based on the chord plot and the correspondence analysis. Based on the chord plot, the Holli sociolinguistic group used the species for medicinal, construction, and handcrafts while the Nago used it for construction, medicine, and cosmetics, and the Wémè for agriculture, cultural, and religious (Fig. 4a). The correspondence analysis indicates on the inertia axes 1 and 2 (89.51%), that the Holli use *H. crepitans* more for construction, handcrafts, and cosmetics, while the Aizo and Nago use it more for medicinal purposes, and the Fon and Adja for religious purposes (Fig. 4b). Meanwhile on the inertia axes 1 and 3 (87.85%) it is revealed that the Goun and Wémè use *H. crepitans* more for cultural and agricultural purposes (Fig. 4c).

*Modes of knowledge transmission and local perception of main threats on the species*

When considering sociodemographic attributes, only sociolinguistic group ($\chi^2$ = 123.76; p-value <0.0001); *age category* ($\chi^2$ = 20.56; p-value = 0.002); Religious ($\chi^2$ = 41.24; <0.0001); *education level* ($\chi^2$ = 21.374; p-value = 0.045) are associated to knowledge transmission process. When considering sociolinguistic groups (Fig. 5), the primary mode of knowledge transmission is oral, passed from father to son among the Holli and Wémè, whereas transmission is based on observation among the Fon and the Mahi.

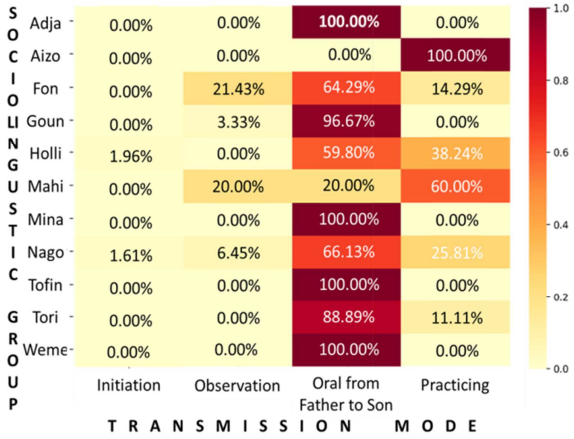


**Fig. 5.** Knowledge transmission modes of Hura crepitans by sociolinguistic groups

Regarding local communities' perception of the main threats faced by the population of the species, the repartition of threats permitted the identification of deforestation and excessive harvest as the two main threats perceived by respondents (Fig. 4d). There is a significant linkage between the different sociolinguistic group and their perceived threats on *H. crepitans* ($\chi^2$ = 43.955, p-value = 0.048). Indeed, while Holli perceived Deforestation and excessive harvest as the main threats to *H. crepitans*, Wémè, perceived Urbanization and climate change.

**Discussion**

The current ethnobotanical investigation on *H. crepitans* in the Ouémè and Plateau departments of Southern Benin has revealed a complex interplay between people' characteristics and uses showing the species' significance diversity in local communities. The diversity in local names and their meanings across different sociolinguistic groups in the study area highlights the cultural significance of the plant. Indeed, local plant names offer valuable insights into species recognition, knowledge acquisition, and the substitution of African species with American ones (Van Andel *et al.*, 2014). Furthermore, the reliance of rural communities in West Africa on local plant species for their livelihood underscores the cultural and economic significance of ethnobotanical knowledge and practices (Zizka *et al.*, 2015).

The wide range of applications identified for *H. crepitans* highlights its capacity as an adaptable tree species, especially in the fields of agroforestry and sustainable resource management (Kurnianto *et al.*, 2022). The plant proves significant potential as a natural support system for black or white pepper cultivation as observed in the agroecological practices at Ahita Pepper Plantation (Centre agro-écologique de la Poivrière de Ahita – CAEPA. Lat: 6.72. Lon: 2.62.). This innovative use does not only support sustainable agriculture but also enhances productivity and promotes environmental health in the region.

The incorporation of *H. crepitans* into local farming systems proves its significant role in agroforestry. The entire tree serves multiple purposes including providing shade, acting as a support for other crops, and contributing to pest control. This multifunctional approach aligns with the principles of agroforestry, which has been shown to enhance crop productivity, soil fertility, and ecosystem services (Nair *et al.*, 2021). The use of *H. crepitans* for shade and crop support highlights an efficient land-use strategy that maximizes vertical space and creates beneficial microclimates for understory crops. A distinct number of uses was reported for the plant suggesting that respondents' knowledge was influenced by their sociolinguistic background. Similar ethnolinguistic variations in the use of baobab products and wild edible plants in Benin were observed (Assogbadjo *et al.*, 2011; Segnon and Achigan-Dako, 2014).

These consistent findings across multiple studies reinforce the critical role of cultural context in shaping human-plant relationships and underline the need for culturally sensitive approaches to conservation and sustainable use of plant resources. As argued by Gaoue *et al.* (2017), understanding these cultural nuances is crucial for developing effective, culturally appropriate conservation strategies that resonate with local communities and their diverse needs. The preponderance of medical treatments (8 uses) among the known uses of *H. crepitans* highlights its considerable contribution to local healthcare system (Tine *et al.*, 2017). The species potential in the realm of traditional medicine is highlighted by past studies in Nigeria (Treasure *et al.*, 2020; Oraegbunam *et al.*, 2020). Indeed, *H. crepitans* has been extensively utilized in ethnomedicinal practices due to its diverse pharmacological properties, such as hepatoprotective, anti-inflammatory, antimicrobial, and purgative effects (Owojuyigbe *et al.*, 2020). The plant is recognized for its efficacy in treating various conditions, including leprosy, microbial infections, gastrointestinal disorders, inflammatory conditions, and cancer (Crossay *et al.*, 2023). The analysis of consensual values among different user groups revealed a specific pattern of specialized knowledge. The strong agreement among carpenters and hunters on the use of *H. crepitans* in construction shows a well-established and shared knowledge base within these specialized socioprofessional groups. Other studies have proved the importance of occupation-specific knowledge in ethnobotanical systems. Indeed, it has been observed a specialized knowledge among woodcrafters in Brazil (Albuquerque *et al.*, 2014) while occupation-based variations in plant knowledge was reported in Burkina Faso (Ouédraogo *et al.*, 2017). These consistencies across different geographical contexts underscore the universal importance of professional specialization in deciding

ethnobotanical knowledge. The variability in agreement among traditional healers concerning the medicinal and religious uses of *H. crepitans* seen in both departments can be attributed to several factors. These factors include regional differences in healing traditions, the esoteric nature of some medicinal and religious knowledge, and potential competition or secrecy among healers (Keikelame and Swartz, 2015; Masango, 2020). It has been reported that many traditional healers, who are often the primary healthcare providers for many individuals, have various levels of education, with a significant proportion having only received primary education (Masango, 2020). This lack of formal education may affect the transmission and standardization of knowledge among healers, leading to discrepancies in their practices and beliefs. That is confirmed in our findings, where most of the healers had limited formal education at the primary level, which influences their access to and interpretation of traditional knowledge. The limited formal education also contributes to the preservation of oral traditions and the reliance on experiential learning rather than documented evidence (Quiroz *et al.*, 2016). The minimal gender differences in the use value of *H. crepitans* contrast some other ethnobotanical studies in West Africa. Indeed, while studies have reported significant gender-based differences in plant knowledge and use (Fandohan *et al.*, 2010; Gaoue *et al.*, 2017), the current findings suggest a more equitable distribution of *H. crepitans* knowledge between men and women.

The predominance of oral transmission from father to son as the main mode of knowledge transfer across most sociolinguistic groups aligns with traditional patterns of intergenerational knowledge transmission seen in many indigenous and local communities. Similar patterns have been reported by Reyes-García *et al.* (2009) among the Tsimane' in Bolivia and by Gaoue *et al.*, (2017) in Benin. However, the variations seen among diverse groups (e.g., Holli and Wémè emphasizing practical learning alongside oral transmission; Fon prefers observational learning) highlight the diversity of cultural approaches to knowledge transmission. These differences may reflect variations in social structures, educational practices, or the nature of activities involving *H. crepitans* within each community. The association between religious affiliation and knowledge transmission patterns, particularly the emphasis on practical learning, observation, and oral transmission among adherents of traditional religions, underscores the interconnectedness of spiritual beliefs and ethnobotanical knowledge. This relationship has been noted in other studies of sacred plants and traditional ecological knowledge in West Africa, such as Koura *et al.* (2011) for sacred groves in Benin and Quiroz *et al.* (2016) for medicinal plants in Burkina Faso. These findings collectively emphasize the importance of considering spiritual and cultural beliefs in ethnobotanical research and conservation efforts.

Through the Correspondent Analysis, the medicinal category for Aizo and Nago sociolinguistic groups highlights the importance of *H. crepitans* in their traditional medicine systems. This aligns with global trends in ethnopharmacology, where local plant knowledge continues to be a valuable source for drug discovery and healthcare in many communities (Heinrich *et al.*, 2022). Indeed, ethnopharmacology plays a crucial role in bridging traditional knowledge with modern scientific research, offering a promised future for drug development from indigenous medicinal plants (Bhagawan *et al.*, 2023). Furthermore, the religious applications prioritized by the Fon and Adja underscore the cultural and spiritual significance of *H. crepitans*. In many traditional societies, plants hold symbolic meanings and are often integrated into religious rituals and ceremonies as sacred entities (Dafni, 2006). The spiritual significance attributed to *H. crepitans* by these sociolinguistic groups underscores the intricate relationship between humans, plants, and the divine, emphasizing the interconnectedness of all living beings within the cosmological worldview of these communities (Sandalayuk *et al.*, 2023).

A key finding of our study is that there has been a perceived decline in the abundance of *H. crepitans* over the last decades. Most individuals showed that they saw it change from "common" to "scarce" over this period. Indeed, this can be explained through the lens of anthropogenic pressures on natural resources, a key concept in conservation biology. This theory, articulated by researchers such as Díaz *et al.* (2019) posits those human activities, driven by growthy population and changing land-use patterns, exert increasing pressure on ecosystems and their constituent species. In the case of *H. crepitans*, local perceptions of decline reflect real changes in the species' abundance resulting from habitat loss, overexploitation, or other human-induced factors. This aligns with global trends of biodiversity loss in tropical regions (Ceballos *et al.*, 2017; Díaz *et al.*, 2019) and similar perceptions of decreasing plant populations have been also reported in other West African studies (Assogbadjo *et al.*, 2012; Dossou-Yovo *et al.*, 2020). The differences observed between the Ouémè and Plateau departments suggest that local ecological conditions, land-use patterns, or cultural factors may influence the species' distribution and abundance. For instance, Gaoue *et al.* (2017) and Houehanou *et al.* (2011) have demonstrated how the use and management of plant resources can vary significantly even within relatively small geographic areas. The current results reinforce the need for locally tailored conservation strategies that count for these spatial differences in plant-human interactions. The high availability of *H. crepitans* in agro-systems in Ouémè, contrasting with its perceived forest association in Plateau, reflects the species' adaptability to different land-use patterns.

Assogbadjo *et al.* (2009) and Fandohan *et al.* (2010) documented similar patterns for species such as baobab (*Adansonia digitata*) and tamarind (*Tamarindus indica),* highlighting the complex relationship between human land use and plant population dynamics. These studies collectively underscore the potential for integrating valuable tree species into agroforestry systems as a conservation strategy. In terms of threats to *H. crepitans*, our research found deforestation and excessive harvesting to be the primary concerns among local communities. This aligns with global patterns of biodiversity loss driven by habitat destruction and overexploitation (Maxwell *et al.*, 2016). In West Africa, similar threats have been reported for other valuable tree species. For instance, Houehanou *et al.* (2011) identified habitat loss and overexploitation as key threats to *Pentadesma butyracea* in Benin, while Assogbadjo *et al.* (2012) reported similar pressures on baobab populations. These parallels suggest that addressing deforestation and promoting sustainable harvesting practices should be the priority keys in regional conservation efforts for *H. crepitans*.

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**References**

**Agoyi EE, Padonou EA, Amoussa W, Assogbadjo AE, Kakaï RG, Sinsin B.** 2015. Morphological variation, cultivation techniques and management practices of *Moringa oleifera* in Southern Benin (West Africa). International Journal of Agronomy and Agricultural Research **6**(3), 97-105.

**Ajani OO, Owoeye TF, Owolabi FE, Akinlabu KD, Audu OY.** 2019. Phytochemical screening and nutraceutical potential of sandbox tree (*Hura crepitans* L.) seed oil. Foods and Raw Materials **7**(1), 143-150.

**Albuquerque UP, Ramos MA, Lucena RF, Alencar NL.** 2014. Methods and techniques used to collect ethnobiological data. Methods and Techniques in Ethnobiology and Ethnoecology 15-37.

**Assogbadjo AE, Glele Kakaï R, Adjallala FH, Azihou AF, Vodouhê GF, Kyndt T, Codjia JTC.** 2011. Ethnic differences in use value and use patterns of the threatened multipurpose scrambling shrub (*Caesalpinia bonduc* L.) in Benin. Journal of Medicinal Plants Research **5**(9), 1549-1557.

**Assogbadjo AE, Glele Kakaï R, Vodouhê FG, Djagoun CAMS, Codjia JTC, Sinsin B.** 2012. Biodiversity and socioeconomic factors supporting farmers' choice of wild edible trees in the agroforestry systems of Benin (West Africa). Forest Policy and Economics **14**(1), 41-49.

**Assogbadjo AE, Kyndt T, Chadare FJ, Sinsin B, Gheysen G, Eyog-Matig O, Van Damme P.** 2009. Genetic fingerprinting using AFLP cannot distinguish traditionally classified baobab morphotypes. Agroforestry Systems **75**, 157-165.

**Avakoudjo HGG, Hounkpèvi A, Idohou R, Koné MW, Assogbadjo AE.** 2020. Local knowledge, uses, and factors determining the use of *Strychnos spinosa* organs in Benin (West Africa). Economic Botany **74**, 15-31.

**Bhagawan WS, Ekasari W, Agil M.** 2023. Ethnopharmacology of medicinal plants used by the Tenggerese community in Bromo Tengger Semeru National Park, Indonesia. Biodiversitas Journal of Biological Diversity **24**(10), 5464-5477.

**Ceballos G, Ehrlich PR, Dirzo R.** 2017. Biological annihilation via the ongoing sixth mass extinction signaled by vertebrate population losses and declines. Proceedings of the national academy of sciences **114**(30), 6089-6096.

**Crossay E, Jullian V, Trinel M, Sagnat D, Hamel D, Groppi E, Fabre N.** 2023. Daphnanes diterpenes from the latex of Hura crepitans L. and their PKCζ-dependent anti-proliferative activity on colorectal cancer cells. Bioorganic & Medicinal Chemistry **90**, 117366

**Dafni A.** 2006. On the typology and the worship status of sacred trees with a special reference to the Middle East. Journal of Ethnobiology and Ethnomedicine **2**, 1-14.

**Dagnelie P.** 2000. La planification des expériences: choix des traitements et dispositif expérimental. Journal de la Société française de statistique **141**(1-2), 5-29.

**Díaz S, Settele J, Brondízio ES, Ngo HT, Agard J, Arneth A, Zayas CN.** 2019. Pervasive human-driven decline of life on Earth points to the need for transformative change. Science **366**(6471).

**Dossou-Yovo HO, Kindomihou V, Sinsin B.** 2020. Ethnobotanical research of tree species used in wood carving in Southern Benin: Perspective for sustainable forest conservation. Ethnobotany Research and Applications **20**, 1-10.

**Dossou-Yovo HO, Vodouhè FG, Kaplan A, Sinsin B.** 2022. Application of ethnobotanical indices in the utilization of five medicinal herbaceous plant species in Benin, West Africa. Diversity **14(8)**, 612.

**Dougnon G, Dougnon VT, Klotoé JR, Agbodjento E, Zoumarou D, Lègba B, Ladékan EY.** 2023. Local knowledge, practices, challenges of ethnopharmacologically used medicinal plants in Benin and implications for brain illnesses. Scientific Reports **13(1)**, 19743.

**Fandohan AB, Gouwakinnou GN, Tovissode CF, Bonou A, Djonlonkou SFB, Houndelo LF, Assogbadjo AE.** 2017. Usages traditionnels et valeur économique de *Synsepalum dulcificum* au Sud-Bénin. Bois & Forêts des Tropiques **332**, 17-30.

**Fandohan B, Assogbadjo AE, Kakaï RG, Kyndt T, Caluwé ED, Codjia JTC, Sinsin B.** 2010. Women's traditional knowledge, use value, and the contribution of tamarind (*Tamarindus indica* L.) to rural households' cash income in Benin. Economic botany **64**, 248-259.

**Favi GA, Dassou GH, Djidohokpin D, Ouachinou JMAS, Kpétikou CG, Gbedolo E, Adomou AC.** 2022. The resource availability hypothesis (RAH) and cross-cultural patterns: which one explains West African *Cochlospermum* species' uses in Benin? Journal of Ethnobiology and Ethnomedicine **18**(1), 56.

**Gaoue OG, Coe MA, Bond M, Hart G, Seyler BC, McMillen H.** 2017. Theories and major hypotheses in ethnobotany. Economic Botany **71**, 269-287.

**Gbesso GHF, Gbesso FK, Adoukonou RCF, Akabassi GC, Padonou EA, Tente ABH.** 2021. Traditional knowledge and uses of *Argemone mexicana* L. (Papaveraceae) in southern Benin. Ethnobotany Research and Applications **21**, 1-11.

**Hadonou-Yovo AG, Houessou LG, Lougbegnon TO, Adebi Y, Sinasson GKS, Semevo DF, Boko M.** 2019. Diversité et formes d'utilisation des espèces ligneuses de la Réserve de biosphère du Mono (Bénin). VertigO-la revue électronique en sciences de l'environnement **19**(2).

**Heinrich M, Jalil B, Abdel-Tawab M, Echeverria J, Kulic Z, McGaw LJ, Wang JB.** 2022. Reporting guidelines for medicinal plant extracts used in pharmacological and toxicological research: ConPhyMP. British Journal of Pharmacy **7**(2).

**Houehanou TD, Assogbadjo AE, Kakaï RG, Houinato M, Sinsin B.** 2011. Valuation of local preferred uses and traditional ecological knowledge in relation to three multipurpose tree species in Benin (West Africa). Forest Policy and Economics **13**(7), 554-562.

**Keikelame MJ, Swartz L.** 2015. 'A thing full of stories': Traditional healers' explanations of epilepsy and perspectives on collaboration with biomedical health care in Cape Town. Transcultural psychiatry **52**(5), 659-680.

**Kurnianto AS, Septiadi L, Firmansyah P, Dewi N.** 2022. Communities and tree-species preferences of birds in traditional agroforestry system in Meru Betiri National Park. Berkala Penelitian Hayati **27**(2), 83-90.

**Lykke AM, Kristensen MK, Ganaba S.** 2004. Valuation of local use and dynamics of 56 woody species in the Sahel. Biodiversity & Conservation **13**, 1961-1990.

**Martin JF, Roy ED, Diemont SA, Ferguson BG.** 2010. Traditional Ecological Knowledge (TEK): Ideas, inspiration, and designs for ecological engineering. Ecological Engineering **36**(7), 839-849.

**Masango CA.** 2020. Indigenous knowledge codification of African traditional medicine: Inhibited by status quo based on secrecy? Information Development **36**(3), 327-338.

**Maxwell SL, Fuller RA, Brooks TM, Watson JE.** 2016. Biodiversity: The ravages of guns, nets and bulldozers. Nature **536**(7615), 143-145.

**Montcho PS.** 2016. Production et caractérisation du biodiesel éthylique à partir de l'huile végétale non conventionnelle de *Hura crepitans* du Bénin. (Diplôme d'Études Approfondies en Chimie et Applications (DEA-CA)). Université d'Abomey-Calavi, Laboratoire d'Etude et de Recherche en Chimie Appliquée (LERCA). (88_2016/EDSEA/FDCA/UAC)

**Nair PR, Kumar BM, Nair VD.** 2021. An introduction to agroforestry: four decades of scientific developments (pp. 3-20). Cham: Springer.

**Oraegbunam JC, Oladipo B, Falowo OA, Betiku E.** 2020. Clean sandbox (*Hura crepitans*) oil methyl esters synthesis: A kinetic and thermodynamic study through pH monitoring approach. Renewable energy **160**, 526-537.

**Ouédraogo P, Bationo BA, Sanou J, Traoré S, Barry S, Dayamba SD, Thiombiano A.** 2017. Uses and vulnerability of ligneous species exploited by local population of northern Burkina Faso in their adaptation strategies to changing environments. Agriculture & Food Security **6**, 1-16.

**Owojuyigbe OS, Firempong CK, Larbie C, Komlaga G, Emikpe BO.** 2020. Hepatoprotective potential of *Hura crepitans* L.: A review of ethnomedical, phytochemical and pharmacological studies. Journal of Complementary and Alternative Medical Research **9(2)**, 1-10.

**Owojuyigbe OS, Firempong CK, Larbie C, Komlaga G, Emikpe BO.** 2020. Hepatoprotective potential of *Hura crepitans* L.: A review of ethnomedical, phytochemical and pharmacological studies. Journal of Complementary and Alternative Medical Research **9**(2), 1-10.

**Quiroz D, Sosef M, Van Andel T.** 2016. Why ritual plant use has ethnopharmacological relevance. Journal of ethnopharmacology **188**, 48-56.

**Rahman SU, Ullah Z, Ali A, Aziz MA, Alam N, Sher H, Ali I.** 2022. Traditional knowledge of medicinal flora among tribal communities of Buner Pakistan. Phytomedicine Plus **2**(3), 100277.

**Reyes-García V, Broesch J, Calvet-Mir L, Fuentes-Peláez N, McDade TW, Parsa S, TAPS Bolivian Study Team.** 2009. Cultural transmission of ethnobotanical knowledge and skills: an empirical analysis from an Amerindian society. Evolution and human behavior **30(4)**, 274-285.

**Salako KV, Moreira F, Gbedomon RC, Tovissodé F, Assogbadjo AE, Glèlè Kakaï RL.** 2018. Traditional knowledge and cultural importance of *Borassus aethiopum* Mart. in Benin: interacting effects of socio-demographic attributes and multi-scale abundance. Journal of ethnobiology and ethnomedicine **14**, 1-16.

**Salako VK, Kégbé AM, Chadare FJ, Kafoutchoni KM, Amagnidé A, Gbedomon RC, Glèlè Kakaï R.** 2019. Potential for domestication of *Borassus aethiopum* Mart., a wild multipurpose palm species in Sub-Saharan Africa. Genetic Resources and Crop Evolution **66**, 1129-1144.

**Sandalayuk D, Ruruh A, Suma ZNY.** 2023. Ethnopharmacology Potentials of Mangrove Bulalo, North Gorontalo. Jurnal Penelitian Pendidikan IPA, **9**(11), 10349-10355.

**Segnon AC, Achigan-Dako EG.** 2014. Comparative analysis of diversity and utilization of edible plants in arid and semi-arid areas in Benin. Journal of Ethnobiology and Ethnomedicine **10**, 1-20.

**Sidohounde A, Nonviho G, Bothon FTD, Montcho PS, Dossa CPA, Tchiakpe L, Sohounhloue DCK.** 2019. Biodiesel synthesis by ethanolysis of *Hura crepitans* seed oil unfit for consumption in Benin. American Journal of Physical Chemistry **8**(3), 50-57.

**Siraj J.** 2022. Medicinals plants. Ethnobotany.

**Tine Y, Diop A, Diatta W, Desjobert JM, Boye CSB, Costa J, Paolini J.** 2017. Chemical diversity and antimicrobial activity of volatile compounds from *Zanthoxylum zanthoxyloides* Lam. according to compound classes, plant organs and Senegalese sample locations. Chemistry & Biodiversity **14**(1).

**Treasure IO, Adjene JO, Odigie MO.** 2020. Ethnobotanical survey of medicinal plants in Ughelli North Local Government Area of Delta State. Journal of Medicine: Study and Research **3**(14), 1-9.

**Van Andel TR, van't Klooster CI, Quiroz D, Towns AM, Ruysschaert S, van den Berg M.** 2014. Local plant names reveal that enslaved Africans recognized substantial parts of the New World flora. Proceedings of the National Academy of Sciences **111**(50), 5346-5353.

**Zizka A, Thiombiano A, Dressler S, Nacoulma BM, Ouédraogo A, Ouédraogo I, Schmidt M.** 2015. Traditional plant use in Burkina Faso (West Africa): A national-scale analysis with focus on traditional medicine. Journal of Ethnobiology and Ethnomedicine **11**, 1-10.