



ETHNOBOTANICAL STUDY AND PHYTOCHEMICAL SCREENING OF UTEROTONIC MEDICINAL PLANTS USED IN SOUTHERN BENIN

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ABSTRACT

Maternal mortality remains high in sub-Saharan Africa, where uterotonic plants are an essential therapeutic resource. This study aimed to inventory species with uterotonic potential used in southern Benin and validate their activity through qualitative phytochemical screening. An ethnobotanical survey was conducted among 608 informants across seven departments and 15 sociolinguistic groups, followed by phytochemical analysis of the nine most cited species. Data were analyzed using descriptive statistics, PCoA, PERMANOVA, Mantel, and Procrustes. The survey recorded 107 species from 54 families, dominated by Fabaceae (13.08%), Malvaceae (10.28%), and Lauraceae (6.54%), with herbaceous plants (42.05%) and leaves (54.39%) being the most used, and decoction (45.39%) the main preparation method. *Petiveria alliacea* stood out with the highest frequency of mention (44.56%) and consensus index (0.754). Phytochemical screening revealed tannins, alkaloids, flavonoids, mucilages, reducing compounds, and C-heterosides, with *P. alliacea* being among species presenting all four major metabolites. PCoA revealed knowledge structuring by ethnolinguistic groups (94.6% variance explained), with a remarkable correlation for *P. alliacea* ($r = -0.990$; $p < 0.001$), confirmed by strong concordance between ethnobotanical and phytochemical profiles in Procrustes analysis ($r = 0.906$; $p = 0.001$). Integrating ethnobotanical surveys, multivariate analyses, and phytochemical validation confirms the scientific value of traditional knowledge and contributes to the valorization of local plant resources for improving maternal health in sub-Saharan Africa.

Keywords: Ethnobotany, Uterotonic plants, Phytochemical screening, *Petiveria alliacea*

1 INTRODUCTION

For centuries, human societies have used plants to relieve pain, treat illnesses, and support crucial stages of life. This empirical knowledge, passed down from generation to generation, constitutes a valuable intangible cultural heritage [1]. Plants, natural resources of proximity, play an essential role not only for human health but also for the conservation of biodiversity [2]. In addition to cultivated species, several thousand little-known wild plants are of major sociocultural and socioeconomic importance and possess nutritional and therapeutic properties [3,4]. The effectiveness of herbal medicine is now widely recognized, and its benefits have enabled natural medicine to become a permanent part of everyday practices, even in the most developed countries [5]. In Africa, the traditional pharmacopoeia remains central, due to economic constraints and limited access to modern medicines [6]. In Benin, of the approximately 2,807 species inventoried in forest ecosystems, several hundred to about 1,000 are considered to have medicinal or cultural uses [4].

Maternal health is a particularly telling example of this dependence on plant-based resources. Each year, nearly 260,000 women die as a result of pregnancy or childbirth, the majority of them in sub-Saharan Africa, where the risk of maternal mortality remains high, with hemorrhage and hypertensive disorders being the leading direct obstetric causes [7,8]. While motherhood is often a positive experience, for many it remains synonymous with suffering and mortality [9]. In this context, uterotonic herbs play a central role: they are used to induce or speed up labor, reduce the risk of postpartum hemorrhage, and facilitate the expulsion of the placenta [10,11]. The importance of these plants in traditional medicine is supported by several studies. A recent systematic review examined 3,659 studies on the use of medicinal plants by pregnant women in Africa [12]. Other studies have specifically inventoried the species used to facilitate childbirth, listing 57 species in Cameroon [13], 208 species in sub-Saharan Africa [14], and 112 species in the Democratic Republic of Congo [15].

However, despite the abundance of ethnobotanical and pharmacological research carried out in various African countries, scientific data on uterotonic plants in Benin, and particularly in the south of the country, remain fragmentary and insufficiently documented. This gap limits the valorization of traditional knowledge and the implementation of appropriate public health strategies. Furthermore, most existing studies focus on general inventories of medicinal flora, without in-depth analyses of species specifically used for maternal health. Furthermore, advances in modern phytochemistry have confirmed that plants share a common biological heritage with animals, which highlights their fundamental role in human survival and well-being [1]. Although about 370,000 species of vascular plants have been described worldwide, only a small fraction has been systematically evaluated pharmacologically in relation to their traditional uses [11]. The documented therapeutic efficacy of numerous plant species has spurred extensive research into their bioactive constituents and mechanisms of action [16]. However, in developing countries, and particularly in Africa, this knowledge is often limited to empirical observations, which are rarely validated by integrated experimental approaches [17,18].

Thus, in response to the growing demand for new therapeutic compounds and the urgent need to reduce maternal mortality, the scientific valorization of natural resources has become a strategic priority for research and the pharmaceutical industry, which are intensifying the systematic screening of medicinal plants [19]. The present study is part of this dynamic by combining an ethnobotanical survey on uterotonic medicinal plants among the populations of southern Benin and a qualitative phytochemical screening of the most cited species. This integrated approach aims to link traditional knowledge with experimental evidence, paving the way for sustainable pharmaceutical valorization of local plant resources and improved health safety for pregnant women.

2 MATERIALS AND METHODS

2.1 Geographical context and scope of the study

Southern Benin was chosen as the study area because of its rich flora and exceptional ethnocultural diversity. This region, which lies between latitudes 6°22'N and 7°38'N and longitudes 1°22'E and 3°3'E, covers an area of approximately 20,000 km². It encompasses a mosaic of ecosystems (forests, savannahs and wetlands) that support a diverse medicinal flora, including numerous species with uterotonic potential. The climate is sub-equatorial, characterised by an average annual rainfall of 900–1,500 mm [20], a mean temperature of 26.5 °C and a relative humidity of 75% [21]. The vegetation consists of a mosaic of woodland and savannah on a variety of soil types [20,22]. Furthermore, the coexistence of 15 distinct sociolinguistic groups (Adja, Aizo, Cotafo, Fon, Goun, Holly, Mahi, Mina, Nago, Ouémin, Pédah, Sahoué, Tori, Watchi and Xwlà) provides an insight into the diversity of traditional knowledge and therapeutic practices relating to maternal health. The geographical accessibility of the survey sites and the high prevalence of maternal mortality in this region [23] also justify the choice of this study area. The selection of 30 sites spread across seven departments (Mono, Couffo, Atlantique, Littoral, Ouémé, Plateau and Zou) was carried out in a systematic manner to ensure optimal representation of sociolinguistic groups and to guarantee an exhaustive inventory of floristic diversity (Figure 1).

The phytochemical studies were performed at Laboratoire de Génétique, Biotechnologies et Botanique Appliquées (GeBBA) of ENSBBA/UNSTIM.

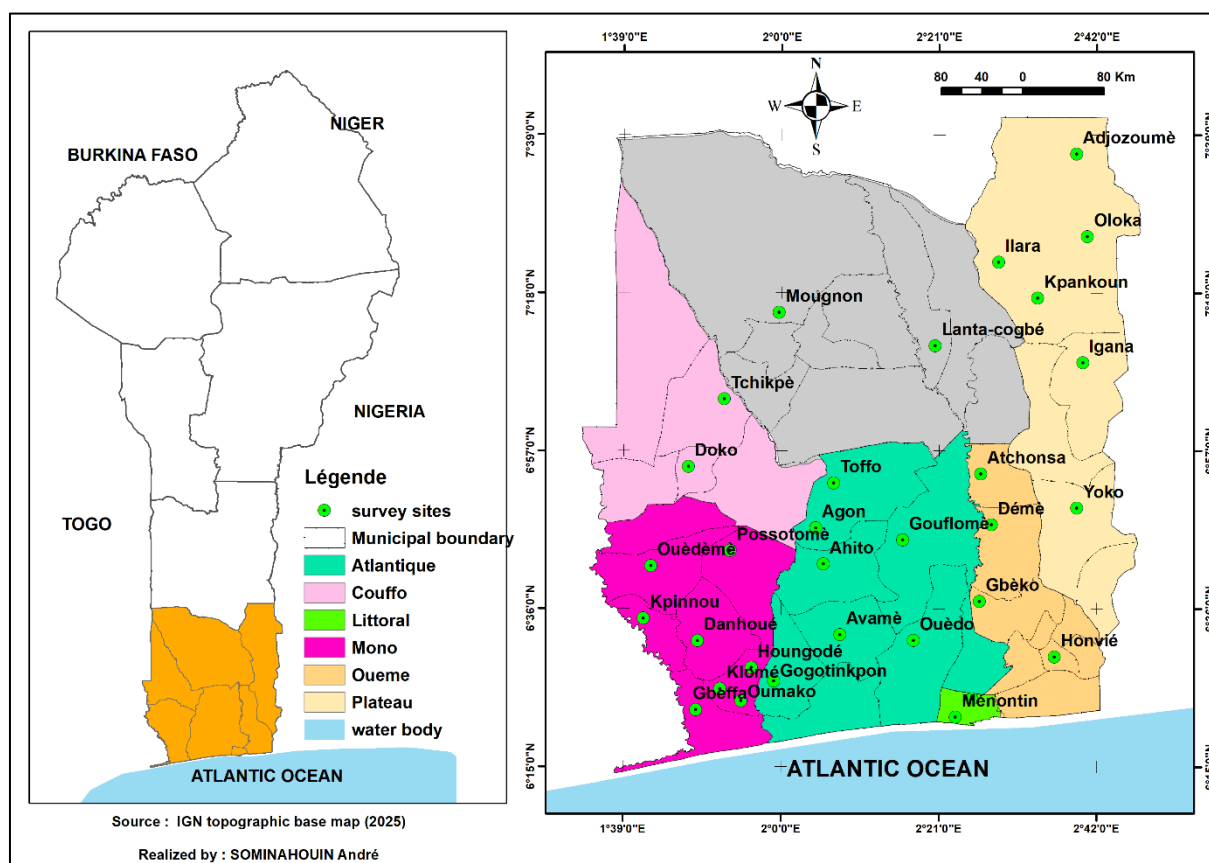


Figure 1: Map of southern Benin showing the geographical location of the villages prospected

2.2 Study population and socio-demographic characteristics

The target population consisted of residents of the six departments of southern Benin. The inclusion of various sociolinguistic groups enables a broad range of traditional knowledge to be covered, reducing the risk of cultural bias and ensuring that ethnopharmacological practices are represented.

A preliminary survey conducted in all the municipalities of the departments in southern Benin was used to determine the sample size using a probabilistic method. This involves selecting a sample from the target population based on their knowledge about uterotonic plants, using Dagnelie's formula [24]:

$$n = \frac{\mu^2 p(1 - P)}{d^2}$$

In formula 1, **n** is the sample size, **μ** is the mean of the normal distribution at a 5 per cent confidence level (**μ = 1.96**), and **d** is the permitted margin of sampling error. The margin of error chosen in our case is 8 per cent, or 0.08, and **p** is the percentage of people who exhibit the observed trait.

Informants were included on the basis of the following criteria: having knowledge of uterotonic medicinal plants, whether they were traditional practitioners, traditional midwives, healers, herbalists or simply knowledgeable users, and living within the study area. Individuals who refused to take part in the survey or who had no knowledge of uterotonic plants were excluded. Free and informed consent was obtained from each participant prior to the interview. A total of 608 people completed the questionnaire, ensuring sufficient statistical power for the analysis of the ethnobotanical data and guaranteeing the reliability of the estimates.

The variables studied included: the socio-demographic characteristics of the respondents; their knowledge of uterotonic plants; ethnobotanical characteristics (vernacular name, nature, status, habitats, perceived abundance, parts collected); and ethnopharmacological characteristics (forms of use, method of preparation, period of use, method of

administration, and diseases and symptoms treated). This multidimensional approach allows cultural, biological and therapeutic aspects to be integrated into the analysis.

The semi-structured interviews were conducted in local languages, with or without the assistance of locally recruited interpreters, in order to ensure the reliability of the data collected and to respect cultural contexts. The systematic herbarium documentation of the samples ensures rigorous taxonomic validation and scientific traceability.

2.3 Methodology for qualitative phytochemical screening

The plant material used for the phytochemical analysis comprises nine species with uterotonic potential identified during ethnobotanical surveys (Table 1). These are *Carica papaya*; *Petiveria alliacea*; *Sida acuta*; *Rourea coccinea*; *Cassytha filiformis*; *Corchorus aestuans*; *Moringa oleifera*; *Hybanthus enneaspermus*; and *Rhodognaphalon brevisuspe*.

Drying at room temperature (22 °C) for 14 days was chosen in order to preserve the integrity of heat-sensitive secondary metabolites. Standardised mechanical grinding and sieving ensure the homogeneity of the powders, which is essential for the reproducibility of phytochemical tests. Storage in airtight vials protects the samples from moisture and oxidation, ensuring the stability of the bioactive compounds.

Qualitative phytochemical screening was performed to identify the main bioactive groups with uterotonic potential (alkaloids, flavonoids, saponins, tannins). The use of colourimetric and precipitation reactions, in accordance with validated methods [25,26], ensures the reliability of the results and their comparability with previous studies.

2.4 Data processing and statistical analysis

The data were entered and organised in Excel 2016. Statistical analyses and the creation of graphs were carried out using R 4.6.1. The species selected for phytochemical screening were chosen on the basis of ethnobotanical evidence, thereby linking cultural relevance to scientific validation.

The frequency of mention (FC) reflects how often a species is mentioned by respondents. A high value indicates widespread use and suggests that the species is of practical importance in traditional medicine.

$$FC = \frac{CP}{CT} \times 100 \quad (\text{Formula 2})$$

In formula 2, CP represents the number of times a given species is mentioned by all respondents, whilst CT represents the total number of mentions of all species.

The Informants Consensus Index (ICF) measures the degree of agreement among informants. A high consensus reflects shared knowledge and increased reliability of reported uses, which justifies the selection of these species for scientific validation.

$$ICF = \frac{IP}{IT} \quad (\text{Formula 3})$$

In Formula 3, IP is the number of informants who mentioned a species, while IT is the total number of informants. The ICF ranges from [0 to 1]. A low value, close to 0, indicates that the informants disagree on the proposed uses. When this value is close to 1, it indicates a high level of agreement regarding the use of the plant.

The use value (UV) is used to estimate the relative importance of species within communities. Species with a high UV are considered a priority for screening, as they combine cultural significance with therapeutic potential.

$$UV = \sum_{i=1}^n U_i / n \quad (\text{Formula 4})$$

In formula 3, U_i is the number of uses mentioned by set i of a given sociolinguistic group and n is the total number of informants surveyed without distinction of sociolinguistic group.

A principal coordinate analysis (PCoA) based on the Bray-Curtis distance was carried out on the citation frequencies of the nine species selected for phytochemical screening, in order to visualise the inter-ethnic structure of traditional knowledge. Species-axis correlations were calculated to identify discriminating species. A PERMANOVA test (999 permutations) compared the usage patterns of the identified ethnic groups.

A Mantel test (999 permutations) assessed the correlation between the ethnobotanical (Bray-Curtis) and phytochemical (Jaccard) distance matrices.

3 RESULTS

3.1 Sociodemographic characteristics of the respondents

The majority of respondents were female (60.52 %), compared with 39.47 % who were male, giving a female-to-male ratio of 1.53 (Figure 2A).

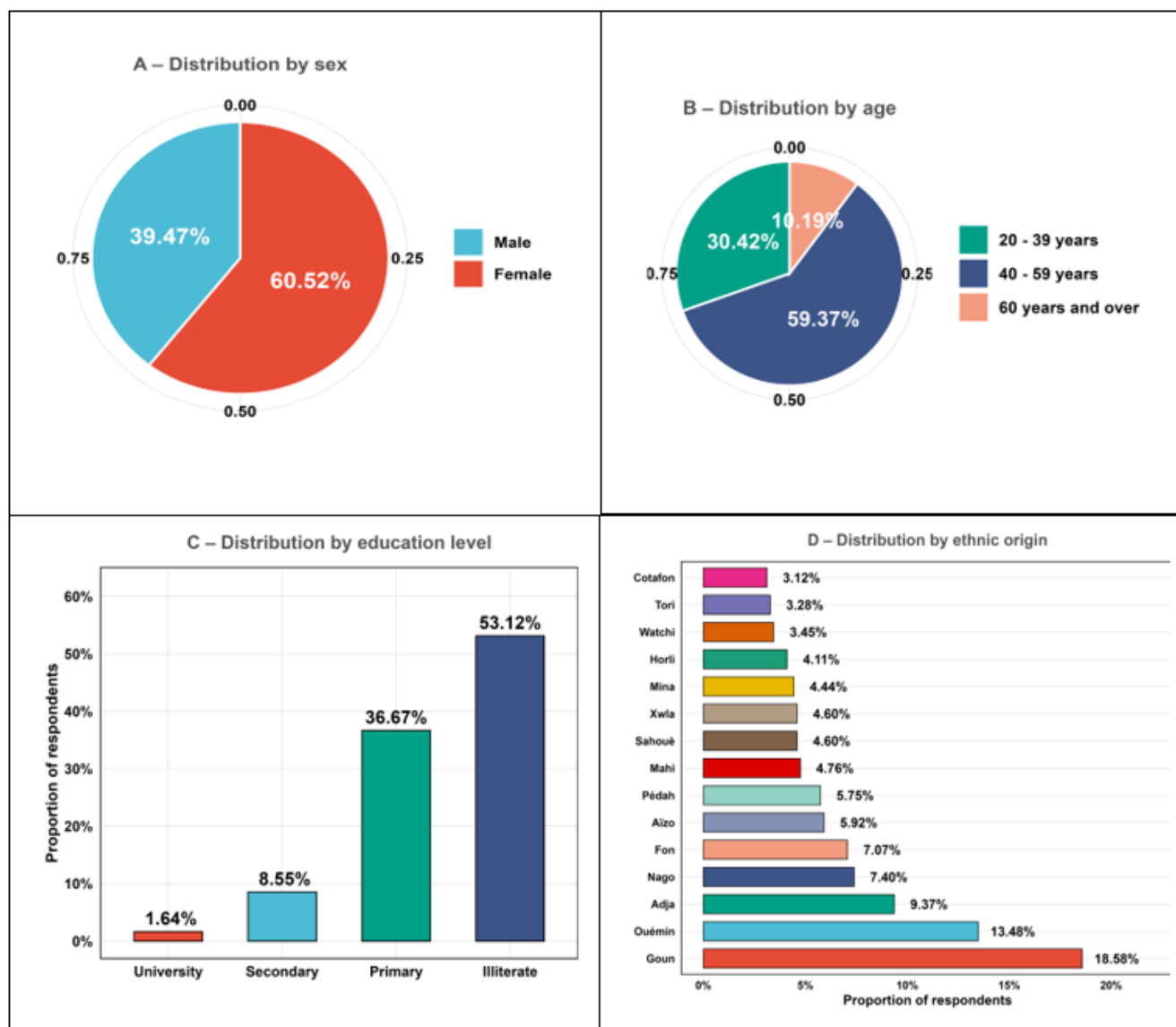


Figure 2: Sociodemographic characteristics of informants (N = 608)

The informants' ages ranged from 20 to 80, with an average of 44. The majority (59.37 %) were in the 40 - 59 age group, whilst those aged over 60 accounted for 10.19 % (Figure 2B).

The majority of users of uterotonic plants were illiterate (53.12 %). Those with a primary school education accounted for 36.67 %, those with a secondary school education for 8.55 %, and those with a university education for 1.64 % (Figure 2C).

The distribution of respondents by ethnic group showed a predominance of Goun (18.58 %) and Ouémins (13.48 %). They were followed by Adja (9.37%), Nagos (7.40%), Fons (7.07%), Aizo (5.92%) and Pédah (5.75%). The other groups (Tori, Cotafon, Xwla, Mina, Sahoué, Watchi, Horlli, Mahi) each accounted for less than 5% (Figure 2D).

3.2 Diversity and ethnobotanical characteristics of uterotonic plants

Based on the ethnobotanical records from the surveys, an inventory of the species and their characteristics was compiled (Table 1).

A total of 107 species with uterotonic potential, comprising 95 genera and belonging to 54 botanical families, were recorded. The most well-represented families were Fabaceae (14 species, 13.08 %), Malvaceae (11 species, 10.28 %) and Lauraceae (7 species, 6.54 %). Annonaceae, Poaceae, Euphorbiaceae, Cucurbitaceae, Burseraceae and Asteraceae each contained three (03) species. The remaining 45 families were represented by one (01) or two (02) species (Figure 3F).

The most frequently cited species were *Petiveria alliacea* (44.56 %), *Hybanthus enneanspermus* (11.35 %), *Newbouldia laevis* (5.04 %), *Carica papaya* (3.59 %), *Rourea coccinea* (2.13 %), *Corchorus aestuans* (2.13 %), *Sida acuta* (1.55 %), *Moringa oleifera* (1.45 %), *Cassytha filiformis* (1.35 %), *Rhodognaphalon brevicuspe* (1.35 %), *Elaeis guineensis* (1.16 %), *Adenia lobata* (1.16 %) and *Sesamum radiatum* (1.06 %). The other species had frequencies of less than 1 per cent (Table 1).

The highest ICF values were recorded for *Petiveria alliacea* (0.754) and *Hybanthus enneanspermus* (0.192). The other species had ICF values below 0.192 (Table 1).

Herbs account for 42.05 % of the species, followed by trees (30.84 %), shrubs (15.88 %) and vines (11.21 %) (Figure 3A). The most commonly used parts are leaves (54.39 %), followed by the whole plant (21.02 %), roots (11.59 %) and seeds (6.80 %). Other parts (bark, fruits, flowers) account for less than 4 % (Figure 3B).

Plants are used in fresh or dry form (54.46%), with a predominance of the fresh form (44.34%) (Figure 3C). The most common preparation methods are decoction (45.39%) and trituration (29.12%), followed by infusion (18.77%) and powder (3.13%) (Figure 3D). The other modes (chewing, maceration, crushing) represent less than 2%.

The oral route is the most used (85.81%), followed by personal hygiene (11.60%), bath (2.49%) and massage (0.08%) (Figure 3E).

Table 1: Diversity and ethnobotanical characteristics of uterotonic plants recorded in the study area in southern Benin

SCIENTIFIC NAMES	BOTANICAL FAMILIES	M	FC	ICF	OU	FU	MU	MA
<i>Abelmoschus esculentus</i>	Malvaceae	Herb	0.77%	0.013	Leaves, Seed, Fruit, flowers	Dried	Herbal tea,Sauce, Trituration	Oral and toilet
<i>Abrus precatorius</i>	Fabaceae	Vine	0.19%	0.003	Leaves	Dried/Fresh	Decoction	Oral
<i>Adansonia digitata</i>	Malvaceae	Tree	0.09%	0.001	Leaves	Fresh	Pounding	bath
<i>Adenia lobata</i>	Passifloraceae	Vine	1.16%	0.019	Root	Fresh	trituration, Maceration	oral
<i>Aframomum melegueta</i>	Zingiberaceae	Herb	0.87%	0.014	Seed	Dried	infusion	Oral
<i>Allium porrum</i>	Alliaceae	Herb	0.09%	0.001	Leaves	Fresh	Trituration	Oral and toilet
<i>Anogeissus leiocarpus</i>	Combretaceae	Tree	0.09%	0.001	leafy stem	Fresh	Decoction	Oral
<i>Argemone mexicana</i>	Papaveraceae	Herb	0.09%	0.001	Leaves	Fresh	Decoction	Oral
<i>Asystasia gangetica</i>	Acanthaceae	Herb	0.19%	0.003	Leaves	Fresh	Decoction	Oral
<i>Avicennia germinans</i>	Verbanaceae	Tree	0.09%	0.001	Leaves	Dried/Fresh	Trituration	Personal toilet
<i>Banisteriopsis caapi</i>	Malpighiaceae	Vine	0.09%	0.001	Leaves	Fresh	Pounding	Oral
<i>Blighia sapida</i>	Sapindaceae	Tree	0.29%	0.004	Leaves	Fresh	Decoction	Oral
<i>Bombax brevisuspe</i>	Bombacaceae	Tree	0.97%	0.016	Whole plant	Fresh	Decoction	Oral
<i>Bursera simaruba</i>	Burceraceae	Tree	0.87%	0.014	Bark, seeds	Fresh	Pounding	Bath
<i>Cajanus cajan</i>	Fabaceae	Shrubs	0.29%	0.004	Leaves	Fresh	Trituration	Oral
<i>Calotropis procera</i>	Apocynaceae	Shrubs	0.09%	0.001	Leaves	Dried	Trituration	Oral
<i>Capsicum annuum</i>	Solanaceae	Shrubs	0.09%	0.001	Leaves	Fresh	Decoction	bath
<i>Carica papaya</i>	Caricaceae	Tree	3.59%	0.06	Leaves, roots	Fresh	Fresh, Herbal tea,Chewing	Oral
<i>Cassia alata</i>	Fabaceae	Shrub	0.19%	0.003	Leaves	Fresh	Decoction	oral
<i>Cassytha filiformis</i>	Lauraceae	Vine	1.35%	0.023	Whole plant	Dried/ Fresh	Trituration, Herbal tea	Oral
<i>Cerathoteca sesamoides</i>	Pedaliaceae	Herb	0.48%	0.008	Leaves	Dried/Fresh	Decoction, Herbal tea, Trituration	Personal Toilet, Oral
<i>Cissampelos owariensis</i>	Menispermaceae	Vine	0.48%	0.008	Leaves	Fresh	Trituration, Decoction	oral
<i>Cissus petiolata</i>	Vitaceae	Vine	0.09%	0.001	Leaves	Dried/Fresh	Decoction	Oral

<i>Citrus limon</i>	Rutaceae	Shrub	0.38%	0.006	Leaves, roots	Fresh	Maceration,Trituration	Oral
<i>Citrus sinensis</i>	Rutaceae	Shrub	0.09%	0.001	Leaves	Dried	Decoction	Oral
<i>Cleistopholis patens</i>	Annonaceae	Tree	0.19%	0.003	Leaves	Dried	Decoction	Oral
<i>Cleome viscosa</i>	Capparaceae	Herb	0.48%	0.008	Leaves	Dried /Fresh	Trituration	Oral
<i>Cocos nucifera</i>	Arecaceae	Tree	0.09%	0.001	Fruit	Fresh	Chewing	Oral
<i>Cola acuminata</i>	Malvaceae	Tree	0.09%	0.001	Leaves, fruit	Fresh	Charring	Oral
<i>Cola millenii</i>	Malvaceae	Tree	0.19%	0.003	Leaves	Dried/Fresh	Decoction	oral
<i>Combretum micranthum</i>	Combretaceae	Shrub	0.48%	0.008	Leaves	Dried/ Fresh	Decoction	Oral
<i>Commelina erecta</i>	Commelinaceae	Herb	0.09%	0.001	Leaves	Fresh	Trituration	Oral
<i>Commiphora africana</i>	Burceraceae	Shrub	0.19%	0.003	Leaves	Dried	Trituration	Oral
<i>Corchorus aestuans</i>	Malvaceae	Herb	2.13%	0.034	Leaves	Dried	Trituration	oral
<i>Corchorus olitorius</i>	Malvaceae	Herb	0.58%	0.009	Leaves, Whole plant	Fresh	Sauce	Oral
<i>Costus afer</i>	Costaceae	Herb	0.09%	0.001	Leaves	Fresh	Decoction	oral
<i>Crateva adansonii</i>	Capparaceae	Tree	0.09%	0.001	Whole plant	Fresh	Decoction	oral
<i>Cucumeropsis mannii</i>	Cucurbitaceae	Herb	0.09%	0.001	Seeds	Fresh	Charring	massage
<i>Dacryodes edulis</i>	Burceraceae	Tree	0.09%	0.001	Leaves	Fresh	Trituration	Oral
<i>Desmodium ramosissimum</i>	Fabaceae	Herb	0.19%	0.003	Leaves	Fresh	Decoction	oral
<i>Dialium guineense</i>	Fabaceae	Shrub	0.09%	0.001	Leaves	Fresh	Decoction	oral
<i>Dracaena arborea</i>	Asparagaceae	Tree	0.29%	0.004	Leaves, Root	Dried/ Fresh	Trituration	Personal toilet
<i>Eichhornia crassipes</i>	Pontederiaceae	Herb	0.09%	0.001	Leaves, Bark	Fresh	Decoction	Personal toilet
<i>Elaeis guineensis</i>	Arecaceae	Tree	1.16%	0.019	Leaves, Root, Seeds	Fresh	Decoction	Oral
<i>Erythrina senegalensis</i>	Fabaceae	Tree	0.29%	0.004	Leaves	Fresh	Decoction	Oral
<i>Euphorbia nivulia</i>	Euphorbiaceae	Herb	0.09%	0.001	Leaves	Fresh	Decoction	Personal toilet
<i>Ficus exasperata</i>	Moraceae	Tree	0.09%	0.001	Leaves	Fresh	Decoction	oral
<i>Flueggea virosa</i>	Phyllanthaceae	Tree	0.19%	0.003	Whole plant	Fresh	Decoction, Parfume	Oral, bath

<i>Garcinia kola</i>	Clusiaceae	Tree	0.09%	0.001	fruits	Fresh	Chewing	oral
<i>Ginkgo biloba</i>	Ginkgoaceae	Tree	0.09%	0.001	Leaves	Fresh	Decoction	Personal toilet
<i>Gliricidia sepium</i>	Fabaceae	Tree	0.38%	0.006	Whole plant	Fresh	Trituration	Oral
<i>Haematoxylum campechianum</i>	Fabaceae	Tree	0.09%	0.001	Leaves	Fresh	Decoction	Personal toilet
<i>Heliotropium indicum</i>	Boraginaceae	Herb	0.09%	0.001	Leaves	Dried/ Fresh	Trituration	Oral
<i>Hibiscus surattensis</i>	Malvaceae	Vine	0.19%	0.003	Whole plant	Fresh	Decoction	Oral
<i>Hybanthus enneanspermus</i>	Violaceae	Herb	11.35%	0.192	Whole plant	Fresh	Trituration, Herbal tea	Oral
<i>Imperata cylindrica</i>	Poaceae	Herb	0.29%	0.004	Leaves	Fresh	Decoction	Oral
<i>Indigofera hirsuta</i>	Fabaceae	Shrub	0.19%	0.003	Whole plant	Fresh	Trituration, Decoction	Oral
<i>Jatropha curcas</i>	Euphorbiaceae	Shrub	0.48%	0.008	Leaves	Fresh	Decoction, Pounding	Oral, bath
<i>Kalanchoe crenata</i>	Crassulaceae	Herb	0.19%	0.003	Leaves, Bark	Dried/Fresh	Trituration	Oral
<i>Kalanchoe pinnata</i>	Crassulaceae	Herb	0.29%	0.004	Leaves	Fresh	Trituration	Oral
<i>Kigelia africana</i>	Bignoniaceae	Tree	0.19%	0.003	Leaves	Fresh	Decoction	Bath
<i>Launaea taraxacifolia</i>	Asteraceae	Herb	0.09%	0.001	Leaves	Fresh	Sauces	Oral
<i>Luffa cylindrica</i>	Cucurbitaceae	Herb	0.09%	0.001	Leaves	Fresh	Decoction	Personal toilet
<i>Mercuriale vivace</i>	Euphorbiaceae	Herb	0.19%	0.003	Leaves	Dried/ Fresh	Trituration, Infusion	Personal toilet, Oral
<i>Merremia tridentata</i>	Convolvulaceae	Herb	0.09%	0.001	Leaves	Fresh	Decoction	Oral
<i>Mimosa pudica</i>	Fabaceae	Herb	0.09%	0.001	Leaves	Fresh	Herbal tea, Decoction	Personal toilet, Oral
<i>Momordica charantia</i>	Cucurbitaceae	Vine	0.09%	0.001	Whole plant	Dried/Fresh	Trituration	Oral
<i>Moringa oleifera</i>	Moringaceae	Tree	1.45%	0.024	Leaves	Fresh	Decoction, Sauces	Oral
<i>Musa sinensis</i>	Musaceae	Herb	0.19%	0.003	Root	Dried	Charring	oral
<i>Musa spp</i>	Musaceae	Herb	0.19%	0.003	Root	Fresh	Chewing /Charring	Oral
<i>Newbouldia laevis</i>	Bignoniaceae	Tree	5.04%	0.085	Leaves	Fresh	Herbal tea, Decoction	Oral, Personal toilet
<i>Ocimum basilicum</i>	Lamiaceae	Herb	0.09%	0.001	Leaves	Fresh	Decoction	oral

<i>Ocimum canum</i>	Lamiaceae	Herb	0.09%	0.001	Leaves	Fresh	Decoction	Oral
<i>Ocimum gratissimum</i>	Lamiaceae	Herb	0.29%	0.004	Leaves	Dried/ Fresh	Decoction, Trituration	oral
<i>Paspalum vaginatum</i>	Poaceae	Herb	0.09%	0.001	Leaves	Dried	Trituration	Oral
<i>Passifolia foetida</i>	Passifloraceae	Vine	0.09%	0.001	Leaves	Dried	Trituration	Oral
<i>Pavetta corymbosa</i>	Rubiaceae	Shrub	0.09%	0.001	Root	Dried /Fresh	Trituration; Maceration	oral
<i>Petiveria alliacea</i>	Phytolaccaceae	Shrub	44.56%	0.754	Whole plant, Leaves, Root	Dried /Fresh	Decoction, Infusion, Trituration, Powder	oral
<i>Phyllanthus amarus</i>	Phyllanthaceae	Herb	0.67%	0.011	Whole plant	Fresh	Decoction	Oral
<i>Phymatosorus scolopendria</i>	Polypodiaceae	Herb	0.19%	0.003	Leaves	Fresh	Decoction	Oral
<i>Piper nigrum</i>	Piperaceae	Vine	0.09%	0.001	Leaves	Fresh	Decoction, Sauce	Oral
<i>Pteridium aquilium</i>	Dennstaedtiaceae	Herb	0.19%	0.003	Leaves	Fresh	Decoction	Personal toilet
<i>Pterocarpus santalinoides</i>	Fabaceae	Tree	0.19%	0.003	Leaves	Dried/ Fresh	Trituration	oral
<i>Raphiostylis beninensis</i>	Metteniusaceae	Vine	0.19%	0.003	Whole plant	Fresh	Decoction	oral
<i>Rhizophora racemosa</i>	Rhizophoraceae	Shrub	0.09%	0.001	Leaves	Fresh	Decoction	Oral
<i>Rhodognaphalon brevisuspe</i>	Malvaceae	Tree	1.35%	0.023	Leaves	Dried/ Fresh	trituration	oral
<i>Rinorea dentata</i>	Violaceae	Shrub	0.19%	0.003	Leaves, fruits	Fresh	Trituration	Oral
<i>Rourea coccinea</i>	Connaraceae	Vine	2.13%	0.036	Whole plant	Fresh	Trituration, Decoction ,	oral
<i>Schrankia leptocarpa</i>	Fabaceae	Herb	0.19%	0.003	Whole plant	Fresh	Decoction	oral
<i>Schwenkia americana</i>	Solanaceae	Herb	0.29%	0.004	Leafy stem	Fresh	Maceration, Decoction	orale
<i>Selaginella lepidophylla</i>	Selaginellaceae	Herb	0.58%	0.009	Whole plant	Fresh	Maceration	Bath, toilet; oral
<i>Sesamum indicum</i>	Pedaliaceae	Herb	0.29%	0.004	Leafy stem	Fresh	Decoction	Oral
<i>Sesamum radiatum</i>	Pedaliaceae	Herb	1.06%	0.018	Whole plant	Dried/ Fresh	Trituration, Sauces, Decoction, Herbal tea	Oral
<i>Sida acuta</i>	Malvaceae	Herb	1.55%	0.026	Whole plant	Fresh	Decoction/ Trituration	Oral, Personal toilet
<i>Sida rhombifolia</i>	Malvaceae	Herb	0.19%	0.003	Whole plant	Dried/ Fresh	Herbal tea	Oral
<i>Spondias mombin</i>	Anacardiaceae	Tree	0.58%	0.009	Leaves	Dried /Fresh	Trituration Decoction	Oral

<i>Sterculia foetida</i>	Malvaceae	Tree	0.09%	0.001	Leaves	Dried	Trituration	Oral
<i>Talinum triangulare</i>	Portulacaceae	Herb	0.87%	0.014	Leaves	Dried /Fresh	Decoction, Trituration	Oral, Personal toilet
<i>Tektona grandis</i>	Lamiaceae	Tree	0.09%	0.001	Leaves	Fresh	Trituration	Oral
<i>Tetrapleura tetraptera</i>	Fabaceae	Tree	0.09%	0.001	fruits	Fresh	Decoction	Oral
<i>Uraria picta</i>	Fabaceae	Herb	0.29%	0.004	Whole plant	Fresh	Herbal tea, Pounding	Oral, Personal toilet
<i>Uvaria chamae</i>	Annonaceae	Shrub	0.09%	0.001	Root	Fresh	Charring	Oral
<i>Vernonia amygdalina</i>	Asteraceae	Shrub	0.09%	0.001	Leaves	Dried /Fresh	Trituration	Oral
<i>Vernonia cinerea</i>	Asteraceae	Herb	0.09%	0.001	Root	Fresh	Decoction	Personal toilet
<i>Vitex doniana</i>	Lamiaceae	Tree	0.09%	0.001	Leaves	Fresh	Sauces	Oral
<i>Xylopia aethiopica</i>	Annonaceae	Tree	0.29%	0.004	Flowers, Bark	Fresh	Pounding	Bath
<i>Zea mays</i>	Poaceae	Herb	0.19%	0.003	Ripe corn silk	Fresh	Decoction	Oral

Legend : Ouémin (O) ; Goun (G) ; Pédah (P) ; Aizo(Az) ; Tori (T) ; Fon(F) ; Cotafo(C) ; Xwlà (X) ; Mina (Mi) ; Sahoue (S) ; Watchi (W) ; Adja(Ad) ;Mahi (Ma) ; Nagos (N) ; Horli (H) ; Morphology (M) ; Frequency of mention (FC) ; Organs used (OU) ; Form of use (FU) ; Mode of use (MU) ; Mode of administration (MA) ; Informants Consensus Index (ICF)

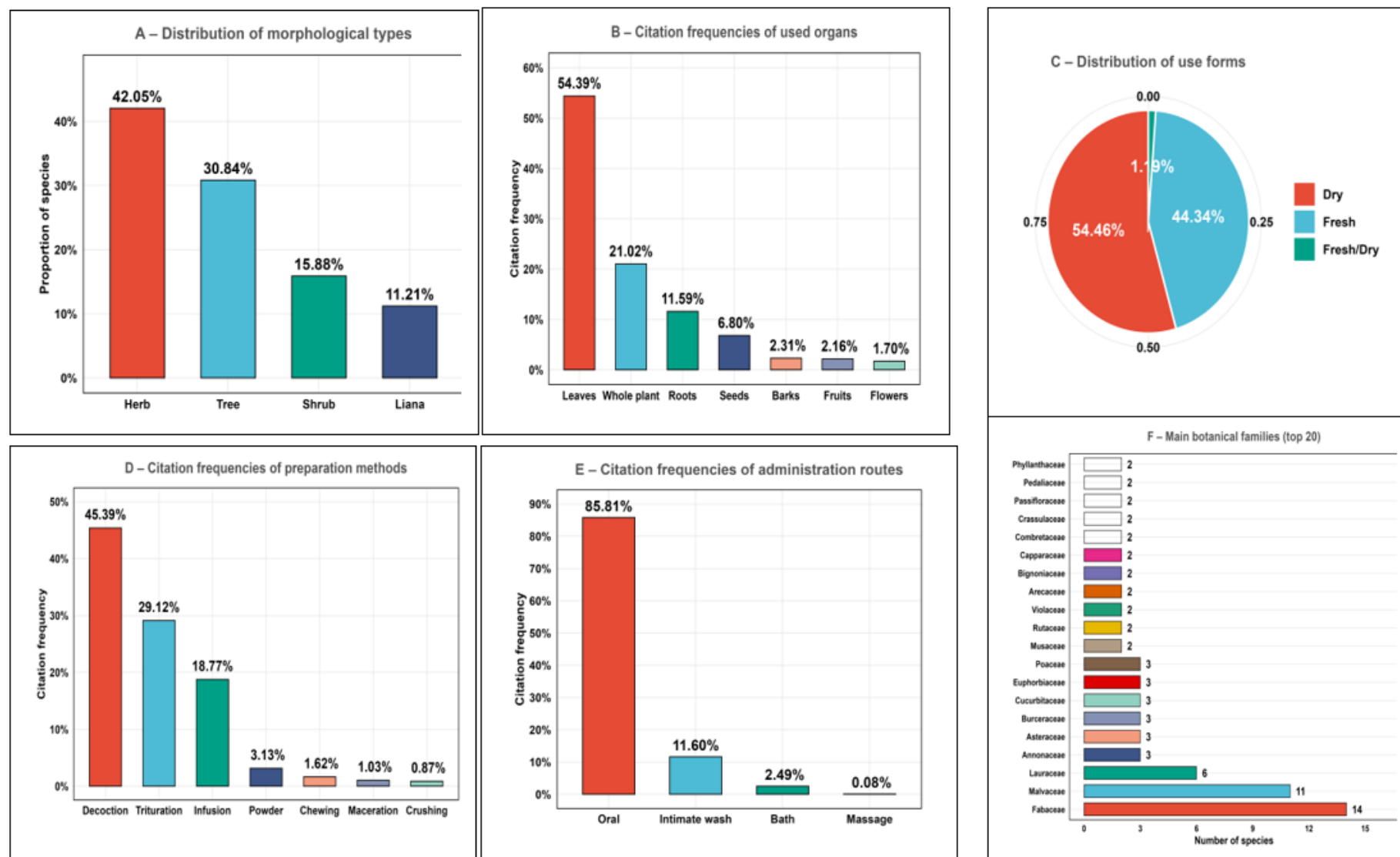


Figure 3: Ethnobotanical characteristics of the uterotonic plants surveyed (N = 107 species)

3.3 Inter-ethnic structuring of knowledge on uterotonic plants by PCoA

Principal coordinate analysis (PCoA) carried out on the frequencies of mention of the nine species that were the subject of the phytochemical screening (Figure 4) identified two ethnic groups based on the intensity of use of uterotonic plants. The first two axes account for 94.6 % of the total variance, with a marked predominance of axis 1 (86.7 %), providing a satisfactory representation of inter-ethnic differences in the two-dimensional space.

Group 1 comprises seven ethnic groups with high usage: Goun, Ouémin, Adja, Nago, Fon, Aïzo and Cotafofon. Group 2 (Dim-1 positive) comprises eight ethnic groups with low usage: Pédah, Tori, Xwlà, Mina, Sahoué, Watchi, Horli and Mahi. A PERMANOVA test (999 permutations, Bray-Curtis distance) confirms that the usage profiles of the two groups are very significantly different ($F = 28.484$; $R^2 = 0.687$; $p = 0.002$), indicating that group membership explains 68.7 % of the total variance.

The intermediate position of Cotafofon suggests a gradation in the intensity of use rather than a clear break between the two groups.

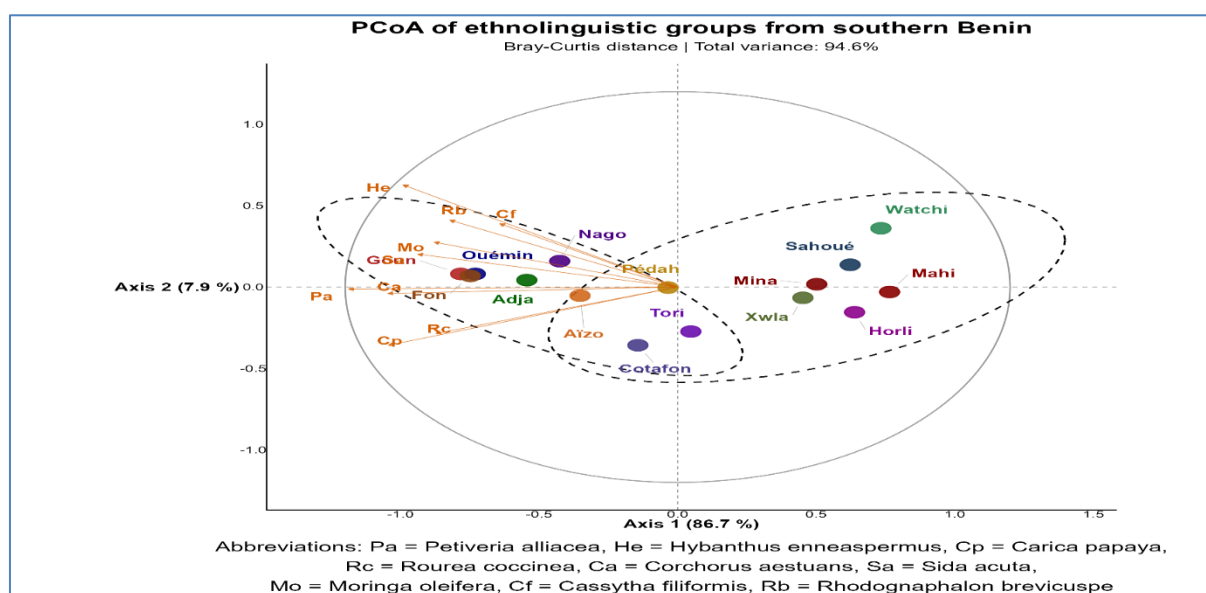


Figure 4: PCoA of the 15 ethnolinguistic groups in southern Benin, based on the frequency of mention of the nine uterotonic plants.

The Bray-Curtis distance was used. The first two axes represent 94.6 % of the total variance (Dim-1: 86.7 %; Dim-2: 7.9 %). The grey circle represents the unitary correlation circle. The red arrows indicate the species significantly correlated with axis 1 ($p < 0.05$): Pa = *Petiveria alliacea* ; He = *Hybanthus enneaspermus* ; Cp = *Carica papaya* ; Rc = *Rourea coccinea* ; Ca = *Corchorus aestuans* ; Sa = *Sida acuta* ; Mo = *Moringa oleifera* ; Cf = *Cassythia filiformis* ; Rb = *Rhodognaphalon brevisuspe*.

The species-axis correlations show that all nine species are significantly correlated with axis 1 ($p < 0.05$), indicating a strong association between the frequency of species use and the ethnic group structure observed on the first axis. *Petiveria alliacea* stands out clearly with a correlation coefficient of -0.990 ($p < 0.001$), which highlights its importance in shaping the patterns of use of uterotonic plants. It is followed by *Corchorus aestuans* ($r = -0.872$; $p < 0.001$), *Carica papaya* ($r = -0.870$; $p < 0.001$) and *Hybanthus enneaspermus* ($r = -0.826$; $p < 0.001$), which also contribute significantly to the differentiation of the groups. *Cassythia filiformis* ($r = -0.535$; $p = 0.040$) shows the weakest correlation, although it is still significant.

3.4 Qualitative analysis of phytochemicals

Qualitative phytochemical screening revealed the presence of tannins, flavonoids, alkaloids, reducing compounds, mucilages and C-heterosides in the nine species studied (Table 2).

Table 2: Results of the qualitative phytochemical screening of the nine most commonly used medicinal plants in southern Benin to facilitate childbirth.

Metabolites	Plants								
	A	B	C	D	E	F	G	H	I
Alkaloids	+	+	-	+	+	+	+	+	+
Tannins	+	+	+	+	+	+	+	+	+
Gallic tannins	-	+	+	-	+	-	+	+	-
Catechin tannins	+	+	-	+	+	+	+	-	+
Flavonoids	+(R)	+(O)	+(O)	+	+	+(O)	+(O)	+(R)	-
Reducing compounds	+	+	+	+	+	+	+	+	+
Anthocyanins	-	+	+	-	-	-	-	+	-
Leucoanthocyanins	-	+	-	+	+	-	-	-	-
Mucilages	-	+	+	+	+	+	+	+	+
Free anthracenes	-	-	-	-	-	-	-	-	-
Quinone derivatives	-	-	-	-	+	-	-	-	-
Saponosides	+	-	-	+	-	+	+	-	-
Triterpenoids	+	-	-	+	-	-	-	+	-
Steroids	-	-	-	-	-	-	-	-	-
Coumarines	-	-	-	+	+	-	+	-	-
O-Heterosides	-	-	-	-	-	-	-	-	-
C-Heterosides	-	+	+	+	+	+	+	+	-
Cardiotonic glycosides	-	-	-	-	-	-	-	-	-
Total per plant	6/18	8/18	6/18	10/18	9/18	8/18	8/10	8/18	4/18
Search by plant	4/4	3 /4	2/4	4/4	3/4	4/4	4/4	3/4	2/4
Legend: (-) = absence; (+) = presence; (O) = orange ; (R) = red. (A) <i>Petiveria alliacea</i> ; (B) <i>Cassytha filiformis</i> ; (C) <i>Rourea coccinea</i> ; (D) <i>Carica papaya</i> ; (E) <i>Rhodoglyphon brevisuspe</i> ; (F) <i>Sida acuta</i> ; (G) <i>Corchorus aestuans</i> ; (H) <i>Moringa oleifera</i> ; (I) <i>Hybanthus enneaspermus</i> .									

Among these, *Petiveria alliacea*, the species most frequently cited by respondents (44.56 %) with a consensus index of 0.754, is one of the species containing all four major metabolites investigated (alkaloids, flavonoids, tannins and saponosides), thereby corroborating its use as a uterotonic agent favoured by local communities.

3.5 Validation of the link between ethnobotanical knowledge and phytochemistry using Procrustes analysis

The Procrustes analysis, based on ethnobotanical (Bray-Curtis) and phytochemical (Jaccard) distances, enabled the superimposition of two multidimensional configurations derived from the PCoA. The results show a strong and highly significant correlation between the two distance matrices (Mantel's $r = 0.773$; $p = 0.001$). The Procrustes analysis also reveals a high degree of agreement, with a correlation of 0.906 ($p = 0.001$). These results highlight a strong association between ethnobotanical and phytochemical patterns: ethnolinguistic groups with similar usage profiles, as previously identified by PCoA, also tend to exhibit phytochemical profiles that are relatively similar to those of the species they use. Figure 5 illustrates this overlap, where the circles (ethnobotanical pattern) and triangles (phytochemical pattern) are closely aligned for most ethnic groups.

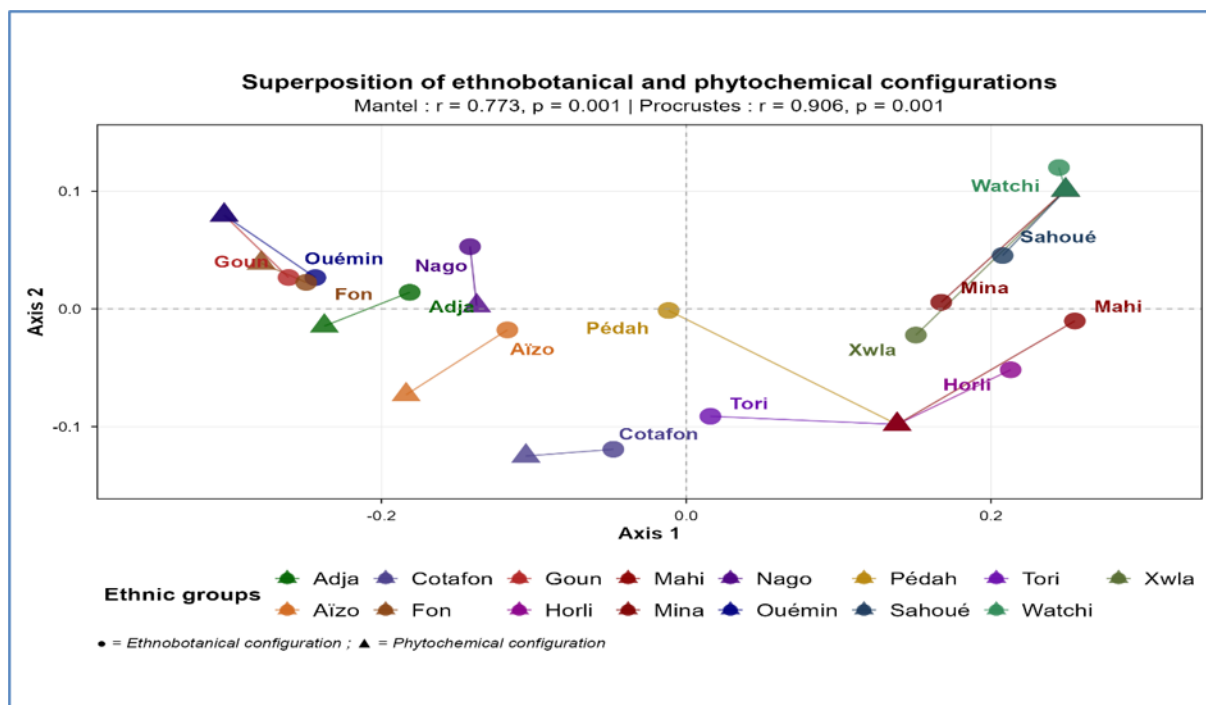


Figure 5: Procrustes analysis of the superimposition of the ethnobotanical (circles) and phytochemical (triangles) patterns for the 15 ethnolinguistic groups.

The lines connect the two configurations for each ethnic group. The Mantel correlation ($r = 0.773$; $p = 0.001$) and the Procrustes correlation ($r = 0.906$; $p = 0.001$) indicate a very strong agreement between the two configurations, suggesting an association between traditional knowledge profiles and the phytochemical characteristics of plants.

4 DISCUSSION

The ethnobotanical survey carried out in southern Benin has highlighted a remarkable diversity of uterotonic plants, revealing the wealth of traditional knowledge passed down orally and through experience within communities. The results show that people aged over 40 are the main custodians of this knowledge, confirming their role in the preservation and intergenerational transmission of therapeutic practices [27]. This trend contrasts with the findings of Nama Mwengu *et al.* [15] in DRC, where young women aged 20 to 34 represent the majority of users, highlighting the importance of the socio-cultural context in the distribution of knowledge. The predominance of women (60.52 %) confirms their central role in the transmission of practices relating to maternal health [28].

The majority of respondents were illiterate (53.12 %), which supports the work of Nnanga Nga *et al.* [29] and Ackah *et al.* [30], showing that the use of medicinal plants is more common amongst rural populations with low levels of education.

From a botanical perspective, the most commonly represented families were the Fabaceae, Malvaceae and Lauraceae, confirming their importance in African pharmacopoeia [13]. Herbaceous plants dominated (42.05 %), followed by trees (30.84 %), reflecting an adaptation to available resources in a context of deforestation [27,4]. Leaves were the most commonly used plant parts (54.39 %), due to their accessibility and high content of secondary metabolites [4]. Decoction (45.39%) and trituration (29.12%) were the most common modes of preparation, while the oral route (85.81%) largely dominated, confirming the simplicity and effectiveness of this method of administration. Among the species recorded, *Petiveria alliacea* stands out with a frequency of mention of 44.56 % and a high consensus index (ICF > 0.5). Multivariate analysis of the ethnobotanical data confirmed this structuring of knowledge according to ethnolinguistic groups, as previously observed in other African contexts [29,1,3].

The prominent role of *Petiveria alliacea* in the differentiation of ethnic groups corroborates its central role in the local pharmacopoeia, confirming the importance of this species in West Africa.

Statistical analysis supports these observations by confirming the consistency of the reported uses and the prominent role played by certain sociolinguistic groups in the transmission of knowledge relating to this plant. These ethnobotanical findings pave the way for experimental validation, which will enable us to verify whether the identified metabolites do indeed correspond to the therapeutic effects reported by the communities.

The correlation observed between the patterns of plant use and their phytochemical characteristics suggests that traditional therapeutic choices are based on an objective biochemical reality.

Phytochemical screening revealed the recurrent presence of alkaloids, tannins, flavonoids, reducing compounds, mucilages and C-heterosides in the nine species studied. These results are consistent with the data reported in the literature, confirming the prevalence of these families of metabolites in African flora. In addition to confirming the chemical composition, several studies provide direct evidence of the uterotonic potential of the identified metabolites.

A comparison of ethnobotanical data and phytochemical findings demonstrates that traditional knowledge regarding uterotonic plants is underpinned by tangible scientific evidence. In particular, the cultural and therapeutic significance of *Petiveria alliacea* is confirmed by the presence of active metabolites consistent with its reported uses, establishing a strong link between empirical practices and phytochemical validation.

The integrated approach, which combines multivariate ethnobotanical analyses with phytochemical validation, reinforces the scientific validity of indigenous knowledge and is in line with the recommendations of several authors [19,1] in favour of translational research aimed at the sustainable use of plant resources.

5 CONCLUSION

This study highlights the relevance of ethnobotanical knowledge relating to uterotonic plants in southern Benin and its validation through qualitative phytochemical screening. It confirms that the integration of traditional knowledge and scientific approaches constitutes a methodologically reliable and scientifically sound strategy for identifying therapeutic resources of interest. Future plans should include *in vivo* and *in vitro* pharmacological and toxicological studies to confirm the efficacy and safety of the extracts, as well as the implementation of pilot community-based clinical trials to assess their actual impact on maternal health. At the same time, the conservation of biodiversity and the transmission of indigenous knowledge must be integrated to ensure sustainable development.

This integrated approach therefore paves the way for translational research capable of transforming local knowledge into validated therapeutic solutions, thereby helping to reduce maternal mortality and promote health security tailored to African contexts.

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

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Disclosure of conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

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