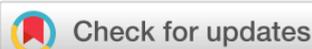


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## Ethnopharmacological survey of six medicinal plants used in the traditional treatment of urinary tract infections and other infectious diseases

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**ABSTRACT:** Benin has attractive ethnobotanical potential with a vast diversity of medicinal plants widely used to treat human diseases. Urinary tract infections are among the diseases traditionally treated by medicinal plants. *Mangifera indica*, *Bridelia ferruginea*, *Alstonia boonei*, *Morodora myristica*, *Xylopi aethiopica* and *Zanthoxylum zantoxylodes* are six plants used in the traditional treatment of urinary infections in Benin. The general objective of this study was to identify the ethnopharmacological uses of these six plants used in traditional medicine in South Benin. To this end, an ethnopharmacological survey was conducted using the semi-structured interview method among herbalists in the markets of South Benin. The ethnobotanical data collected were analyzed using the use-value, the informant consensus factor and the medicinal plant fidelity index. A total of 98 herbalists participated in this study. The six plants studied were involved in 15 different diseases divided into seven disease categories. The most mentioned disease categories are infectious diseases, blood and digestive diseases. Malaria, ulcers, anemia and urinary tract infections are the pathologies most commonly treated by these plants. Informants agreed on the use of these plants in these disease categories. Bark, leafy stems and roots are the parts of the plants most used to treat diseases. Decoction and maceration are the two main methods of preparation, and the oral and cutaneous routes are the main routes of administration. These data constitute ethnopharmacological documentation that can be used for further pharmacological and toxicological studies.

## 1. INTRODUCTION

Infectious diseases are caused by pathogenic microorganisms, such as bacteria, viruses, parasites or fungi. (Lagnika et al., 2012). They are responsible for more than 17 million deaths per year worldwide and account for 43% of deaths in developing countries. (Ganfon et al., 2019). Bacterial infections are responsible for 70% of these deaths. (Ganfon et al., 2019). Urinary tract infection is one of the most common bacterial infections globally, with a high incidence in less developed countries, such as Benin (Guérin, 2015). The effective management of urinary tract infections caused by Enterobacteriaceae species in modern therapy is faced with bacterial resistance to commonly used antibiotics (Guérin, 2015). Indeed, antibiotics in modern therapy have revolutionized the treatment of bacterial infections, saving many lives. Unfortunately, antibiotic resistance has emerged over

the last 30 years and has become a significant concern of many clinicians (Okou et al., 2018). This antibiotic resistance phenomenon is justified because we are witnessing a continuous progression of difficulties in treating the various infections, which increasingly leads to therapeutic deaths. While the discovery and use of antibiotics have been at the origin of the greatest successes in medicine, today, the emergence and spread of multiresistant bacteria in human populations have become a very worrying public health problem (Toty et al., 2013). The progression of multi-resistance and the prospects for the discovery of new antibiotics evoke the urgency to explore traditional medicine to study the effectiveness of plants with therapeutic virtues and to isolate their active ingredients. This approach is all the more justified since more than 80% of the population in developing countries continues to treat itself using medicinal plants (OMS, 2009) .

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Benin has attractive ethnopharmacological potential. Adjanohoun et al. (1989) identified nearly 501 species used in traditional medicine, including a relatively large number for treating infectious diseases, including diarrheal diseases. The Beninese scientific literature is very rich in ethnopharmacological surveys of medicinal plants used to treat various diseases (Agbankpé et al., 2014; Agbodjento et al., 2020; T.V. Dougnon et al., 2017; V. Dougnon et al., 2018; Kpodji et al., 2019). It should be noted that none of them was interested in the plants sold by herbalists for the traditional treatment of urinary tract infections in southern Benin. Several species of plants have been identified by ethnopharmacological surveys conducted on medicinal plants with anti-infectious effects.

Additionally, a study in Lomé on the medicinal plants used against infections brought out *Mangifera indica*, *Alstonia boonei*, *Bridelia ferruginea*, *Morodora myristica*, *Xylopiya aethiopica* and *Zanthoxylum zantoxylodes*, similar to the plants most used to treat urinary infections (V. Dougnon et al., 2020). These six plants have been cited by some herbalists in the markets of South Benin in the treatment of infections in general and in the treatment of salmonellosis by traditional healers. However, no study has been carried out on the ethnopharmacological usefulness of these plants in the traditional treatment of urinary tract infections in the Beninese context.

This study was initiated to improve the level of knowledge on these plants used to treat these South Benin urinary tract infections. Its general objective was to identify the ethnopharmacological uses of these six plants used in traditional Beninese medicine in South Benin.

## 2. MATERIALS AND METHODS

### 2.1. Study Area

An ethnopharmacological survey was conducted in three communes in South Benin during a three-month period (October to December 2020). These communes included Cotonou, Abomey-Calavi, and Ouidah (Figure 1). South Benin is located between 6°25' and 7°30' north latitude and spans an area of 17109 km<sup>2</sup>. The climate is subequatorial, with a bimodal rainfall regime consisting of two rainy seasons followed by two dry seasons. The annual average temperature is 28°C, while the relative humidity ranges between 69% and 97% (Akoègninou, 2004). Ferritic soils on clayey deposits, hydromorphic soils in valleys, lowlands, and alluvial plains, vertisols in the Lama Depression, and tropical eutrophic brown soils are the prominent soil types (Igue et al., 2013). It is located within the Guinean-Congolese zone, which is characterised by a mosaic of islands covered in lush rainforests, savannahs, grasslands, mangrove swamps, and fallow land. Fon and associated ethnic groups account for 39.2 percent of the population, Adja and related ethnic groups account for 15.2 percent, and Yoruba and related ethnic groups account for 15.2 percent (14.5 percent) INSAE and National Institute of Statistics and Economic Analysis, Republic of Benin (Cotonou) (2013). Commerce and agriculture are the two most important

economic activity. Additionally, there is market gardening, livestock husbandry, fishing, handicrafts, and tourism.

### 2.2. Data Collection

This study targeted herbalists in southern Benin markets and was conducted using the semistructured interview method described by Agbodjento et al. (2020). Herbalists were interviewed in 13 markets. These are the markets of Calavi kpota, Cococodji, Cocotomey, Pahou, Akassato, Glo, Ouèdo, Godomey, Vedoko, Menontin, Fifadji, Saint Michelle and Tokpa. Interviews with the herbalists were conducted in one of the indigenous languages (Fon, Goun, Mahi, Azo and Adja) after they had been randomly selected. The collected data was related to sociodemographic (origin, gender, age, ethnicity, level of education, source of knowledge) and ethnopharmacological (infectious diseases treated, usefulness of plants in traditional treatment of urinary tract infections and others) data.

### 2.3. Data Analysis

SPSS 26.0 was used to do statistical analysis on the survey data entered into the Microsoft Excel 2016 spreadsheets. The sociodemographic data was analysed using quantitative descriptive statistics. In order to determine the link between the number of plants cited in each disease group and the consensus of respondents, Pearson's correlation test was utilised.

The analysis of the ethnopharmacological data took into account the use-values, the medicinal plant fidelity index and the informant consensus factor (ICF). The significance level was set at 5%.

- The use-value of medicinal plants

The use-value (UV) is the number of times a plant has been cited to treat a given category of diseases (Shalukoma et al., 2015). It was determined from the disease categories. Diseases or conditions and symptoms are categorized according to the system or device that is affected (Andrade-Cetto & Heinrich, 2011). The following formula was used to assess the use-value of medicinal plants:

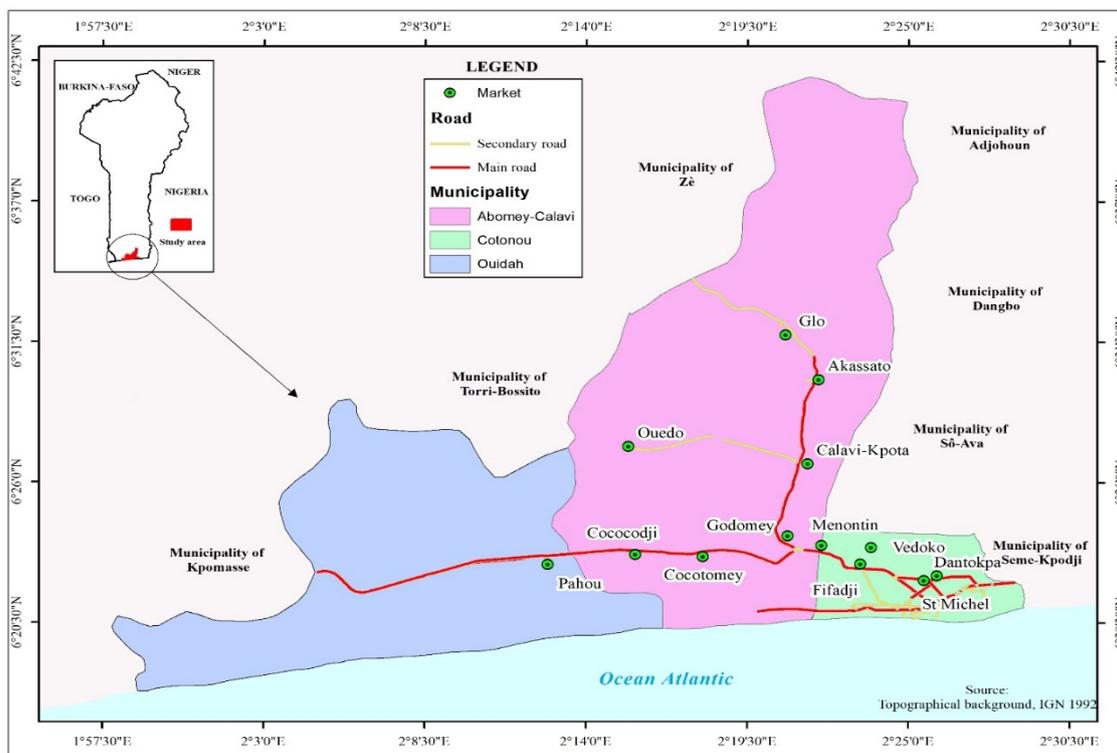
$$VU = \frac{NC}{NT} * 100$$

NC: Number of plant citations for the disease categories in which the plant is solicited

NT: Number of citations of all plants for all disease categories where the plant is cited.

- Informant Consensus and Fidelity of Medicinal Plants

The cultural importance of plants is based on the consensus of informants, which reflects the degree of agreement among different respondents regarding the use of a medicinal plant (Albuquerque, 2009). This study reached consensus through two approaches: the informant consensus factor (ICF) and the plant fidelity index (FI). The CIF allows for assessing the consistency of informants' knowledge based on the diseases they treat and the plants they use (Musa et al., 2011). A high FCI for a given disease category suggests a consensus among informants about their plants for the diseases they treat. If



**Figure 1.** Map of South Benin showing the municipality and markets surveyed

high, it reflects a well-defined tradition related to the medicinal plants associated with these disease categories (Heinrich et al., 1998). This informant consensus factor expresses their approval rate based on the number of mentions of a disease category and the total number of plants used to treat diseases in the given category. The index is calculated by disease category according to the following formula:

$$Fci = \frac{nr - nt}{nr - 1}$$

where nr is the number of mentions of diseases in the category by informants and nt is the total number of mentions of plants used to treat the identified diseases.

The Fci varies from 0 to 1 (Ugulu et al., 2009)

- A rating of zero indicates a lack of agreement among respondents on how to employ plants to cure a specific illness category;
- It is generally accepted that plant use is underrepresented when the value is less than 0.5;
- The factor's average degree is 0.5, indicating an average agreement on plant use. 0.5;
- Between 0.5 and 1, the degree of agreement in the use of plants to treat disease is rather strong, indicating a high degree of agreement in the use of plants to cure disease.;
- The value 1 indicates complete agreement on the use of plants to treat the illness category.

The fidelity index (FI) is used to quantify the degree to which respondents associate a medicinal plant with its involvement in

a particular category of disorders. This index is calculated using the percentage of informants who confirmed the use of a plant in the treatment of a particular disease category. It is calculated using the formula below (Ugulu, 2012)

$$IF (\%) = \frac{Ip}{Iu} * 100$$

where Ip denotes the number of informants who utilised a particular species to treat a particular disease category and Iu denotes the total number of traditional healers who referenced the same species at least once for all disease categories. This gives a value for each pair of disease categories and species.

### 3. RESULTS

#### 3.1. Socio-demographic characteristics of respondents

A total of 98 herbalists were surveyed in this study. Analysis of the various data showed that all respondents were female. The majority were between 40 and 60 years old (48.98%), followed by those between 20 and 39 years old (42.86%). The vast majority of informants were uneducated (53.06%), but 30.61% had a primary school education, and 16.33% had a secondary school education. Most of the informants (51.02%) said they had inherited the knowledge and medicinal practices of the plants studied from their parents. However, they have pretty remarkable experience (66.33%) in traditional medicine in South Benin. Additionally, the herbalists surveyed belong to different ethnic groups, of which Aizo (32.65%) and Mahi (24.49%) are the most represented. The sociodemographic data

of these respondents are summarized in **Table 1**.

**Table 1**  
Sociodemographic characteristics of respondents

Variables	Categories	Total	Percentage (%)
Sex	Féminin	98	100
	20 -39 ans	42	42.86
Age	40-60 ans	48	48.98
	> 60 ans	8	8.16
Year	0-10 ans	29	29.59
	11-20 ans	65	66.33
Number of Experience	> 20 ans	4	4.08
	Heritage	50	51.02
Knowledge Source o	Apprentissage sur le tas	44	44.90
	Documentation	4	4.08
Education Level	Illettré	52	53.06
	Primaire	30	30.61
Ethnicity	Secondaire	16	16.33
	Fon	22	22.45
	Mahi	24	24.49
	Goun	4	4.08
Ethnicity	Aizo	32	32.65
	Adja	4	4.08
	Yoruba	12	12.24

### 3.2. Ethnopharmacological Data

The analysis of the ethnopharmacological data collected made it possible to identify the frequencies of use, the fidelity of the medicinal plants, the consensus of the informants, the parts of the plants used, the mode of preparation and the route of administration.

**Table 2** presents the categorization of diseases and their number of mentions. In total, the plants studied for this work are used to treat fifteen (15) different diseases divided into seven (7) categories. The most mentioned categories of diseases are infectious diseases followed by digestive diseases.

Regarding the use-value of the medicinal plants that were the subject of this study, they have several pharmacological applications. They have therapeutic effects on 15 different diseases identified in this study with different use values (**Table 3**). *Mangifera indica* is the plant that has been the most cited by herbalists to treat human diseases. It is used to treat several diseases classified into six different categories with a frequency of use of 27.37%.

In addition, concerning the consensus factor (Fci) and the fidelity index of the plants studied, it appears that 100% of the plants studied have a consensus factor ranging from 0.87 to 0.98; therefore, all of them are above 0.70. This indicates that the vast majority of the informants or all our informants agree on the uses of these plants in the traditional treatment of the indicated diseases.

Similarly, Pearson's correlation test ( $r_s = 0.785$ ;  $p < 0.05$ ) showed that the higher the consensus rate among informants, the higher the mention of each disease category. These positive linear correlations suggest that the more a disease category is

**Table 2**

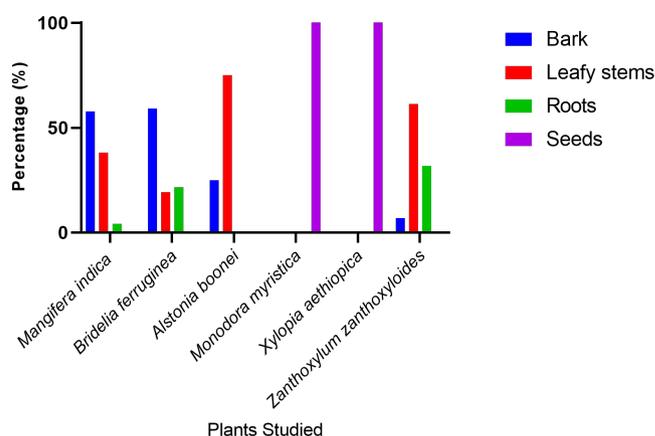
Categorization of diseases and their number of mentions

Disease Categories	Pathologies	Mentions
Infections (I)	Sexual	250
	Cutaneous	
	Parasites	
	Urinary	
Digestives Diseases (DD)	Unspecified Infections	109
	Ulcer	
	Diarrhoea	
Blood Diseases (BD)	Malaria	87
	Icter	
Respiratory Diseases (RD)	Anaemia	87
	Angina	
Circulatory System Affection (CSA)	Cough	17
	Hypertension	
Metabolic Diseases (MD)	Diabetes	10
Sexual and Reproductive Disorders (SRD)	Infertility	10

treated, the more the plants listed are used (**Table 4**).

Plant fidelity to disease categories ranged from 1.76% to 73.43%. The plants in this study showed maximum fidelity for disease categories such as infections and digestive and blood disorders (**Table 4**).

This study also determined the parts of the plants used to treat the different diseases indicated, the mode of preparation and the route of administration of the different plants studied. Thus, the bark, leafy stem and roots were the most commonly used parts for the plants studied during this survey. The bark is the most commonly used part for *M. indica* and *B. ferruginea*, followed by the leafy stem for the two species of medicinal plants. However, *A. boonei* and *Z. zanthoxyloides* are leafy stems, which are the most commonly used. On the other hand, only the seeds are used in the case of species such as *M. myristica* and *X. aethiopica*. Its information is summarized in **Figure 2**.



**Figure 2.** Most used parts of the medicinal plants studied

**Table 3**

Utilization value of medicinal plants and disease categories identified in the ethnobotanical survey

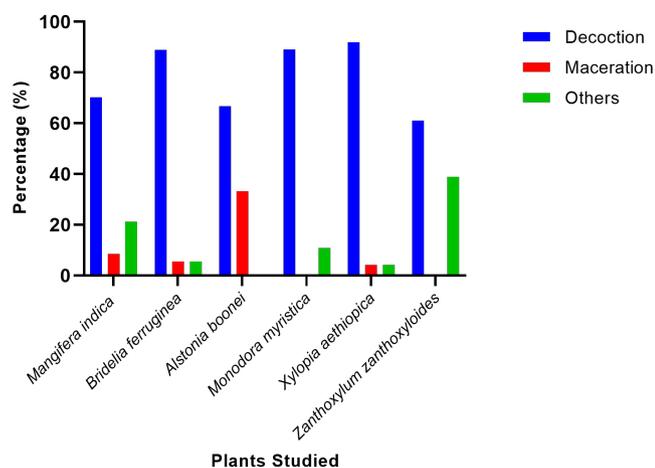
Medicinal Plants	Botanical Families	Vernacular Names	Frequency of Use	Diseases Categories
<i>Mangifera indica</i>	Anacardiaceae	Mangati	27,37%	MD, RD, DD, CSA, BD, I
<i>Bridelia ferruginea</i>	Euphorbiaceae	Honsoukouékoué	14,83%	RD, DD, BD, I
<i>Alstonia boonei</i>	Apocynaceae	Yanglé	5,96%	DD, CSA, BD, I, SRD
<i>Morodora myristica</i>	Annonaceae	Sassalikoun	14,98%	DD, BD, I
<i>Xylophia aethiopica</i>	Annonaceae	Kpédjrékoun	17,27%	MD, RD, DD, CSA, I
<i>Zanthoxylum zanthoxyloides</i>	Rutaceae	Hétin	19,57%	DD, BD, I, SRD

**Table 4**

Informant consensus factors and indices of medicinal plant fidelity

Disease Categories	Metabolic Disease (MD)	Respiratory Disease (RD)	Digestives Disease (DD)	Circulatory System Affection (CSA)	Blood Disease (BD)	Infection (I)	Sexual and Reproductive Disorders (SRD)
Number of mentions / Categories	10	87	109	17	87	250	10
Number of mentions / Plants	2	2	6	3	5	6	2
<b>Consensus Factors (Fci)</b>	<b>0,88</b>	<b>0,98</b>	<b>0,95</b>	<b>0,87</b>	<b>0,95</b>	<b>0,97</b>	<b>0,88</b>
<b>Medicinal Plants</b>	<b>Fidelity Index</b>						
<i>Mangifera indica</i>	2,23	12,23	4,46	2,24	26,25	52,51	0
<i>Bridelia ferruginea</i>	0	8,24	15,46	0	12,37	63,91	0
<i>Alstonia boonei</i>	0	0	20,51	10,25	10,25	48,71	10,25
<i>Morodora myristica</i>	0	0	27,55	0	4,08	68,36	0
<i>Xylophia aethiopica</i>	5,30	3,53	26,54	1,76	0	62,83	0
<i>Zanthoxylum zanthoxyloides</i>	0	0	9,37	0	12,5	73,43	4,68

Decoction is the most often utilised technique of preparation for all herbs, according to the herbalists polled. Maceration, as well as other forms of preparation, such as powders and trituration, were also cited (Figure 3).

**Figure 3.** Different modes of preparation of the studied plants

Two main routes of administration were indicated by the herbalists surveyed. These were oral and dermal. For all plants, the oral route is used in more than 85% of cases. Additionally,

it is indicated only for *B. ferruginea* and *Z. zanthoxyloides*.

#### 4. DISCUSSION

The purpose of this study was to determine the ethnopharmacological applications of six medicinal plants from the Beninese flora that are used in traditional medicine in South Benin to treat urinary tract infections.

This study, which targeted herbalists in the markets of the municipality of Abomey-Calavi, Ouidah and Cotonou, was carried out among 98 respondents. These herbalists were all female. This can be explained by the fact that Benin's sale of items at the market is usually reserved for women. (Fah et al., 2013). It is mainly accepted in Africa that elderly individuals hold traditional knowledge of disease treatment. Additionally, the therapeutic properties of plants are a form of ancestral wisdom passed down through generations (Klotoé et al., 2013). The work of V. Dougnon et al. (2018) has also shown that herbalists in the markets of South Benin are mainly women. These authors conducted their study in the same area as our study, and their work focused on the role of market herbalists in South Benin in treating typhoid fever. The same applies to the work of Kpodji et al. (2019), who discovered the plants that are used to treat inflammatory illnesses in the same study region. The majority of the people surveyed were between 40 and 60 years old (48.98%) and had professional experience ranging

from 11 to 20 years (66.33%) in sales of medicinal articles. The majority of these individuals were illiterate (53.06%) and reported having inherited from their parent's knowledge of the therapeutic properties of medicinal plants (51.02%). These results could be explained by traditional medicinal knowledge being transmitted from ascendants (wise men) to descendants (young people). Knowledge about medicinal plants is held by the elderly and is transmitted orally to the youngest. This could justify the high number of people between 40 and 60 years old compared to people between 20 and 39 years old (42.86%). Other authors have reported similar data in the same study area (Agbodjento et al., 2020; Fah et al., 2013; Koudokpon et al., 2017). The high illiteracy rate among the informants in this study would be linked to the fact that these people very quickly drop out of school for other sectors of activity. These observations also suggest that the practice of traditional medicine in South Benin remains the prerogative of most illiterate populations.

The ethnopharmacological data collected in this study provide information on the use of the 6 plants studied in 15 different diseases divided into 7 disease groups or categories. The most frequently mentioned disease categories are infectious diseases and blood and digestive disorders. Diarrhoea, ulcer, malaria and anemia are the most treated diseases in digestive and blood diseases. Infection of the urinary tract is the most treated disease in the category of infections, followed by unspecified infections and skin infections. These results could be related to unhealthy and precarious living conditions. As an example, the city of Cotonou is home to swampy areas. These inhabitants live in daily contact with larval gites and microbes of all kinds. These living conditions are linked to the underdevelopment of our country, which is common problem in many developing countries (Collins et al., 2006; Molares & Ladio, 2009). It should also be noted that malaria is still an endemic disease in Africa and continues to wreak havoc. Urinary tract infection is the most common infectious disease in Africa. Victorien et al. (2020) reported that urinary tract infections are the most common in general medicine and that the bacteria involved are mostly multiresistant. Indeed, the emergence and increasing spread of antimicrobial resistance is a real public health problem limiting the range of antibiotic molecules to be used. According to Koudokpon et al. (2017), traditional medicine is proven to be helpful in the treatment of infectious diseases.

These respondents mentioned that all the plants that were the subject of the present study are indicated in treating infectious diseases with a maximum fidelity for *M. indica*, *B. ferruginea* and *M. myristica*. As an example, *M. indica* was cited by traditional healers against several diseases in West Africa. Indeed, it is quoted against the traditional treatment of malaria in Cameroon, cardiovascular diseases in Thad, muscular contusions and Togo, and ulcers in Congo (Dongock et al., 2018; Hélé et al., 2014; Ibara et al., 2007). Beninese respondents also cited these conditions in this study. These data suggest that medicinal plants' treatment of particular ailments is essentially the same in West Africa, with some diversity

depending on the country and the plant.

These plants are also indicated in the treatment of other ailments after infections. It has been reported that both *M. indica* and *B. ferruginea* exhibit good antibacterial action against both gram-positive and gram-negative bacteria, according to literature and pharmacological tests. Multiple-resistant bacteria cannot develop in the presence of these compounds, even when they are administered intravenously. Diarrhea, gastric disorders, asthma, mouth sores, liver diseases and infections, diabetes, rheumatism, leucorrhoea, haemorrhoids, pulmonary haemorrhage, nervous system disorders, syphilis, cough and jaundice can all be treated with the various portions of *M. indica*. Mango peel resins have been used to cure skin and foot fissures. This plant is specifically indicated to treat hypertension and anaemia in benign individuals (Ediriweera et al., 2017). One of the most widely-used plants in traditional medicine around the world is *A. boonei*, which has been used for centuries to cure a wide range of human ailments (Adotey et al., 2012; Alowanou et al., 2015). These plants are also nontoxic, according to toxicological studies.

Regarding the consensus factor (Fci) and the fidelity index of the plants studied, 100% of the plants studied had a consensus factor ranging from 0.87 to 0.98. higher than 0.70. This indicates that the vast majority of the informants agreed on the uses of these plants in the traditional treatment of the indicated diseases. These results show that traditional healers or practitioners do not randomly select the plants to treat a disease. Choices are based on knowledge and the usefulness of the plant in each case of disease.

Additionally, the Pearson correlation test ( $r_s = 0.785$ ;  $p < 0.05$ ) showed that the higher the consensus rate of informants, the higher the mentions of each disease category. These positive linear correlations suggest that the more a disease category is treated, the more used the indicated plants. The results of this test confirm the data on the consensus factor of plants according to herbalists. Plant fidelity to disease categories ranged from 1.76% to 73.43%. The plants in this study showed maximum fidelity for disease categories such as infections and digestive and blood disorders.

The bark, leafy branches, and roots of these plants are the most often used portions. Numerous investigations have revealed that these are the areas that traditional healers most frequently employ to treat the sick. This frequent usage of these sections may be justified by the simplicity and speed with which they can be harvested, as well as a necessary physiological process, as they are the sites of photosynthesis and occasionally the storage of secondary metabolites responsible for the plant's biological features (Agbodjento et al., 2020). However, the usage of these plant parts in recipes may have a detrimental effect on the longevity of plant species. While using fruits and leaves appears to have no effect on the plant, using roots and bark appears to be damaging to the plant. These plants are often prepared as a decoction or maceration and are generally administered orally and dermally. The same observations were made in this study. In addition, it should be noted that these

plants are still not used alone but sometimes in association with other plant species. This shows the synergy of action between the bioactive molecules of the plants for a better therapeutic effect.

## 5. CONCLUSION

The current study established the ethnopharmacological applications of six medicinal plants from the Beninese flora that are used in traditional medicine in South Benin to treat urinary tract infections. These six plants are used to treat a total of fifteen different ailments, which are classified into seven categories. Infectious diseases and digestive and blood disorders are the three categories of diseases most treated by these plants. *M. indica*, *B. ferruginea* and *A. boonei* are the plants most faithful to the categories of the treated diseases. The usefulness of these plants in traditional medicine against several diseases is documented in the literature. Extensive toxicological tests are necessary to attest to the innocuousness of these plants to ensure better traditional management of urinary tract infections in Benin.

## CONFLICTS OF INTEREST

The authors state that this article has no known conflicts of interest.

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## AUTHOR CONTRIBUTIONS

PA, VD and JRK - Research concept and design, PA, EA, RA and JRK - Collection and/or assembly of data, PA, EA, RA and JRK - Data analysis and interpretation, PA, RA and JRK - Writing the article, PA, VD and JRK - Critical revision of the article, PA, VD and JRK - Final approval of the article.

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