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Ethnobotanical and ethno-pharmacological approach to ichthyotoxic plants of Gabon

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This ethnobotanical and ethno-pharmacological study was conducted to know the plants used in fishing practices and to show their importance in traditional medicine in Gabon. For this study, 100 questionnaires were administered to individuals in the fishing and traditional medical domains. 701 plants belonging to 16 different floristic families, including Fabaceae (41%), Rubiaceae (13%), and Rutaceae (15%) were commonly used. Most of the plants were used for fishing and in traditional medicine. Shrubs and trees such as *Tephrosia vogelii*, *Brenania brieyi*, highly recognized by the respondents, were used to treat certain diseases such as the 'night gunshot' of witchcraft origin, which modern medicine sometimes comes up against. Diseases such as hemorrhoids, malaria, sinusitis and chicken pox were common. On the one hand, the results obtained constitute a source of essential information that could be used to assess the risks of intoxication in populations that consume fish caught from ichthyotoxic plants. On the other hand, this study would permit the understanding of the Gabonese medicinal flora, and could act as a database for subsequent research in pharmacology.

Key words: Medicinal plants, ichthyotoxic plants, ethno-pharmacology, ethnobotany.

INTRODUCTION

Globally, plants are used in several domains such as health, food, and construction. In Gabon as in other regions of the world, some of these plants are widely exploited not only for their medicinal purposes, but also for fishing and hunting (Tag et al., 2005; Yumnam and Tripathi, 2013).

Relationships between humans and plants have existed for several decades (Chikamai et al., 2009). In terms of health, nearly 80% of populations depend on traditional medicine. Naturally, in Africa, the use of plants for therapeutic purposes is part of the culture and tradition for these populations (Koudokpon et al., 2017). Ghourri et al. (2012) provided a list of 131 medicinal species used to treat diseases that affect certain body systems (respiratory, urinary, genital, digestive), like cancer and diabetes. These medicinal properties of plants are also indicated in the Pocket Guide to Phytotherapy by Caroline Gayet (2013), revealing that plants could act on the nervous system and on other systems (digestive, respiratory, immune, hormonal and urinary). In Gabon, 117 plants used by pygmies in pharmacopoeia and traditional medicine have been

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recorded (Kwenzi et al., 2009). In general, literature reveals that there would be more than 200,000 plant species in the tropical countries of Africa with medicinal properties out of the 300,000 listed on the whole planet (Sofowora, 1993). In terms of number and medicinal properties, plants are invaluable resources for the pharmaceutical industry (Jiofack et al., 2010). In Congo, nearly 1500 traditional medicines are made from plants by the traditional healers in this country (Nkeoua and Boundzanga, 1999). Despite the satisfactory results of plant medication (Jiofack et al., 2010), it is nonetheless true that some of these plants are sometimes the cause of inexplicable poisonings observed in many individuals. This means that medicinal plants in addition to their therapeutic aspect can also be toxic. In Cameroon, for example, a study indicated that drugs derived from plants are not very toxic compared to synthetic drugs (Dibong et al., 2011).

Highly toxic plants such as *Carica papaya* and *Pentaclethra macrophylla*, used in fishing practices, have been sources of medicines in the traditional pharmacopoeia (N'Guessan et al., 2009; Djego et al., 2011). *Carica papaya*, a native to tropical America and grown in several other tropical regions, is used to treat diseases such as malaria and cancer (Nnanga Nga et al., 2016). *Pentaclethra macrophylla* is a medium-sized tree found along rivers and people use it in indigenous medicine as an anti-dysenteric in enema, and as an antipsoric in frictions (Nnamani et al., 2020). It seems these two ichthyotoxic plants, like other plants used in traditional fishing (*Tephrosia Vogelii*, *Erythrophleum ivorense*, *Tetrapleura tetraptera*, etc.), are medicinal and do not affect human organisms, warm-blooded animals (Amakoe, 2011), but are very toxic to cold-blooded animals.

It should be noted that the permanent ingestion of fish obtained from these plants could lead to serious long-term poisoning in humans (Kimpouni et al., 2011). It has been reported that the ingestion of a small quantities of the prepared parts of some of these plants (seeds, leaves, roots, fruits or sap) would cause lesions (internal or external), to humans and animals (Kabemba, 2015).
Literature provides a considerable list of plants involved in traditional fishing (Kimpouni et al., 2011). However, experiments conducted to clarify the ethnobotany and ethno-pharmacology of these plants in Gabon are rare. A recent study carried out in three provinces of Gabon (Haut-Ogooué, Ogooué lolo and Nyanga) reported some 15 plants frequently used in fishing by the populations of these different localities (Mouele et al., 2021), and that could probably serve as phytomedicines. Little is known on the use of these plants in pharmacopoeia and traditional medicine.

Historically, fishing from plants is an ancient practice. Bishop et al. (1982) and Heizer (1953) listed some of these plants in several regions globally. Furthermore, Kerharo et al. (1960) retraced the history of these plants and other authors described fishing sessions using fish-toxic plants. Plant species belonging to families such as *Annonaceae*, *Papilionaceae*, *Rubiaceae*, *Myrsinaceae*, *Mimosaceae*, *Gnetaceae* and *Passifloraceae* have been cited for this purpose (Kimpouni et al., 2011; Moyon and Arunkumar, 2018). Likewise, species of the Fabaceae family are known to be widely used as fish poisoning agents. This group of plants are used in the form of raw pastes, and are said to kill fish in streams and ponds very quickly (Tag et al., 2015). In Africa, there are more than 325 species of poisonous plants which are commonly used to capture fish (Neuwinger, 2004). In Gabon, knowledge on the plants used both for fishing, pharmacopoeia and traditional medicine is in the hands of very few individuals, and is thought to be disappearing disappearing. It is noticed from literature that the transmission of this knowledge is currently in danger since it is not always assured. No specific research has been conducted on this subject regarding ichthyotoxic plants even though there is a need to preserve and enhance this knowledge in Gabonese populations. Consequently, ethnobotanical and ethno-pharmacological research on ichthyotoxic plants is essential to safeguard the knowledge acquired by the indigenous populations of the various localities of Gabon.

The aim of the study is to conduct an inventory on the ichthyotoxic plants used in the pharmacopoeia and traditional medicine to collect as much information as possible on their parts used, the methods of preparation and the diseases they treat. This will contribute not only to the assessment of the potential risks for the health of the individuals who exploit these different plants, but also for a better understanding of the toxic and medicinal plants of Gabon.

MATERIALS AND METHODS

Study localities

This study was conducted in several localities of the seven provinces (Haut-Ogooué, Nyanga, Ngounié, Ogooué-Ivindo, Ogooué-Lolo, Moyen-Ogooué and Woleu-Ntem) of Gabon (Figure 1). Indeed, Gabon extends over a total surface area of 267,667 km². It is a country bordered to the North-West by Equatorial Guinea, to the North by Cameroon, to the North-East and to the South by Congo and to the West by the Atlantic Ocean (Figure 1) (Nzigou et al., 2021). The country has an equatorial climate-type, characterized by four seasons: two rainy seasons (from mid-September to mid-January and from mid-February to mid- June) and two distinct dry seasons (from mid-June to mid-September, and from mid-January to mid-February) (Tamura and Akomo-Okoue, 2021).

Gabon has a maritime region of 800 km with coasts, lagoon environments, estuaries, and deltas which are concentrated along the coast (Ekouala, 2013). Fishing from fish-toxic plants is non-existent in these environments, because the populations of the coast rather use other types of methods to fish such as the net which is adapted for this kind of marshy areas. However, the rest of the country is covered with forests, that is, 88% of the national territory (Poulsen et al., 2021). Fishing from poisonous plants exists

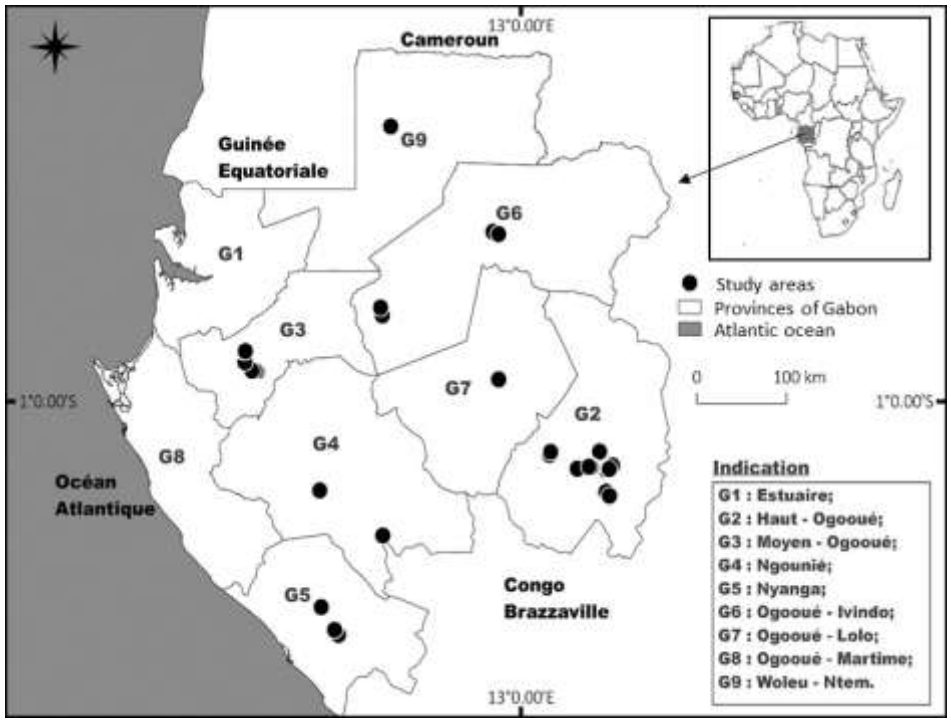

Figure 1. Location of study sites (black dots) in the different localities of Gabon. GX: provinces of Gabon. 701 plants sampled in 27 villages and 9 subdivisions of Gabon (Kokolo, 2021).

in this part of the country. The presence of many rivers and the seasonal variability are suitable for fishing in these forest environments. Our survey only focused on forest areas.

Ethnobotanical and ethno-pharmacological data collection

The data were collected in the period from January to May 2021. The ethnobotanical and pharmacological study focused on interviews of men and women whose ages were between 28 and 68. There were 48 women and 52 men. The method used was the administration of questionnaire to collect information from the target populations. The main language of communication was French. For every study location, people with knowledge on the use of plants for fishing were the first to be interviewed. After collecting all the necessary information and harvesting the corresponding plant sample, traditional healers were then consulted. In total, 100 people chosen at random were questioned about ichthyotoxic plants and their importance in traditional medicine. For this, 37 people agreed to give information on poisonous plants and 63 traditional healers who agreed to talk on the importance of each plant species in traditional medicine. In both cases, the parts of the plants investigated, the protocol used and the type of diseases they treat were noted (Table 1). The determination of the scientific names was carried out at the herbarium of the Department of Biology of the University of Science and Technology of Masuku. The frequency of citation (FC) of each of the species collected in this study was calculated according to the formula by Orsot (2016) and Yolidje et al. (2020):

$$\mathbf{FC} = \frac{\mathbf{n}}{\mathbf{N}} \mathbf{x\ 100}$$

Where:
n: the number of people who mentioned the species,
N: the total number of people questioned.

To compare the toxic effects of each plant, statistical tests (Wilcoxon test) were applied using the R statistical software of version R.3.4.3. In case of multiple comparisons, the P-values were adjusted by the Holm's method.

RESULTS

Ethnobotanical characteristics of fish poisonous plants

From the ethnobotanical study, women (70%) knew more about the plants used for fishing than men (30%) (Figure 2A). The results suggest that the use of ichthyotoxic plants is a common practice in the age groups ranging from 28 to 68 years old with a predominance among individuals between 58 and 68 years (37%) followed by those from 48 to 58 years (28%), 38 to 48 years (22%) and 28 to 38 years (13%) (Figure 2B).

The present study identified 701 plants belonging to 16 botanical families, and the majority in terms of number of species were Fabaceae (41%), Rubiaceae (13%), Rutaceae (15%). Species such as *T. vogelii*, *Fillaeopsis discophora*, *Cylicodiscus gabunensis*, *Brenania brieyi* and *Zanthoxylum gilletii* were cited several times by the

Table 1. Information on ichthyotoxic plants, recipes, mode of administration and the diseases they treat.

Species	Family	No of citation	Morphotype	Part used	Diseases treated	Mode of preparation	Mode of administration	Frequency of citation (%)
Pentaclethra macrophylla	Fabaceae	8	Tree	Bark	Convulsive coughing, Bronchitis, Asthma	Decoction	Vapour bath	12.69
Asystasia vogeliana	Acanthaceae	5	Grass	Leaf	Wounds	Blending, Kneading	Instillation	7.93
Tephrosia vogelii	Fabaceae	39	Shrub	Leaf	Night gunshots, Wounds, Antimicrobial (infections) and Diarrhea	Ash, Powder	Painting	61.90
Tetrapleura tetraptera	Fabaceae	19	Tree	Bark	Febrifuge	Maceration	Drink (herbal tea), enema (purge)	30.15
Manihot esculenta	Euphorbiaceae	1	Shrub	Leaf	Chicken pox, Heals cuts	Blending	Massage	1.58
Vernonia colorata	Asteraceae	4	Shrub	Leaf	Antiparasitic, Febrifuge, Scabies	Decoction, Blending	Purgatif, bathing	6.34
Pentaclethra eetveldeana	Fabaceae	1	Tree	Bark	rib pain	Decoction	Drink	1.58
Anthocleista vogelii	Loganiaeae	2	Tree	Fruit	Used to purge	Maceration	Purgatif	3.17
Zanthoxylum heitzii	Rutaceae	5	Tree	Bark	Stomach pain, Cervical cancer	Decoction	Drink	7.93
Carica papaya	Cariaceae	2	Tree	Leaf	Malaria (roots, leaves)	Decoction	Drink	3.17
Elaeophorbia drupifera	Euphorbiaceae	2	Shrub	Leaf	Paronychia (leaves)	Braising, Kneading	Poultice, Brushing	3.17
Chromolaena odorata	Astéraceae	10	Grass	Leaf	Ulcer, Sinusitis, Injuries, Stomachache, Antimicrobial	Trituration	Instillation	15.87
Fillaeopsis discophora	Fabaceae	2	Tree	Bark	Facilitates childbirth in pregnant women	Decoction	Drink	3.17
Cylicodiscus gabunensis	Fabaceae	11	Tree	Bark	Stomach pain and rheumatism	Decoction, Evaporation	drink, vapour bath	17.46
Brenania brieyi	Rubiaceae	8	Tree	Bark	Gastrointestinal disorders, Rib and heart ailments	Decoction, Evaporation	drink, vapour bath, Purgatif	12.69
Adenia lobata	Passifloraceae	4	Lianas	Leaf	Clears the nostrils and Flu	Maceration, Trituration	Instillation	6.34
Pausinystalia johimbe	Rubiaceae	2	Tree	Bark	Aphrodisiac	Maceration, Mastication	Ingurgitation	3.17
Colocasia esculenta	Araceae	1	Grass	Leaf	Inflammation of the subcutaneous cell tissue	grating	Poultice	1.58
Justicia extensa	Acanthaceae	1	Grass	Leaf or whole plant	Ringworms, Fungal infections, Healing wounds	Blending, Crushing	Brushing, Purgatif,	1.58
Palisota hirsuta	Commélinaceae	3	Grass	Seve	Pain, Healing umbilical cord injuries	Root scraping	Poultice	4.76
Diospyros piscatoria	Ebenaceae	2	Tree	Fruit	Against helminths	Decoction	Drink	3.17
Strychnos aculeata	Loganiaceae	8	Lianas	Fruit	Antimalarial, Wounds, Varicella, Dermatoses	Decoction, Blending	Drink	12.69
Zanthoxylum gilletii	Rutaceae	7	Tree	Bark	Wounds, Ulcers	Powder	Dusting	11.11

Table 1. Contd.

Erythrophleum ivorense	**Fabaceae**	**3**	Tree	Bark	Purification, Wounds	Decoction, Grating	Vapour bath, Cataplasm	**4.76**
Pachyelasma tessmannii	Fabaceae	1	Tree	Bark	Rhumatism	Decoction	Vapour bath	1.58
Erythrophleum suaveolens	Fabaceae	3	Tree	Bark	Dermatoses, chickenpox	Decoction	Cataplasm	4.76
Raphia sp	Palmeae	2	Tree	Fruit	Abscess	Oil	Whitewashing	3.17
Chrysophyllum africanum	Sapotaceae	1	Tree	Bark	Hemorroides	Evaporation	Intimate bath	1.58
Cactus Euphorbia	Euphorbiaceae	2	Grass	Whole plant	Anthelminths	Maceration	Purge	3.17
Cissus quadrangularis	Vitaceae	2	Lianas	Leaf	antifilaria, women stomach ache	kneading, grating	Whitewashing	3.17
Bridelia ferruginea	Euphorbiaceae	3	Shrub	Bark, fruit	malarai, wounds	Decoction, grating	Drink, vapour bath	4.76
Nauclea latifolia	Rubiaceae	4	Shrub	Leaf	malaria, fever, tooth ache	Maceration	Drink	6.34
Desmodium velutinum	Fabaceae	2	Shrub	Leaf	Wounds, Antimalaria	grating, Decoction	Cataplasm, drink	3.17
Guarea cedrata	Meliaceae	3	Tree	Bark	Stomach ache, Gonorrhea	Decoction Maceration	Drink	4.76
Baillonella toxisperma	Sapotaceae	3	Tree	Bark, fruit	Secondary sterility, Rhumatism	Decoction	Vaginal bath	4.76
Macaranga saccifera	Euphorbiaceae	1	Tree	Bark	Abscess	Rust	Cataplasm	1.58
Cayratia pedata	Vitaceae	2	Lianas	All parts	Back ache	Rust	Massage	3.17

respondents (Figure 3). The majority of plants identified were trees (60%), followed by shrubs (18%) and small proportions of lianas (12%) and grasses (10%) (Figure 4A). The parts of the plants used during fishing were barks, leaves, fruits, sap and even the whole plant in the case of certain lianas and herbs. It was noticed that the bark (53%) is the most used plant part followed by the leaves (30%). A small proportion of fruits (11%), saps (3%) and whole plants (3%) were recorded (Figure 4B).

In addition, comparing the toxic effects of each plant part revealed that for all the trees studied, the fruits took less time to intoxicate fish than the bark (Wilcoxon test 1, W = 100, Padj = 0, 009567) (Figure 5A). In the case of shrubs, the leaves took less time than the saps (Wilcoxon test 3, W = 89.5, Padj = 0.00302) (Figure 5B). However, no significant difference was obtained between the leaves and fruits of the shrubs (Wilcoxon test 1, W = 62, Padj = 0.3834) (Figure 5B). Similarly, the time taken to kill the fish did not differ significantly between the use of sap and fruit (Wilcoxon test 2, W = 25.5, Padj = 0.06566) (Figure 5B).

Ethnobotanical results showed that most plants are used in association, and the different modes of their preparation were crushing, crumpling, and cutting. Grinding (74%) was the most used technique, even though some people conducted crumpling (15%) and cutting (11%) (Figure 6).

Ethno-pharmacological characteristics of ichthyotoxic plants

For the use of ichthyotoxic plants in traditional medicine, the results obtained showed high usage by men (65%) than women (35%) (Figure 7A). It was also found that several methods were used for drug preparation to facilitate their administration. Decoction, maceration, powder, grating, roasting and expression were the main methods of drug preparations used in the study area. However, decoction (43%) was the most used preparation approach (Figure 7B).

In general, this ethno-pharmacological study has made it possible to distinguish 14 recipes based on medicinal plants which are likely to treat several diseases. The ichthyotoxic species considered as herbal medicines and the frequency of their usage, the different recipes, their mode of preparation and administration are recorded in Table 1. Figures 8, 9 and 10 show three fish poisonous plants collected during this

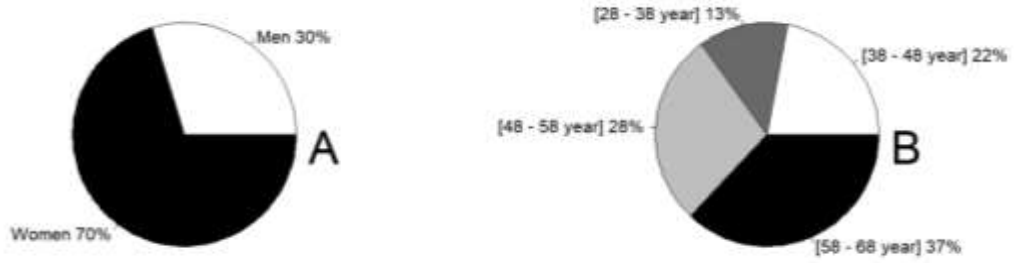

Figure 2. Distribution of the frequency of usage of ichthyotoxic plants by sex and by age group. A – frequency by sex ; B – frequency by age cohort

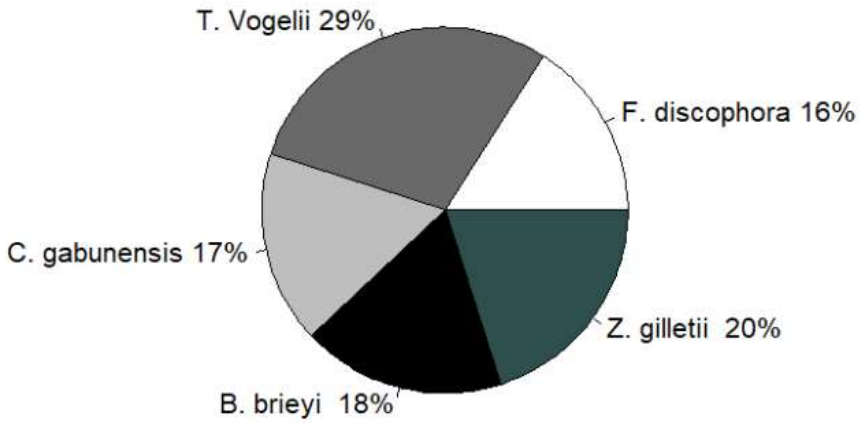

Figure 3. Distribution of major plant species, expressed in percentage of the total ichthyotoxic plants documented in the study localities.

study.

DISCUSSION

The ethnobotanical studies conducted in several localities in Gabon made it possible to identify several morphological types of plants involved in fishing practices, that could be associated to the group of into rivers to intoxicate the fish, numb it, and then capture it very easily. It is a known fishing practice in almost all parts of the world (Kimpouni et al., 2011). It has been reported in other African countries such as Republic Democratic of Congo (Koto-te-Nyiwa et al., 2018) and Nigeria (Akpa, 2010). In addition, it is important to recall that the drunken behavior of fish is due to the phytochemicals of these ichthyotoxic plants. The chemical composition of many ichthyotoxic plants has already been the subject of several studies, and the capture it very easily. It is a known fishing practice in almost all parts of the world (Kimpouni et al., 2011). It has been reported in other African countries such as Republic Democratic of Congo (Koto-te-Nyiwa et al., 2018) and Nigeria (Akpa, 2010). In addition, it is important to recall that the drunken behavior of fish is due to the phytochemicals of these ichthyotoxic plants. The chemical composition of many ichthyotoxic plants has already been the subject of several studies, and the main active compounds identified were rotenone, saponins and tephrosin (Mouele et al., 2021). Recently, (Mouele et al., 2021) reported in a phytochemical study the presence of certain secondary metabolites which could be strongly involved in the plant poison. On the other hand, the difference observed could be linked to the high experience of men in the field of indigenous medicine. In Gabon, women are more specialized in the field of artisanal fishing, while men are destined for hunting.

Our results are similar to those of other authors from Cameroon (Ngoule et al., 2015) and Ivory Coast (N'guessan et al., 2011), with 60.41 and 87% of men reported to have a high knowledge on the use and properties of medicinal plants. It appears that knowledge of the use of plants is acquired through long experience (Ghourri et al., 2012). Our study suggests that men whose ages varied between 58 and 68 years had high knowledge on ichthyotoxic plants compared to all the

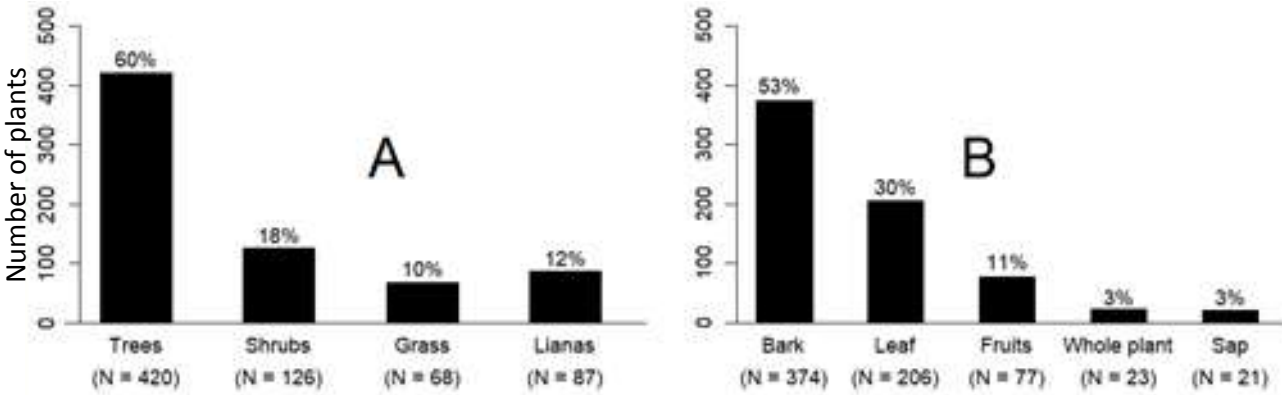

Figure 4. Distribution of the plant species by morpotypes and the importants of parts used. A –Morphotypes of the plants used; B – Plant parts used.

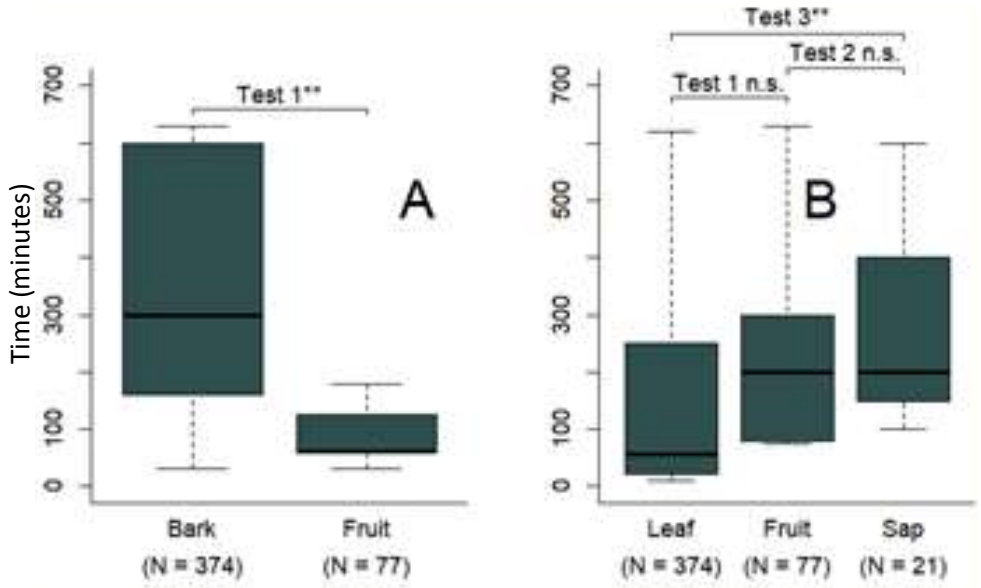

Figure 5. Effects of the different trees and shrub parts with time. The two asteriks (**) on the same boxplots represents p<0.001 (statistically significant difference); n.s on the same boxplots represents a non statistically significant difference.

other age groups of the study population. This agrees with the results of the study of Ghourri et al. (2012) which revealed that older people had high knowledge on medicinal plants than their younger counterparts. Similarly, Gbékley et al. (2015) indicated that the practice of traditional medicine was the prerogative of middle-aged men.

This ethnobotanical and ethno-pharmacological study shows that Gabon has a great floristic diversity of interest in terms of medicinal plants for the treatment of several diseases. Some plants whose proportions are shown in Figure 3 have been studied severally (Kwenzi et al., 2009; Kimpouni et al., 2011). Some diseases such as hemorrhoids, malaria, sinusitis, chickenpox and many more have been cited, and the plants used to treat them are documented. In addition to these pathologies, the « night gunshot » has been identified as a socio-cultural disease. This condition of witchcraft origin (disease due to bewitchment) could sometimes come up against the treatment options of modern medicine (Missounga et al., 2018).

The present study showed that barks (53%) and leaves (30%) were the most frequently used parts of plants and the decoction preparation (43%) was the mode of preparation often practiced by traditional healers. These results are consistent with those of Gnagne et al. (2017)

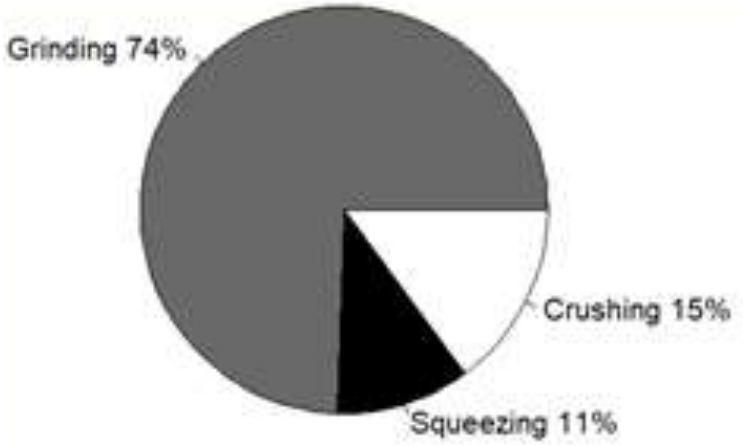

Figure 6. The distribution of the modes of preparation for fishing. The population proceed with 74% grinding, 15% squeezing and 11% cutting of plant parts used.

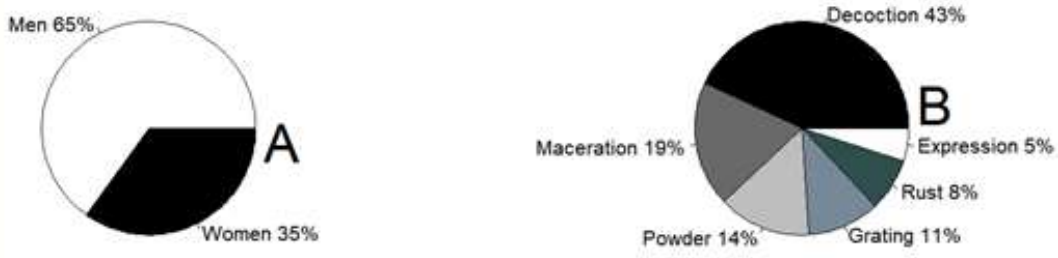

Figure 7. Distribution of the frequency of use of ichthyotoxic plants with sex and mode of preparation of phyto-medications. A – Frequency of use of plants by sex; B – Preparation modes of phyto-medications.

Figure 8. *Zanthoxylum heitzii* (Rutaceae) collected in the Ogooué - Ivindo province precisely in the PK18 village.

Figure 9. *Euphorbia cactus* (Euphorbiaceae) collected in the Nyanga province precisely in the Gnoumbitsi village.

Figure 10. *Tephrosia Vogelii* (Fabaceae) collected in the Haut – Ogooué province precisely in the Ndjoutou village.

and Kpabi et al. (2020) who indicated that decoction is the galenic form mostly used by traditional healers in the Department of Zouénoula in Ivory Coast and the prefecture of Doufelgou in Northern Togo. Moreover, the study of Fah et al. (2013) already indicated that plant medicines were essentially prepared by decoction. Most of the plants were used both for fishing and in traditional medicine. For instance, the fruits of *Raphia* sp and the leaves of *Manihot esculenta* were combined to increase toxicity, and the leaves of *Carica papaya* and *T. vogelii* were combined to asphyxiate fish faster (Mouele et al., 2021).

In view of the frequency of citations from respondents, it appears that *T. vogelii* (61.90%) and *T. tetraptera* (30.15%) seem to be the well-known ichthyotoxic plant species in the populations of the different localities studied. Data from literature show that these are plant species frequently used in fishing and in traditional medicine in several countries around the world (Dougnon et al., 2015; Mouele et al., 2021).

The present study demonstrates that not all plant parts have the same degree of toxicity. Indeed, from the results of this study, fruits seemed to be more effective than the peels when used as fish poison. However, it is known that the bark is the site for the production and even the storage of secondary metabolites responsible for the biological properties of the plant (Vandi et al., 2016). Therefore, the barks of plants must have had a much more intense biological activity than the fruits. On the other hand, a study revealed that fruits were widely requested by people for medicinal preparation (Sereme et al., 2008).

Conclusion

The present ethnobotanical and ethno - pharmacological study carried out in several localities of the seven provinces of Gabon revealed 16 botanical families involved in both fishing and traditional medicine. These are a few trees, shrubs, lianas and herbaceous plants found in most forests and savannahs of Gabon. The different parts of these plants can be used in the form of ashes or powder, or in decoction, and even in maceration to cure several diseases. Of all these diseases, we cite the ‘night gunshot’ of witchcraft origin, which modern medicine sometimes comes up against. Other diseases such as hemorrhoids, malaria, sinusitis and chickenpox have been reported. Overall, this study made it possible to collect the necessary data that could allow for the assessment of the risks of intoxication that people who consume fish caught from ichthyotoxic plants could be exposed to. Also, this is a pilot study which could permit the understanding of the Gabonese medicinal flora, and which could probably serve as a database for subsequent research in pharmacology.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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