

Importance of *Massularia acuminata* (Myrtaceae), *Piptadeniastrum africanum* (Fabaceae), and *Costus afer* (Zingiberaceae), Three Plants of the Cameroonian Traditional Medicine Used in the Treatment of Sinusitis by the Village Populations of Bomb-Lissomb and the Medicinal Plants' Sellers of the Douala Goat Market

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Abstract

Costus afer, *Massularia acuminata* and *Piptadeniastrum africanum* are three plants used in Cameroonian traditional medicine to treat sinusitis. The aim of this study is to justify the interest granted to this three species in the treatment of this disease and to promote their sustainable management. The study was carried out at Bomb-Lissomb and at the goat market.

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Several types of data were collected: data on the use of these plants in traditional anti-sinus medicine, data on their varied other uses by local residents, data on the availability of these plants as well as data on the interest that these species could generate. Furthermore, the evolution of treatment in patients who received plant extracts was followed after two months to justify their efficiency against sinusitis. The technique used for the removal of organs from the plant's vegetative growth was described. Finally, phytochemical screening of extracts obtained after aqueous maceration of plant organs was performed. Amongst the informants who took part to this study, 17 mentioned barks of *Piptadeniastrum africanum* and 29 mentioned fruits of *Massularia acuminata* to treat sinusitis. Treatments administered to patients are made either from monospecific recipes or from a mixture of two or three plants. The average duration of treatment is 29 days when patients are only treated with fruits of *Massularia acuminata* and 12 days when they are subjected to treatments based on a recipe made from stem barks of *Piptadeniastrum africanum* and fruits of *Massularia acuminata*. Treatment seems to be effective from the 2nd time the medication is taken. Harvesting techniques allowing large quantities of organs to be removed from a few individuals affects the regeneration of these individuals. Stems barks and leaves of *Massularia acuminata* contain almost the same bioactive compounds as fruits.

Keywords: *Costus afer*; *Massularia acuminata*; *Piptadeniastrum africanum*; sinusitis; sustainable management.

1. Introduction

The use of plants for therapeutic purposes is reported in ancient literature, Arabic, Chinese, Egyptian, Hindu, Greek, Roman [1]. In Africa, the therapeutic potential of plants was known empirically by our ancestors; but in 1978, the World Health Organization (WHO) made a firm commitment to revalorize the traditional pharmacopoeia in order to meet the health needs of the populations [2]. As a result of this reconsideration of traditional medicine, the renewed interest in medicinal plants as a means of overcoming suffering and improving human health has increased in the health systems of both developing and industrialized countries [3, 4, 5]. Indeed, health care is highly dependent on medicinal plants and associated local knowledge [6, 7]. Starting from this and leading to the fact that plant extracts account for nearly 60% of current medicines; and that nearly 40% of synthetic medicines are often from the chemical synthesis of natural molecules or parts of molecules [5, 8]; it is necessary to continue with ethnobotanical studies in order to make a greater inventory of plant species and their local uses [9, 10, 11, 12]. Numerous studies, as disparate as they may be, have tried to identify traditional medicinal plants that relieve respiratory tract ailments [11, 13, 14]. These conditions are the second most common cause of death in Cameroon after HIV (21%) and before malaria (8%) [15]. From these studies, it appears that sinusitis, an inflammatory or infectious reaction located in the nasal cavity, is treated by three plants commonly used in the Cameroonian traditional medicine. More specifically, these are *Costus afer*, *Massularia acuminata* and *Piptadeniastrum africanum* [11, 14]. Currently in Cameroon, interest in herbal medicine is on high and the sale of medicinal plant organs has become a very lucrative income-generating activity [10, 16, 17]. Thus, traditional medicine, because of its economic contribution, has become the prerogative of many charlatans who sometimes do not have a perfect mastery of the recipes they prescribe or administer to patients. This being the case, there is very often a bias in the information collected during ethnobotanical surveys and, consequently, a margin of reserve regarding this information [10]. However, studies on the biological effects of active plant compounds would therefore be an asset to justify their use in the treatment of diseases and would reinforce the

credibility of the information collected during ethnobotanical surveys [18, 19, 20, 21]. *Costus afer* (Zingiberaceae or Costaceae) is a large herbaceous plant widespread throughout intertropical Africa [22, 23, 24]. It is a species of the secondary formations with a water-soaked cylindrical stem. Its oval, elliptical leaves are 15 to 20 cm long and 4 to 7 cm wide. *Costus afer*, commonly known as twin cane, takes the name 'Mien' in Ewondo [11, 14]. *Piptadeniastrum africanum*, which is a large tree belonging to the Fabaceae family, can reach a height of 50-65 m with a smooth, sometimes ringed bark surface [25]. Its dense dark green foliage dominates the forest. It is supported by extensive and sometimes very large buttresses. Its bipinnate leaves are composed of tiny leaflets reminiscent of a fern. Commonly called sapwood, *Piptadeniastrum africanum* is called 'Atui' by the people of the southern forests and 'Dempah' by those of the western highlands [11, 14]. *Massularia acuminata* (G. Don) Bullock ex Hoyle is a shrub that grows naturally in the forests of the south and those of the Cameroonian coast. Known as Chimpanzee Guava, this shrub of the understorey of the closed forest, which can reach a height of 9 m, is locally known as 'Oyebe'. Its wood is hard and solid. The heartwood is resistant to termites [26]. To date, the majority of studies have focused on identifying plants and their therapeutic interests [9, 10, 11, 12, 17]. Very few studies have focused on the 'resource' and its sustainable management [17, 27, 28]. Indeed, the plants of interest are under pressure due to regular and uncontrolled removal of organs which are brought to the markets where Non-Timber Forest Products (NTFPs) are sold in order to satisfy the growing consumer demand [27, 29, 30, 31]. At this rate, Cameroon's forests may not be able to satisfy the excessive demand for plant-based NTFPs for medicinal use in the long term. It would therefore be wise to approach this aspect from the perspective of partial sustainable management of the medicinal component of plant-based NTFPs. The aim of this study is to justify the interest granted to *Costus afer*, *Massularia acuminata* and *Piptadeniastrum africanum* in the treatment of sinusitis and to promote the sustainable management of these species. Specifically, it will: (i) identify the therapeutic uses of these three plants as well as other uses; (ii) examine the techniques for harvesting these organs as well as their management in the markets, (iii) highlight the chemical profile of different organs of each of the plants.

2. Materials and methods

2.1 Study site

The study was carried out in Bomb-Lissomb, a village in the centre Region of Cameroon (Figure 1), as well as in one of the largest markets for the sale of medicinal NTFPs in the city of Douala; the goat market. Bomb-Lissomb 3° 59' 00" north, 10° 47' 00" has an altitude of 276 m; located in the Dibang, Bot-Makak district in the Department of Nyong-et-Kellé. Bomb's population was 244, including 126 men and 118 women, at the time of the 2005 census. This village is mainly characterised by the holding of a periodic market. The Bomb forest is a secondary forest with little disturbance, belonging to the Ngog Mapubi-Dibang massive forest, which is a wooded area of 14,584 ha with significant ecological interest due to the presence of large primates. Actions carried out since 2012 by the Cameroon Environmental Watch (CEW) with the support of IUCN aimed at giving this inter-communal forest a clearly defined conservation and management status. In addition, green economy activities such as ecotourism have been organised in this site [32]. The goat market in the New-bell district, is along with the Nkololoun market and the Dakar market, one of the largest markets for non-timber forest products [20]. In 2015, studies by [33] identified 35 actors in the sale of NTFPs of plant origin with a

medicinal component. These studies showed that in the goat market, the medicinal plant sales' sector was very well structured. The men, 19 in total, are involved in the sale of plant barks, while the women mostly adults, 16 in total, and from West Cameroon, sell organs such as leaves, fruits and sometimes whole plants of certain herbaceous plants [33].

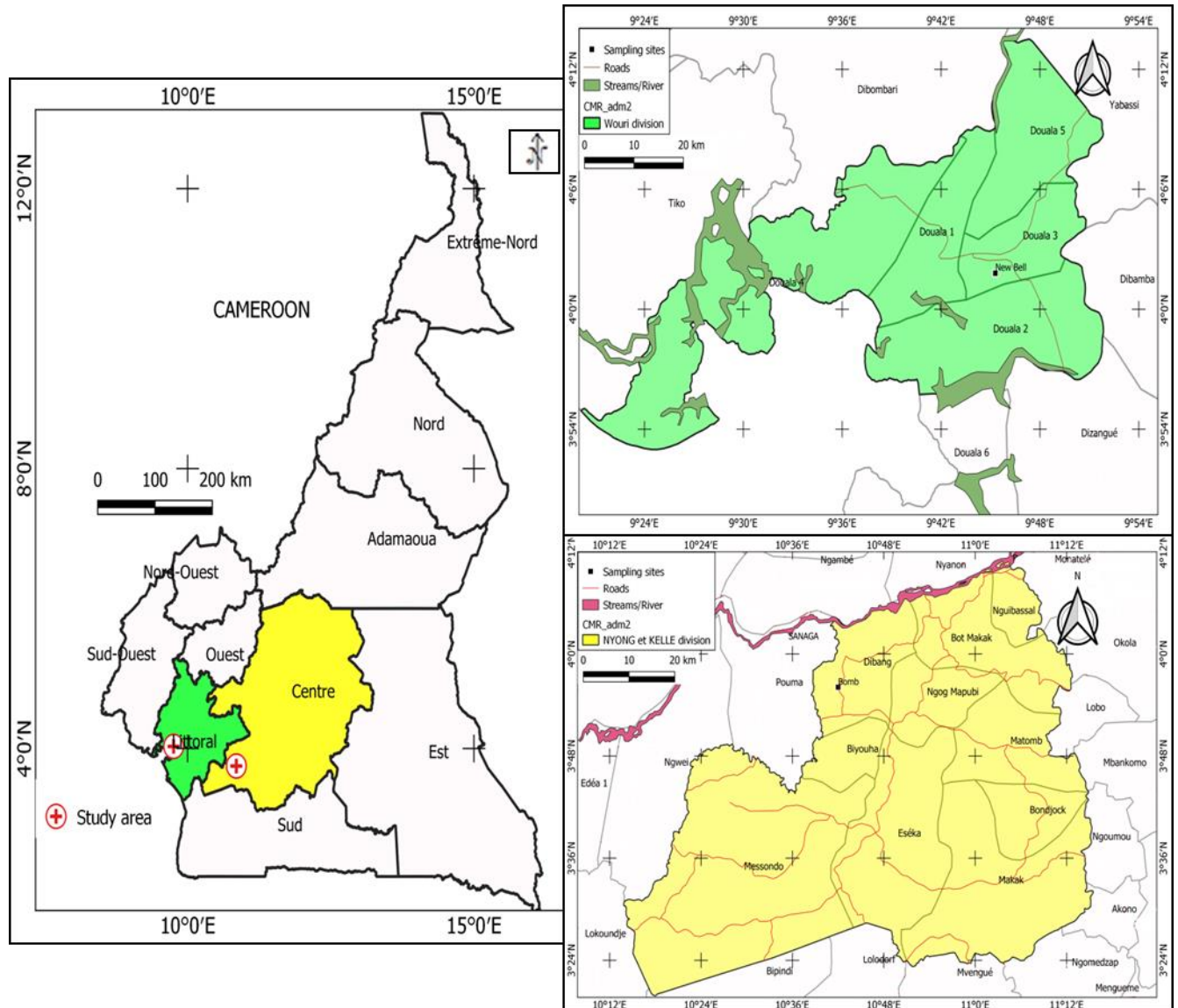


Figure 1: Indicating the different study sites

The choice of village was based on preliminary surveys in the markets which revealed that some organ collectors supplying the markets for medicinal plants were harvesting organs from the Bomb Lissomb village forest, which is a transitional forest between coastal and semicaducifoliated forest. The choice of the market was based on preliminary studies of plants used to treat respiratory tract diseases [11].

2.2 Ethnobotanical surveys

Several types of data were collected at Bomb-Lissomb: data on the use of the three plants in traditional anti-

sinus medicine, data on other medicinal uses of these plants [9, 20, 34]; and data on the various other uses made of them by local residents. In addition, data on the availability of these plants as well as data on the possible interest that these species could generate for local residents were recorded. The same information (sometimes with other details) was collected at the goat market. As an approach used in the villages, visits were made to the local population by going from house to house and proceeding by semi-structured maintenance. The return survey method provided further evidence of the authenticity of the information collected [10, 24]. This method consists of first collecting information on the plant of interest at household level, then, the following day, a diversion into the biotope of the plant in question allows its identification and then a second interview to confirm the information previously collected on the plant. Unlike the first interview, which involved the entire household, this second interview more often involved one household member designated by the head of the household and responsible for accompanying the interviewer to the site where the plant was identified (the plant biotope). At the market, on the other hand, the interview was carried out in a single raid, based on the information obtained beforehand at the Bomb-Lissomb village. In order to justify the therapeutic use of these three plants in anti-sinusitis therapy, a follow-up of patients undergoing treatment with these plants was carried out over a period of two (02) months after the administration of the plant extract in order to be able to highlight the number of patients relieved by the recipe and those whose morbid effects related to sinusitis had disappeared [12, 24]. Specifically, the progress of the treatment was monitored by visiting (once a week) some of the patients and by telephone interviews (once a week) with others. All this depended on the patient's choice of whether to receive the interviewer at home. The patients followed, described the evolution of signs and symptoms related to sinusitis, the number of times they went to the traditional therapist after the first administration of the treatment and the reasons that led them to do so, as well as the side effects or undesirable effects that they experienced during the treatment.

2.3 Organ sample collection

Plant samples were collected *in situ*, in their respective biotope (during village surveys). All plant organs were harvested to continue phytochemical analyses in the laboratory. This harvest was photographed and while it was being carried out, the technique used for the removal of organs from the plant's vegetative growth was described by the harvester. Information on the frequency of organ removal from a specimen was also noted. When this was done for debarking the trees, the number of specimens from which a quantity (10 kg) of bark was removed was also used to assess the harvesting technique. The post-harvest samples were photographed and stored in a control herbarium according to the techniques and methods of [35]. The identification of the plants was confirmed and approved by botanists of the National Herbarium of Cameroon and identification codes were assigned to the plants.

2.4 Preparation of extracts

The plant material included all the plant organs that were the subject of this study. The organ samples were collected in June 2016 in Bomb-Lissomb. They were then dried in the shade at the Laboratory of Biology and Physiology of Plant sciences and after complete desiccation they were crushed using a mechanical grinder and then pulverised until powders were obtained. The aqueous extract of the leaves, fruits, stems and rhizomes of

Costus afer, the aqueous extract of the leaves, fruits, bark and roots of *Massularia acuminata* and the aqueous extract of the leaves, stem barks and root barks of *Piptadeniastrum africanum* were obtained by macerating 50 mg of the powder from each of the organs in 500 ml of distilled water for 24 hours under magnetic stirring. The resulting macerates were filtered on cotton wool and then on number 1 wattman paper, then the filtrates were evaporated in an oven at 60 °C for 72 hours. The extracts thus obtained were stored in the refrigerator at -5 °C.

2.5 Chemical screening of aqueous plant organ extracts

Phytochemical screening of extracts obtained after aqueous maceration of plant organs was qualitatively performed using standard staining and precipitation methods [36]. This analysis determines the composition of secondary metabolites such as flavonoids (cyanidine test), alkaloids (Dragendorff test), saponins (foaming test), triterpenes and steroids (Liebermann-Buchard test), polyphenolic compounds and tannins (ferric chloride test) and coumarins (visualization of the chromatogram at 365 nm) in the plant species [37, 38].

3. Results

3.1 Ethnobotanical surveys

3.1.1 Use of the three plants in anti-sinus recipes

37 informants participated in the current study. As specified in the methodology, in Bomb-Lissomb village, all the informants in a household were considered to have given one piece of information. As a result, 15 informants (households) in Bomb-Lissomb village and 22 informants selling medicinal plants at the goat market participated in the interview. Of these informants, 17 mentioned *Piptadeniastrum africanum* as a plant used to treat sinusitis and 29 were able to identify *Massularia acuminata* as having the same properties. Of the informants who mentioned *Piptadeniastrum africanum*, 13 requested it as the main plant and 4 requested it as an associated plant. In addition, *Massularia acuminata* was requested by 22 informants as the main plant and by the other 7 as a secondary plant for use in anti-sinus mixtures (Table 1). All the informants to prepare the recipes administered to patients to treat sinus disease used exclusively for the *Costus afer* species, the stems; for the *Massularia acuminata* species, the fruits and for the *Piptadeniastrum africanum* species, the stem barks. All these organs are used fresh. The preparation of recipes differs from one informant to another. Some, in addition to *Costus afer*, *Massularia acuminata* and *Piptadeniastrum africanum*, use other species of medicinal plants in association with them. The bark of *Piptadeniastrum africanum*, when used as the main plant, is almost always associated with another plant (11 cases out of 13). Specifically, two (02) informants from Bomb-Lissomb and two (02) informants from the goat market associated the bark of *Piptadeniastrum africanum* with that of *Mammea africana*. In addition, one (01) informant at Bomb-Lissomb and two (02) informants at the goat market associated the bark of *Piptadeniastrum africanum* with that of *Erythrophleum suaveolens*. On the other hand, in the case of *Massularia acuminata*, the juice from the grated fresh fruit is only associated with the sap from the roots of *Musanga cecropioides* in one (01) informant in Bomb-Lissomb village, with the scraping of bark from *Piptadeniastrum africanum* (i.e. 02 cases in Bomb-Lissomb and 02 cases at the goat market) and with the juice from the stems of *costus afer* (i.e. 02 cases in Bomb-Lissomb and 04 cases mentioned at the goat market).

Associations of 3 plants are almost non-existent 8%. Such associations were only recorded among three (03) informants; one (01) at Bomb-Lissomb and two (02) at the goat market.

Table 1: Use of plants in anti-sinusitis recipes

Species	Surveyed		Main plant		Associated plant		Parts used
	V	M	V	M	V	M	
<i>Costus afer</i> (Specimen number: 65988/ IINC)	4	2	0	0	3	3	Stems
<i>Massularia acuminata</i> (Specimen number: 46483/ HNC)	17	12	10	12	3	4	Fruits
<i>Piptadeniastrum africanum</i> (Specimen number: 19102/ HNC)	8	9	5	8	2	2	Stems bark

V=Village, M=Market, HNC= Cameroon National Herbarium

Where they concern associations, the recipes are prepared as follows: Rape a fresh green fruit of *Massularia acuminata* after having previously washed it, then, after having scraped the fresh inner part of the rind of *Piptadeniastrum africanum*, add a few drops of the juice of pressed stems of *Costus afer* previously washed or a few drops of the sap from the roots of *Musanga cecropioides* previously collected. With a dropper or with the help of a traditional funnel made from a leaf of *Musa* sp. or *Anchomanes difformi*, introduce 1 to 2 drop(s) of the preparation into each nostril once a day; preferably before sunrise or after sunset. Head tilted backwards, eyes raised towards the sky for 2 to 3 minutes, avoiding breathing in. Avoid using these recipes more than twice a week; keep them for a maximum of 2 weeks in the open air and away from the sun. Scrape the inner part of the fresh bark (newly harvested organ) of *Piptadeniastrum africanum* and use this scrape by mixing it with the grated bark of *Mammea africana*, or that of *Erythrophleum suaveolens* and or that of the fruits of *Massularia acuminata*. Then add a few drops of water to moisten and homogenise the mixture, and leave it in the open air for 30 to 60 minutes. Using a dropper, make a nasal instillation of 1 to 2 drops of the recipe in each nostril, keeping the head tilted backwards for a few minutes. Avoid using the recipe more than three times a week, store it for a maximum of 2 weeks in the open air and away from the sun.

3.1.2 Follow-up of patients who have received the treatment made from these three plants

The proceeds were administered by traditional therapists (10 at Bomb -Lissomb and 13 at the goat market) to 38 patients (or 20 patients followed by traditional therapists from Bomb-Lissomb village and 18 patients followed by those from the goat market) with sinus disease or with symptoms of sinus disease. The results of the course of treatment are shown in the table below (Table 2). Trad.= Treatment; Pr.= Take; NPPE= Number of takes before the expected effect; Dur.= Duration of treatment; Pat.= Patient; Vill.= Traditional therapists of village; March.= Traditional therapists of Market; Mon. spe.= Mono-specific recipe; Mix 2= Recipe made from a mixture of 2 plants; Mix 3= Recipe made from a mixture of 3 plants; Sem.= Week; Day = Day; Mass. ac.= *Massularia acuminata*; Pip. afr.= *Piptadeniastrum africanum*; Cos. af.= *Costus afer*; Mus. cecr.= *Musanga cecropioides*; Mam. afr.= *Mammea africana*; Ery. sav.= *Erythrophleum suaveolens*

Table 2: Patient follow-up information during the course of treatment

Trad.	Patients	Treatments	NPEE and Dur.	Recurrence	Number of tours at the trad.	Undesirable effects
Vill. A	Pat. A	Mix. 1 (Pip. afr + Mass. acc.)	2 Pr (6 jr.)	No	00	Itchy throat
	Pat. A1		3 Pr (10 jr.)	No	01 (renew the recipe)	Runny nose and itchy throat
	Pat. A2		5 Pr (18 jr.)	No	01 (renew the recipe)	None
	Pat. A3		3 Pr (10 jr.)	No	00	Itchy throat
Vill. B	Pat. B	Mix. 2 (Mass. acc. + Mus. cecr.)	8 Pr (32 jr.)	Yes after 2 months	03 (repeat the recipe and report any side effects)	Itching of the throat and reddening of the eyes
Vill. C	Pat. C	Mon. spec. (Mass. acc.)	6 Pr (24 jr.)	No	01 (report adverse reactions)	Itchy throat
	Pat. C1		8 Pr (32 jr.)	No	05 (renew the recipe)	Feeling of discomfort
	Pat. C2		9 Pr (38 jr.)	No	05 (renew the recipe)	None
Vill. D	Pat. D	Mix. 3 (Mass. acc. + Pip. afr. + Cos. af.)	2 Pr (6 jr.)	No	01 (renew the recipe)	Abundant nasal discharge
Vill. E	Pat. E	Mix. 4 (Mass. acc. + Pip. afr.)	2 Pr (6 jr.)	No	00	None
Vill. F	Pat. F	Mix. 5 (Pip. afr. + Ery. sav.)	6 Pr (24 jr.)	No	03 (report adverse reactions)	Fatigue and violent headaches
Vill. G	Pat. G	Mon. spec. (Pip. afr.)	8 Pr (32 jr.)	No	05 (renew the recipe)	None
Vill. H	Pat. H	Mix. 2 (Mass. acc. + Mus. cecr.)	7 Pr (32 jr.)	Yes after 2 months	04 (repeat the recipe and report any side effects)	Itching of the throat and reddening of the eyes
Vill. I	Pat. I	Mon. spec. (Mass. acc.)	5 Pr (21 jr.)	No	03 (report adverse reactions)	Itchy throat
	Pat. I1		6 Pr (24 jr.)	No	03 (renew the recipe)	Feeling of discomfort
	Pat. I2		4 Pr (14 jr.)	No	02 (renew the recipe)	None

Table 2: Patient follow-up information during the course of treatment (continuation)

Trad.	Patients	Treatments	NPEE and Dur.	Recur- rence	Number of tours at the trad.	Undesirable effects
Vill. J	Pat. J	Mon. spec. (Mass. acc.)	8 Pr (32 jr.)	No	05 (renew the recipe)	None
	Pat. J1		9 Pr (38 jr.)	No	05 (renew the recipe)	Reddening of the eyes
	Pat. J2		5 Pr (20 jr.)	No	03 (symptoms always present and adverse effects)	Itching of the throat, reddening of the eyes and headache
	Pat. J3		9 Pr (38 jr.)	No	04 (renew the recipe)	Ringling in the ears
March. K	Pat. K	Mix. 6 (Pip. afr. + Mam. afr.)	12 Pr (48 jr.)	Yes (No change)	06 (repeat the recipe and report the ineffectiveness of the treatment)	Itching of the throat, excessive salivation, runny nose and nerve pain.
March. L	Pat. L	Mix. 4 (Mass. acc. + Pip. afr.)	02 Pr (08 jr.)	No	00	None
March. M	Pat. M	Mix. 4 (Mass. acc. + Pip. afr.)	5 Pr (20 jr.)	No	02 (repeat the recipe)	Violent headaches and reddening of the eyes
March. N	Pat. N	Mix. 1 (Pip. afr. + Mass. acc.)	03 Pr (14 jr.)	No	02 (repeat the recipe)	Ringling in the ears
March. O	Pat. O	Mix. 3 (Mass. acc. + Pip. afr. +	02 Pr (08 jr.)	No	00	Itchy throat
	Pat. O1	Cos. af.)	03 Pr (12 jr.)	No	02 (repeat the recipe)	Itching of the throat, excessive salivation and ringling in the ears.
March. P	Pat. P	Mix. 4 (Mass. acc. + Pip. afr.)	02 Pr (08 jr.)	No	00	None
March. Q	Pat. Q	Mix. 4 (Mass. acc. + Pip. afr.)	5 Pr (20 jr.)	No	03 (repeat the recipe)	Violent headaches and reddening of the eyes
March. R	Pat. R	Mix. 1 (Pip. afr. + Mass. acc.)	03 Pr (10 jr.)	No	02 (repeat the recipe)	Ringling in the ears

Trad.= Treatment; Pr.= Take; NPEE= Number of takes before the expected effect; Hard.= Duration of treatment; Pat.= Patient; Vill.= Traditional therapists of village; March.= Traditional therapists of Market; Mon. spe.= Mono-specific recipe; Mix 2= Recipe made from a mixture of 2 plants; Mix 3= Recipe made from a mixture of 3 plants; Sem.= Week; Day = Day; Mass. ac.= *Massularia acuminata*; Pip. afr.= *Piptadeniastrum africanum*; Cos. af.= *Costus afer*; Mus. cecr.= *Musanga cecropioides*; Mam. afr.= *Mammea africana*; Ery. sav.= *Erythrophleum suaveolens*

Table 2: Patient follow-up information during the course of treatment (continuation and end)

Trad.	Patients	Treatments	NPEE and Dur.	Recur- rence	Number of tours at the trad.	Undesirable effects
March. S	Pat. S	Mon. spec. (Mass. acc.)	8 Pr (32 jr.)	No	05 (renew the recipe)	None
	Pat. S1		9 Pr (34 jr.)	No	05 (renew the recipe)	Reddening of the eyes
	Pat. S2		5 Pr (20 jr.)	No	02 (renew the recipe)	Itching of the throat, reddening of the eyes and headache
	Pat. S3		10 Pr (32 jr.)	No	05 (renew the recipe)	Ringling in the ears
March. T	Pat. T	Mix. 6 (Pip. afr. + Mam. afr.)	10 Pr (34 jr.)	No	06 (repeat the recipe and report the ineffectiveness of the treatment)	Itching of the throat, excessive salivation, runny nose and nerve pain.
March. U	Pat. U	Mix. 4 (Mass. acc. + Pip. afr.)	02 Pr (08 jr.)	No	00	None
March. V	Pat. V	Mix. 1 (Pip. afr. + Mass. acc.)	04 Pr (15 jr.)	No	02 (repeat the recipe)	Ringling in the ears
March. W	Pat. W	Mix. 3 (Mass. acc. + Pip. afr.)	+02 Pr (08 jr.)	No	00	Itchy throat
	Pat. W1	Cos. af.)	03 Pr (10 jr.)	No	02 (repeat the recipe)	Itching of the throat, excessive salivation and ringling in the ears.

Trad.= Treatment; Pr.= Take; NPEE= Number of takes before the expected effect; Hard.= Duration of treatment; Pat.= Patient; Vill.= Traditional therapists of village; March.= Traditional therapists of Market; Mon. spe.= Mono-specific recipe; Mix 2= Recipe made from a mixture of 2 plants; Mix 3= Recipe made from a mixture of 3 plants; Sem.= Week; Day = Day; Mass. ac.= *Massularia acuminata*; Pip. afr.= *Piptadeniastrum africanum*; Cos. af.= *Costus afer*; Mus. cecr.= *Musanga cecropioides*; Mam. afr.= *Mammea africana*; Ery. sav.= *Erythrophleum suaveolens*

From the table above, we observe patients being subjected to various treatments. Of these, some are mono-specific made from a single organ of a single species. These are: Mon. spe. (Mass. acc.) prepared exclusively from fruits of *Massularia acuminata*, and Mon. spe. (Pip. afr.) prepared only from the bark of *Piptadeniastrum africanum*. Others are mixtures prepared from organs of several species. These are Mix. 1 (Pip. af. + Mass. acc.) prepared from a mixture of *Piptadeniastrum africanum* stem bark and fruits of *Massularia acuminata*, Mix. 2 (Mass. acc. + Mus. cecr.) prepared from the fruits of *Massularia acuminata* and the root sap of *Musanga cecropioides*; Mix. 3 (Mass. acc. + Pip. afr. + Cos. af.) prepared from the fruits of *Massularia acuminata*, the bark of *Piptadeniastrum africanum* and stems of *Costus afer*. Mix. 1 and Mix. 4 are identical recipes. Traditional therapists, to differentiate between these two mixtures are based on the amount of organs they use. For these, the organs of the plant used as the main plant are used in a larger quantity in the mixture than the organs of the so-called associated plant, whose use in the mixture may be optional. In the villages, the Mon. spe. (Mass. acc.) is the most popular one. It is administered to 10 of the 20 patients whose treatment progress has been monitored in the villages. Mix. 1 and Mix. 4 composed of the same species of medicinal plants were requested once each by the traditional therapists of the Bomb-Lissomb village. On the other hand, traditional therapists in the market, out of the 18 patients subjected to various anti-sinus treatments, preferentially administer the recipes made from the stem barks of *Piptadeniastrum africanum* and the fruits of *Massularia acuminata* (or 3 patients subjected to the treatment based on Mix. 1 and 5 patients treated with Mix 5). Moreover, Mon. spe. (Mass. acc.) is requested as treatment for 4 of the 18 patients whose follow-ups were done in steps. The maximum number of times a treatment is taken is 12 for a duration of said treatment which is spread over 48 days. The average duration of treatment is 29 days when patients are treated with Mon. spe. (Mass. acc.) and 12 days when they are subjected to treatments based on the recipe made from the stem barks of *Piptadeniastrum africanum* and the fruits of *Massularia acuminata*. Patients undergoing the various treatments suffer from many side effects, including itchy throats, excessive salivation, runny noses, nerve pain (severe headaches) and ringing in the ears. The treatment seems to be effective from the 2nd time the medication is taken. Patients very often return to the therapist to repeat the recipe and to report any side effects. The average number of days between one dose and another is 3.71 (approximately 4 days). Recipes are renewed after 6 to 7 days on average. Informants recommend that this should be done after one week. Thus, each preparation will be used for a maximum of 2 takes. Only one (01) case of non-healing was recorded in patient I (Pat. K) who received the mixture of *Piptadeniastrum africanum* bark and *Mammea africana* bark as a recipe. In addition, two (02) cases of recurrence were recorded after the end of the treatment, notably in patient B (Pat. B) and patient H (Pat. H) who received the mixture of the fruits of *Massularia acuminata* and the sap from the roots of *Musanga cecropioides*.

3.2 Interest in the organs of the three plants and techniques for harvesting these organs

3.2.1 Other uses of plant organs and their availability at village and market level

The therapeutic uses of the three plants, the other uses made of them by the Bomb-Lissomb populations and information on the cost of organs sold at the Goat Market are contained in the table below (Table 3).

Table 3: Other uses and costs of different organs of the three plants

Plants	Organs	Other diseases treated	Other uses	Availability/Sampling frequency /Cost	
<i>Massularia accuminata</i>	Leaves		Fishing poison	Available (high demand)	
	Stem barks	1. Dental pain 2. Bad breath	Toothbrush (bark of the stem)	available (rarely used) Sampling frequency = low	
	Fruits	1. Inflammation of the spleen 2. venomous stings and bites		Rare (seasonal) Sampling frequency = high Small fruit 2g at 0.45 USD Medium fruit 5g to 0.63 USD Big fruit 8g at 0.90- 1.09 USD	
	Roots	1. Aphrodisiac (increases libido, sexual weakness)		Rare (pile of small roots weighing 17-20g at 2.72 USD) Sampling frequency = low	
<i>Piptadinastrum africanum</i>	Leaves	1. Abdominal pain 2. Gonorrhoea		Available (rarely used) Sampling frequency = low	
	Stem barks	1. Cough 2. Bronchite 3. Headache, 4. Hemorrhoids 5. Gastric pain 6. Dysmenorrhoea 7. Urogenital infections 8. Male impotence	Fishing poison Arrow poison Soap substitute	Available (high demand) Sampling frequency = very high 2.72 USD the 50kg net 2.72 USD a 500g fragment of bark	
	Fruits				
	Roots	1. Abortive 2. Aphrodisiac		Rare (rarely used) Sampling frequency = low	
	<i>Costus afer</i>	Leaves	1. Headache with dizziness 2. Edema 3. Fever 4. Rheumatism	Ceremonial and religious purposes	Available (high demand) 0.18- 0.36 USD the leafy stem Sampling frequency = very high
		Stems	1. Cough 2. Breathing problems 3. Sore throat 4. Urethral discharge, 5. Venereal diseases 6. Jaundice 7. Open wounds (healing)		
	Fruits	1. Increases the heart rate (tachycardia)		Available (rarely used) Sampling frequency = low	
	Roots	1. Stomach aches		Available (rarely used) Sampling frequency = very high	

From the table above, the stem barks of *Piptadinastrum africanum* and the stems of *Costus afer* are used in the

treatment of many diseases (8 and 7 respectively). In addition, *Piptadeniastrum africanum* stem barks and *Costus afer* stems, although in high demand, are still available both at the goat market and at Bomb-Lissomb village (Figure 2). The difference is in cost. The stem barks of *Piptadeniastrum africanum* is of equal mass, more expensive than *Costus afer* stems. The stem barks and fruits of *Massularia acuminata* are used for two therapeutic purposes each, they are rare organs on the goat market (the fruit is seasonal) and very expensive (ranging from 0.45 to 1.09 USD per fruit). In Bomb-Lissomb, the populations use the stems as a traditional toothbrush.



ruits of *Massularia acuminata*



Stem barks of *Piptadeniastrum africanum*



Stem of *Costus afer*

Figure 2: Organs of the three plants involved in the treatment of sinusitis

3.2.2 Removal of organs from the vegetative bearing of specimens

Massularia acuminata and *Piptadeniastrum africanum* are woody species and therefore have a 'k' development strategy, whereas *Costus afer* is an herbaceous species with an 'r' development strategy. Interviews with the respondents and various visits to the sample collection site made it possible to identify different harvesting techniques. These techniques include, among others:

- for the fruit of *Massularia acuminata*, the picking is done by simple picking of ripe fruit or by hand.

- for the stem barks of *Piptadeniastrum africanum* and the stem barks of *Massularia acuminata*, partial bark removal with a knife or, to a lesser extent, girdling with a machete (Figure 3).
- for the stems of *Costus afer*, and the roots of *Massularia acuminata*, the removal is done by completely uprooting the specimen.

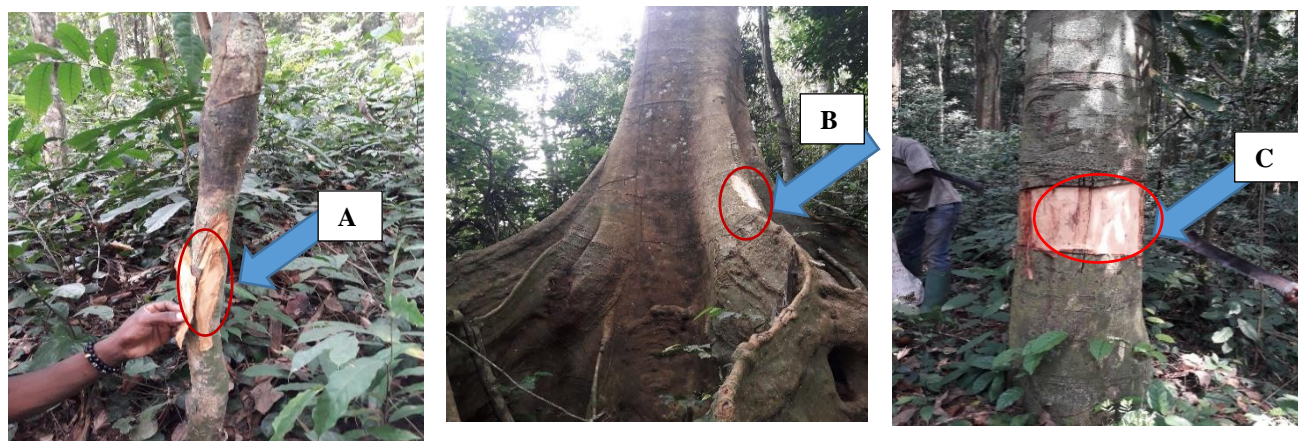


Figure 3: Organ removal from the vegetative growth of specimens

(A) sampling to ensure the reconstitution of the bark of *Massularia acuminata*, (B) sampling of the bark of *Piptadeniastrum africanum* ensuring the reconstitution of the specimen, (C) complete girdling of the trunk of *Anonidium manii* (sampling which starts on the reconstitution of the specimen).

The collection of bark from *Piptadeniastrum africanum* is not an easy practice. Organ harvesters (25%) are placed above the buttresses to collect the bark from the trunk. This harvesting technique, although not very practical, makes it possible to obtain 10 kg of bark from very few specimens (about 3) without leading to the girdling of the specimen. Another technique, less restrictive than the previous one, aims to collect bark as it leaves the foothills (Fig. 3B). This technique, which is practiced by more than 65% of bark collectors from the vegetative growth of *Piptadeniastrum africanum*, involves more specimens (i.e. 9 individuals) to fill a 10 kg bag.

3.3 Establishment of the phytochemical profile of the organs of the three plants

To reduce the pressure on specimens and to compensate for the shortage of certain seasonal organs, it was decided to enhance the use of other plant organs by establishing a phytochemical profile of the plants. The results of the chemical screening contained in Table 4 reveal that the stems bark and leaves of *Massularia acuminata* contain practically the same bioactive compounds as the fruits, the latter sometimes revealing more intense colours for the aqueous extracts of the leaves and barks. Alkaloids were found to be more intensely coloured in the leaves, as were triterpenoids, which are present in the aqueous extracts of the leaves and absent in the fruit. In addition, sterols have been found to be absent in the fruit, with intense colouring in the aqueous extracts of the leaves and bark. In the aqueous leaf and bark extract of *Piptadeniastrum africanum* we note the presence of alkaloids and flavonoids which are not revealed in the bark aqueous extract. In addition, fruits,

leaves and rhizomes extracts of *Costus afer* presented many bioactive compounds that were not revealed in the stem extracts.

Table 4: Result of the chemical screening of the aqueous extracts from the organs of the three plants

Drugs (aqueous extract)		P	Tag	Tac	A	T	AN	F	ST	Co	Sa
<i>Massularia acuminata</i>	Stem barks	-	+	+	+	-	-	-	++	-	++
	Fruits	++	++	++	+	-	-	++	-	+	++
	Leaves	+	+	++	++	++	-	+	++	-	++
	Roots	/	/	/	/	/	/	/	/	/	/
<i>Piptadeniastrum africanum</i>	Stem barks	++	++	++	-	-	-	-	-	+	+
	Leaves	++	+	+	++	-	-	+	-	-	+
	Root bark	+	+	+	+	-	-	+	+	-	+
<i>Costus afer</i>	Stems	+	+	+	+	-	-	-	-	-	-
	Fruits	+	-	-	+	++	+	+	++	-	++
	Leaves	+	+	+	+	+	-	+	+	-	+
	Rhizomes	+	-	-	+	+	-	++	+	-	++

P= Polyphenols, T= Triterpenes, A= Alkaloids, Tag= Gallic tannins, Tac= Catechic tannins, AN= Anthraquinones, F= Flavonoids, ST= Sterols, Co= Coumarins, Sa= Saponins, Ant= Anthocyanins, -= Absence, += Presence, ++ = Strong presence.

4. Discussion

The authors in [39] define a traditional health practitioner as "a person recognized by the community in which he or she lives as competent to diagnose diseases and disabilities prevalent in that community, to provide health care through spiritual treatments, manual techniques and exercises and/or the use of substances of vegetable, animal and/or mineral origin". These authors also point out that, in addition to traditional health practitioners proper, there are traditional herbalists, exorcists, masseurs, midwives and traditional pharmacists who are also linked to the progress of science and medicine in urban areas. All the naturopaths described by these authors contributed to this study except for masseurs and midwives. The rise of herbalists and naturopaths, who are trained and practicing in the sale of medicinal plants in urban markets, is proving to be a considerable asset for the conservation of indigenous knowledge and know-how of the local pharmacopoeia. The results on the different methods of preparation and recipes administration are consistent with those of [14]. These authors in conducting studies on plants used against respiratory tract ailments in villages in the Centre Region of Cameroon already presented sinusitis as a well-controlled disease by the traditional therapists of this region who already mentioned these three species as capable of reducing the morbid effects of sinusitis. The work of the authors in [11] further corroborates these results. These authors found that in the treatment of sinusitis, the traditional therapists, when they used *Costus afer*, *Massularia acuminata* and *Piptadeniastrum africanum*, used exclusively stems, fruits and bark respectively; all in a fresh state. The recipes administered for sinusitis are taken by nasal instillation of 1 to 2 drops per nostril. These recipes are constantly renewed (i.e. a new preparation every 6 to 8 days) [11, 14]; found similar results in their work. Sinusitis being described as sinus inflammation and the microbial strains responsible for this disease being in the nasal sinuses could explain the preferred use of the nasal route for the administration of anti-sinus recipes [40]. However, during interviews

with traditional therapists, they emphasise that this method of administration is very painful and calls for tenacity and vigilance on the part of the patient, who must follow their recommendations to the latter. Mono-specific recipes (44%) are used by traditional therapists as well as recipes made by an association of organs. Reference [11] found 18% mono specific recipes against 82% of plant associations. Bomb-Lissomb traditional therapists preferentially associate the bark of *Piptadeniastrum africanum* with the organs of other plants. They rarely use recipes of more than 03 plants (cases of association of 3 plants representing only 8%). The mono specific associations are precisely for *Massularia acuminata*. The authors in [41, 42] in Ivory Coast, found that the preponderance of mono specific recipes is to the advantage of patients; because they say that in Africa, about 30% of fatal accidents caused by traditional medicines are due to the use of mixtures. This opinion is far from being shared by the traditional therapists in Cameroon, who generally prepare medicines with at least two to three plants to treat illnesses. They use mixtures because each plant has a specific role to play in treating the symptoms of a disease [10, 11, 14]. Although not very toxic as defined by some authors, herbal medicinal preparations are not without danger. Follow-up of patients undergoing anti-sinus treatment shows that only 6 out of 22 patients had no adverse effects. 73% of patients experienced at least one adverse effect throughout the course of treatment. The notion of dose has always been a controversial issue, leading to the unfavourable prejudices that have been held for centuries about traditional medicine. However, the traditional funnel-based dropper counts made from the leaves of *Musa* sp., *Xanthosoma sagittaefolium* or *Anchomanes difformis* allow the dose of '2 drops per nostril' to be respected when administering anti-sinus recipes and therefore to be controlled. In addition to this notion of dose to be respected, there is also the notion of precautions to be taken as indicated by the traditional therapists. Failure to respect these precautions, associated with the proven toxicity of *Piptadeniastrum africanum* and/or *Massularia acuminata* as noted by 38% (i.e. 8 at Bomb Lissomb and 6 at the goat market) of the traditional therapists could be the cause of the various undesirable effects noted in patients undergoing treatment. This is all the more true as when spraying the bark of *Piptadeniastrum africanum* a facial mask is recommended as this powder is highly irritating to the eyes and nasal passages, causing sneezing. The goat market's tradi-therapists recommend it in case the nasal passages are blocked by an excess of fluid or mucus. Moreover, the therapists point out that the oral consumption of the fruit of *Massularia acuminata* irritates the throat and creates a sensation of nausea that can last for several days. The total efficiency rate is 77.37% (i.e. 01 cases of non-healing and 02 cases of recurrence). When the treatment is made with *Piptadeniastrum africanum* bark and *Massularia acuminata* fruit, this rate is 100%. The same is true when this mixture is combined with the juice from the stems of *Costus afer*. Traditional therapists use mixtures in order to achieve medicinal synergy [10, 12]. Indeed, each of the plants used in a mixture has a specific role to play in the treatment of sinus symptoms [11, 14]. Treatments duration also varies according to the recipe used by the tradi-therapist. They range from 06 to 15 days when the treatment involves the bark of *Piptadeniastrum africanum*, the fruit of *Massularia acuminata* and the stems of *Costus afer*. Aqueous extracts of *Piptadeniastrum africanum* bark and *Costus afer* stems have antioxidant, anti-inflammatory and analgesic properties [43, 44]. Extracts from the fruits of *Massularia acuminata* have strong antimicrobial potential [45, 46, 47]. The molecules present in these plants act synergistically in the mixtures to give them a strong anti-sinus potential, thus reducing treatment times. Aqueous fruit extracts revealed the presence of gallic and catechic tannins, flavonoids, coumarins, saponins and other bioactive compounds present in trace amounts. Work by authors in [48] corroborates these results and reveals that aqueous fruit extracts from *Massularia acuminata* are rich in anthocyanins, bones and

holosides, quinones, reducing sugars, catechic tannins and very few alkaloids; in contrast, ethanol extracts from trunk bark show the presence of sterols and triterpenes, gallic tannins and abundant alkaloids. The presence of bioactive compounds in a plant varies according to the organs solicited and the solvents used during extraction [48, 49, 50, 51]. The authors in [49] for example, report an absence of alkaloids, flavonoids, quinones and steroids on the leaves, but reveal the presence of saponosides and tannins on these organs. The authors in [50] working on the roots of *Massularia acuminata* showed the presence of alkaloids, anthraquinones, flavonoids, polyphenolic compounds, saponins and tannins, whereas the studies of [51] in addition to the above compounds with the exception of alkaloids and phenols, reported the presence of anthocyanins, glycosides and phlobatanins. The bark of *Piptadeniastrum africanum* is rich in gallic and catechic tannins, total phenols, saponins and coumarins. The results reveal that the aqueous extract of *Piptadeniastrum africanum* contains no alkaloids, flavonoids, sterols and even less terpenoids. This result corroborates that of the authors in [52] who revealed the presence of tannins and saponins in the bark extracts of this plant. The authors in [53] reveal that in addition to the previously bioactive compounds, the bark of *Piptadeniastrum africanum* is rich in tannins, anthraquinones, saponins, alkaloids and glycosides. Recent studies have revealed the presence of flavonoids, alkaloids, sterols, triterpenes and saponins in aqueous extracts from the roots of this plant [54, 55]. All these molecules acting alone or in synergy would be responsible for the anti-inflammatory, antihypertensive, antifungal and antibacterial potential of these plants [43, 44, 46, 47, 56, 57, 58]. The bark of *Piptadeniastrum africanum*, in addition to being used in anti-sinus recipes, is also highly prized in the treatment of eight (08) other diseases, four of which are inflammatory diseases. On the other hand, the fruits of *Massularia acuminata* are not much in demand but are nevertheless very rare on the market. These fruits are seasonal organs and are not always available. The fruits of *Massularia acuminata* are very popular for treating sinusitis, in addition to being expensive (0.45 to 1.45 USD depending on the size of the fruit), they are also very rare in the markets and very little available in the villages, even during the good season. Thus, methods of preservation are undertaken by the healers who, during the dry season, crush these fruits and pack them in clean, hermetically sealed sachets, in order to use them during periods of shortage which are very long. In addition, the barks of *Piptadeniastrum africanum* and the fruits of *Massularia acuminata* also face the problem of poor harvesting techniques, as villagers improperly throw themselves on species of proven interest without ever worrying about their vegetative and physiological aspect, let alone their regeneration capacity [2, 10, 17]. Harvesting methods (intensity, frequency and techniques of sampling) vary according to the type of organ being harvested. In the forest of the Bomb Lissomb village, for example, when individuals are available, harvesting is done in a sustainable manner, considering the reconstitution of the individual. This is the case for the feet of *Piptadeniastrum africanum*. However, when the number of feet of a species of interest is scarce, no sampling technique is considered (Figure 3C). The only interest of residents is to satisfy the demand of the organ collector and thus the market and to make money. Destructive or high-impact logging includes methods in which large volumes of organs are extracted from specimens or from the tree population, harvesting techniques that result in the elimination of the exploited specimens, and the intensity and frequency of the harvesting applied does not allow for renewal of the resource. Exploitation techniques involving the girdling of the trunk, uprooting, and felling of trees to harvest the bark, fruit or roots of various woody species illustrate an exploitation generally applied by users who regularly or periodically market the resources. The modalities of exploitation are technical characteristics influencing the availability of resources and the survival of 'k' strategy species [27]. R-strategy

species such as *Costus afer* are rarely subject to these exploitation constraints due to their rapid growth, early maturity, and the strong offspring they produce. Numerous studies indicate that exploitation pressure from populations is the main cause of the rarefaction or disappearance of many medicinal plant species [10, 12, 59].

5. Conclusion

The current study carried out with traditional therapists from the Bomb-Lissomb village and those from the Douala goat market, which aimed at justifying the interest given to *Costus afer*, *Massularia acuminata* and *Piptadeniastrum africanum* in the treatment of sinusitis and promoting the sustainable management of these three plants revealed that; stems of *Costus afer*, fruits of *Massularia acuminata* and barks of *Piptadeniastrum africanum* used in combination are more effective in the treatment of sinusitis than when each of these organs is used alone in a recipe. Recipes based on these three plants, administered by nasal drops every 4 days, showed their effectiveness after the second intake of the drug. However, this treatment has some side effects such as throat itching and red eyes. *Costus afer*, *Massularia acuminata* and *Piptadeniastrum africanum* plant species that are highly used in Cameroon traditional medicine and organs used in the treatment of sinusitis are not always available except those of *Costus afer*. These organs are expensive and there are periods of shortage except for stems of *Costus afer*. *Piptadeniastrum africanum* bark harvesting techniques do not always ensure its regeneration. On the other hand, fruits of *Massularia acuminata* are seasonal and therefore not always available. However, preliminary phytochemical studies reveal that other organs of these plants have substantially the same active compounds as those used during the treatment of sinusitis. Interest given to these plants in the treatment of sinusitis has not been proven, subsequent studies should study their toxicity as well as their pharmacological interests with a view to the development of an improved traditional drug with anti-sinus properties.

Also, we recommend:

- to those who harvest plant organs to adopt harvesting techniques that do not hinder the regeneration of species;
- to traditional market therapists to adopt more organ conservation methods in order to compensate for periods of shortage;
- to researchers to consider the possibilities of domestication of these species.

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