INNSPUB

Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 16, No. 4, p. 106-120, 2020
http://www.innspub.net

RESEARCH PAPER OPEN ACCESS

Diversity of medicinal plants used in the treatment of malaria and typhoid fever, two pathologies frequently encountered in Daloa (Central-West, Côte d'Ivoire)

Abba P Obouayeba*[1], Bognan AAJ Ackah[1], Tanoh H Kouakou[2], Allico J Djaman[3,4], Jean D N'guessan[3]

[1]Laboratory of Agrovalorisation, UFR Agroforestry, Jean Lorougnon Guédé University, Daloa, Côte d'Ivoire

[2]Laboratory of Biology and Improvement of Plant Productions, UFR Sciences of Nature, Nangui Abrogoua University, Abidjan, Côte d'Ivoire

[3]Laboratory of Biochemical Pharmacodynamy, UFR Biosciences, Félix Houphouet-Boigny University, Abidjan, Côte d'Ivoire

[4]Pasteur Institute of Côte d'Ivoire, Abidjan, Côte d'Ivoire

Article published on April 30, 2020

Key words: Medicinal plants, Malaria, Typhoid fever, Daloa, Côte d'Ivoire

Abstract

The Haut-Sassandra region located in the Central-West of the Côte d'Ivoire provides a significant part of the national production of food and export products. The local population responsible for this production generally heals with medicinal plants for various reasons. It seemed important to know the medicinal plants used by this population in the treatment of malaria and typhoid fever, two pathologies frequently encountered in this region. It is in this context that an ethnopharmacological study was carried out in the city of Daloa, capital of this region, with 240 people who are traditional healers and herbalists. The results showed that the majority of women are (55.42%) with a dominance of the age groups between 41 and 60 years (54.59%). The vast majority of traditional healers and herbalists have no education (51.25%) and 58.75% of these people are married. The medicinal plants used in Haut-Sassandra; the leaves are the most used organs (51%). Decoction is the most used method (74.47%) and drink (50%) dominates the other administration routes. Thirty-six species (36) of medicinal plants have been identified belonging to 23 families. In addition, 58% of these medicinal plants are used only in the treatment of malaria. The main medicinal plants identified for the treatment of these two pathologies have anti-plasmodial and anti-typhoid properties proven in the literature. The medicinal plants identified will help guide further research on natural substances for the implementation of improved traditional medicines.

***Corresponding Author:** Abba P Obouayeba ✉ obouapac@gmail.com

Introduction

In recent times, focus on plant research has increased all over the world and a large body of evidence has collected to show immense potentials of medicinal plants used in various traditional systems. Various medicinal plants have been studied using modern scientific approaches. Ethnobotany and ethnopharmacognosy, the basis of useful knowledge on plants in their relationship with traditional or popular therapeutic uses, constitute a guide for chemical, pharmacological and physiological studies that allow the establishment of a scientific foundation for supposed therapeutic properties. The results from these plants have revealed the potentials of medicinal plants in the area of pharmacology (Kone *et al.*, 2011 and 2012; Obouayeba *et al.*, 2014 and 2015; Okou *et al.*, 2020).

Infectious diseases, which include a wide range of pathologies (bacterial pathologies, parasitic pathologies, viral pathologies) are responsible for a large number of deaths worldwide (Ackah *et al.*, 2008; Okou *et al.*, 2018). Among these diseases malaria and typhoid fever hold our attention during this study.

Malaria is a potentially fatal disease. An acute febrile illness caused by a parasite of the genus Plasmodium, which is transmitted to humans by the bite of mosquitoes. According to the World Health Organization (WHO), almost half of the world's population is at risk of contracting malaria (WHO, 2016). Malaria remains a factor of high mortality in Africa, especially among children under 5 years of age. He kills a child every two minutes (Aubry and Gaüzère, 2017). Côte d'Ivoire is faced with this scourge as a country at risk; it is ranked among the fourteen (14) African countries most affected by Plasmodium falciparum malaria (Chadi, 2014). Malaria is transmitted throughout the year with an upsurge during the rainy season and is the leading cause of morbidity and mortality with 43% of the reasons for consultation and 62% of hospitalizations of children under 5 years in health facilities in Ivory Coast (Chadi, 2014). Several actions are therefore carried out by the international community to fight against this parasitosis. One of the most reliable means of curative treatment of malaria is the problem of resistance. Resistance to artemisinin-based combination therapy (CTA) has indeed been reported in five countries in the Mekong Basin (OMS, 2019). Faced with this problem of resistance to the treatment of this pandemic, new molecules are to be identified when starting from plants since quinine and artemisinin, two reference antimalarial molecules, have been isolated from plants. According to the WHO in 2013, more than 80% of African populations use traditional medicine and pharmacopoeia to deal with health problems (Mangambu *et al.*, 2014). For these populations, plants are the main source of medication.

Typhoid fever is a serious foodborne illness caused by bacteria, Salmonella typhi, found in water and food contaminated with feces. This disease, which is transmitted through food, rages mainly in regions where hygiene conditions are precarious. The World Health Organization (WHO) estimates that there are 12.6 million cases of typhoid fever, including 600,000 deaths worldwide each year. The incidence of this disease is highest in Asia, followed by sub-Saharan Africa and Latin America (WHO, 2003). Its manifestations are sometimes severe and can lead to death in 30% of cases of complications in the absence of adequate treatment (Bhutta *et al.*, 2006). In Côte d'Ivoire, the recent massive displacements of populations have led to precarious living conditions and hygiene in certain agglomerations. In addition, at the national level, 54% of the population does not have an adequate sanitation system (WHO, 2007) and would be exposed to water-borne illnesses. Typhoid fever has become a rapidly increasing disease. The current treatment is based on 2nd generation fluoroquinolones and ceftriaxone. However, in recent years, there has been an emergence of multi-resistant strains of the causative agent in several regions of the world (Chin *et al.*, 2002; Benoît *et al.*, 2003; Abdullah *et al.*, 2005). This drug resistance is the source of the high cost of treatment. Vulnerable populations being generally poor, it becomes urgent to find new drugs capable of treating this disease at lower cost. Medicinal plants represent a significant source of new drugs; especially since they have fewer side effects (Maghrani *et al.*, 2005).

Faced with these two diseases which constitute a real danger to humanity, a possible alternative solution is the use of medicinal plants from the pharmacopoeia as highlighted in each part concerning each pathology. It is in this context that we undertook an ethnopharmacological study of medicinal plants used in traditional medicine in the town of Daloa (Central-West, Côte d'Ivoire) in the treatment of malaria and typhoid fever.

Materials and methods

Type of study

It was an ethnopharmacological survey. It was done through a two-part fact sheet. The first part related to socio-demographic information (age, sex, family status, level of education, religion, status). The second part related to botanical characteristics (vernacular name, morphological type, preparation of drug recipes).

Presentation of study area

Located in central-western Côte d'Ivoire, the Haut-Sassandra region covers an area of 15,205km². It is limited as follows: to the north, the Worodougou region; to the east, the Marahoué region; to the south, the Fromager and Bas-Sassandra regions; to the west, the Montagnes and Moyen-Cavally regions. The average annual temperature is 26°C, with average rainfall around 1 276mm per year (Minagri, 2010).

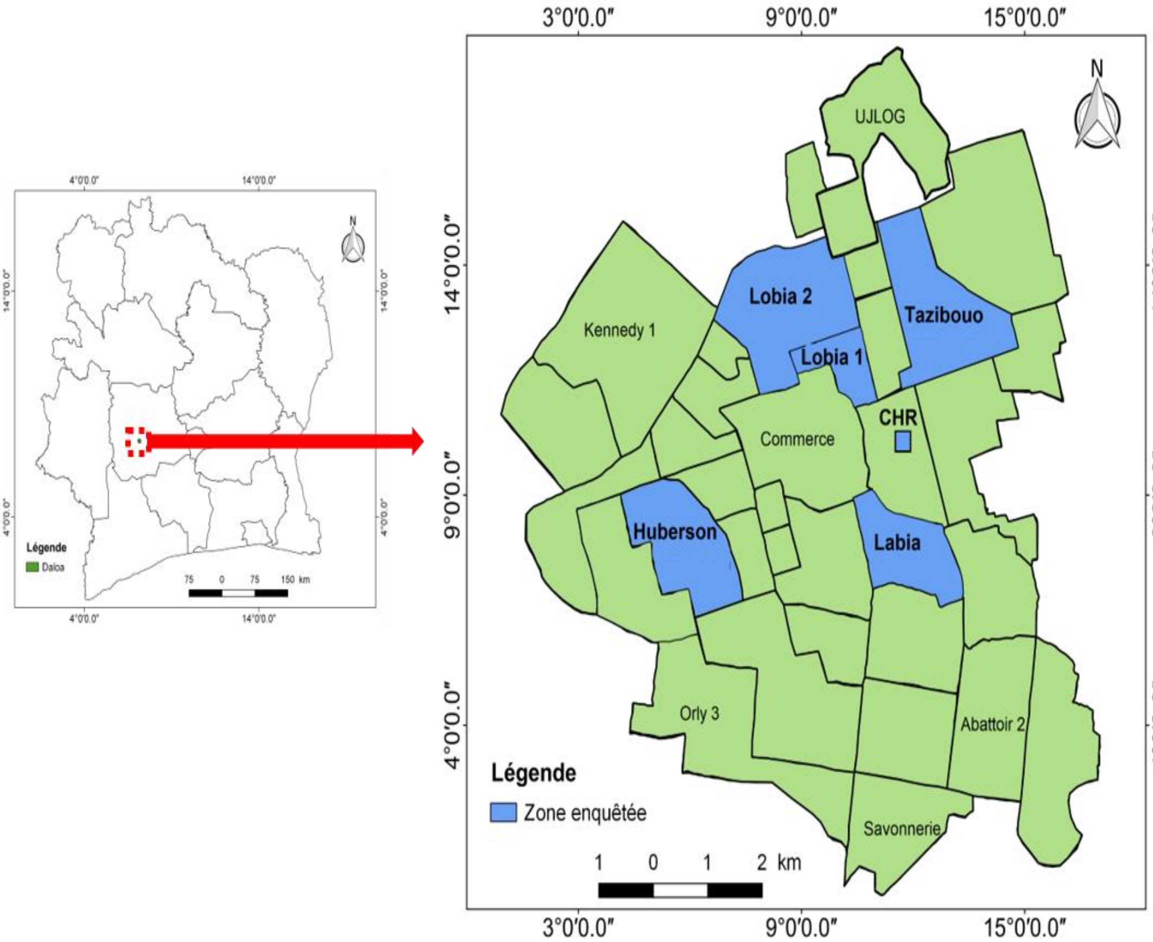

Fig. 1. Main study sites.

A: Map of Côte d'Ivoire with the position of the city of Daloa (the point in red).

B: Map of the city of Daloa.

This region has many advantages not only for food production, but also for marketing. The Haut-Sassandra region is the country's second-largest cocoa production area and first-largest coffee producer (Tra-Bi *et al.*, 2015). The region presents itself as the second pioneering front in the production of these crops (Adou *et al.*, 2012). The region is home to the town of Daloa, the capital of the region and the third largest city in the country, which has a large urban population. It contains several ethnic groups representative of the West African sub-region dominated by the Bété indigenous ethnic group. Survey sites included Gbeuliville, Labia, Lobia and Tazibouo (Fig. 1).

Fact sheet

The material used in this ethnopharmacological study is a fact sheet with questions that allowed us to collect information about people (tradipraticians, herbalists) and medicinal plants. These plants have been identified at the Laboratory of Agricultural Production Improvement of UFR Agroforestery at the Jean Lorougnon Guédé University of Daloa (Côte d'Ivoire).

Study population

The people interviewed during our study were herbalists and tradipraticians who were 240. These people gave us socio-demographic and botanical information.

Ethnopharmacological surveys

The Daloa region contains forests in the mesophilic sector of the Guinean domain, in central-western Côte d'Ivoire. Given that the resultant burden of certain conditions is not only considerable in rural areas, but also in the city (Keiser *et al.*, 2004) and that tradipraticians can be found in rural areas as well, as urban or peri-urban (Piba *et al.*, 2015). Our study method is an ethnopharmacological survey. Reconnaissance and courtesy visits were carried out with respondents in the markets of Gbeuliville, Labia, Lobia and Tazibouo with the aim of creating a certain familiarity useful for such a study. The second step was to conduct an ethnopharmacological survey using a questionnaire sheet. The procedure adopted in this study was a semi-directive interview based on a pre-elaborated questionnaire. The ethnopharmacological fact sheet consists of two main parts (Piba *et al.*, 2015). The first relates to socio-demographic information about the respondent. The second part concerns the botanical and pharmacological characteristics of the plants surveyed.

The survey began on january 28, 2018 and ended on july 18, 2019. It involved 240 people (herbalists, tradipraticians).

Local importance of each plant species was calculated based on the frequency of citation (Tardio and Pardo, 2008). The citation frequency (FC) of each plant species was determined by the formula

$Fc = Fi/n$;

where Fi is number of citation of the species; n the total number of recipes.

Data processing and analysis

On the basis of the survey sheets, the variables were drawn up, in particular the profile of each respondent (sex, age, level of study, etc.). So, we were able to characterize the traders in our study area. For each plant, the data collected included the vernacular name, scientific name, morphological type, organ used, method of preparation, mode of administration and disease treated. For this study, the Microsoft office 2016 (Word, Excel), basic software for calculations and data entry was used.

Results and discussion

Profile of people surveyed

The ethnopharmacological study carried out on the population with the aim of identifying the medicinal plants used in the treatment of two infectious diseases that are malaria and typhoid fever in the city of Daloa in Haut-Sassandra (Central-West, Cote d'Ivoire) allowed to have socio-demographic data relating to several characteristics among which we have gender, marital status, education, religion, status, years of experience and mode of knowledge acquisition - make. From this study it emerges that female persons are more representative with 55.42% of the people questioned. When men represent 44.58% of the respondents as shown in Table 1. These results show that women are more interested in this medical activity. Our results corroborate those of the surveys conducted in Côte d'Ivoire by N'Guessan *et al.* (2010) with 62.50% women and in Benin by Fah *et al.* (2013) with 95.24% (against 4.76% of male sex) who showed that female herbalists are in greater number.

However, work carried out in Guinea by Traoré *et al.* (2013) and in Togo by Klotoé *et al.* (2018) showed contrary results with a dominance of men in this activity with 54.65% and 57.41% respectively.

Table 1. Sociodemographic data of the people surveyed

Group	Number	Percentage (%)
Gender		
Male	107	44.58
Female	133	55.42
Marital status		
Married	141	58.75
Single	99	41.25
Age		
Less than 30 years	12	05
30-40 years	43	17.92
41-50 years	61	25.42
51-60 years	70	29.17
61-70 years	34	14.17
More than 70 years	20	08.33
Educational background		
Illiterate	123	51.25
Primary level	65	27.08
Secondary level	42	17.50
Superior level	10	04.17
Religion		
Christian	34	14.17
Islamic	49	20.42
Animist	57	23.75
Others	100	41.66
Status		
Traditional healer	137	57.08
Herbalist	103	42.92
Number of years of experience		
Less than 10 years	56	23.33
10-20 years	85	35.42
21-30 years	77	32.08
More than 30 years	22	09.17
Mode of acquisition of the knowledge		
Transmission	105	43.75
Don	53	22.08
Self-training	25	10.42
Vocation	57	23.75

Regarding the practice of marketing medicinal plants in relation to marital status, we observe that this activity is exercised with a dominance of married people (58.75%) compared to singles (41.25%) in accordance with the table 2. These results join those obtained by Obouayeba *et al.* (2019) who have shown medicinal plants are sold mainly by married people (78%) against (22%) for singles. Our results are in agreement with those obtained in Morocco (Benkhnigue *et al.*, 2011) with a percentage of 80.80% of married people, against 19.20% of singles.

For the marketing of medicinal plants according to age, it appears that this activity is exercised mainly by age groups from 41 to 60 years with 54.59% (Table 1). These results are in agreement with those of Fah *et al.* (2013). These authors showed in their study that the age of the respondents varied from 20 to 60 years with a dominance of people whose age is between 41 and 50 (51%). Likewise, the results of this study are close to those of Traoré *et al.* (2013) who place the predominance of this activity at the level of age groups between 41 and 70 years. This situation could be explained by the fact that knowledge of the properties and uses of medicinal plants is generally acquired following a long experience accumulated and transmitted from one generation to another. However, the transmission of this knowledge is currently in danger because it is not always ensured in accordance with the results obtained by several authors (Benkhnigue *et al.*, 2010; Yapi *et al.*, 2015). Also, our work showed that the vast majority of respondents had no educational level with 51.25% (Table 1). These results are close to those obtained by Traoré *et al.* (2013), whose illiterates had a rate of more than 65.5%. Regarding, the number of years of experience in practice this activity the preponderance is between 10 and 30 years with 67.5%. These results corroborate the results of the work of Traoré *et al.* (2013) with 76.35% ranging from 11 to 20 years and over.

Botanical characteristics of plants

According to fig. 2, among the medicinal plants used in the city of Daloa in the treatment of the two pathologies that are malaria and typhoid fever, 58% of these medicinal plants are used only for the treatment of malaria, while 31% d 'between them are used for the common treatment of both pathologies and finally 11% of these plants are used only for the treatment of typhoid fever. Our results are in agreement with those of the works of Yetein *et al.* (2013) and Koulibaly *et al.* (2016) who showed in their studies that medicinal plants are used mainly in the treatment of malaria. However, ethnobotanical data from the work of Bolou *et al.* (2010) show that most of the medicinal plants in this study are used in the treatment of these two pathologies.

Table 2. Plants species used in the treatment of malaria and typhoid fever.

Plant species	Family	Local name	Used part	Method of preparation	Method of Adminis tration	Pathology	FC (%)
Ageratum conyzoides	Asteraceae	Lagôhpitii	Leaf	Maceration	Bain	Malaria Typhoid fever	27.08
Afrormosia laxiflora	Papilionaceae	Kolokolo	Leaf Stem bark Root	Decoction Maceration Infusion	Drink Bain Purge	Malaria	4.17
Afzelia africana	Caesalpiniaceae	Dangha	Leaf Stem bark	Décoction	Drink Bain Purge	Malaria	12.5
Alchornea cordifolia	Euphorbiaceae	Djeka	Leaf Stem bark Root	Decoction	Drink Bain	Malaria Typhoid fever	58.33
Alstonia congensis	Apocynaceae	Amia	Stem bark	Decoction	Drink	Malaria	6.25
Anogeissus schimperi	Annonaceae	Krékété	Leaf Stem bark	Decoction	Drink Bain	Malaria Typhoid fever	2.91
Anthocleista nobilis	Annonaceae	Farata-débè	Leaf Stem bark Root	Decoction Maceration	Drink Bain Purge	Malaria	4.17
Azadirachta indica	Meliaceae	Neem	Leaf Stem bark	Decoction	Drink	Malaria	38.75
Bambusa vulgaris	Poaceae	Bambou de chine	Leaf	Decoction	Drink	Malaria Typhoid fever	31.25
Blighia sapida	Bignoniaceae	Kaha	Leaf Root	Decoction Pilage	Drink Bain Purge	Malaria	10.41
Carica papaya	Caricaceae	Oflè	Leaf Root	Decoction Maceration Infusion	Drink Bain	Malaria Typhoid fever	37.5
Cassia nilotica	Mimosaceae	Acacia	Leaf Root	Decoction	Drink	Malaria	6.25
Chlorophora excelsa	Moraceae	Bakana	Leaf Stem bark Root	Decoction Maceration	Drink Bain Purge	Typhoid fever	2.08
Citrus limon	Rutaceae	Citronnier	Leaf Stem bark Fruit	Decoction Pilage	Drink Bain Purge	Typhoid fever Malaria	35.42
Erythrina senegalensis	Ebenaceae	Kiangui	Leaf	Decoction	Drink Bain	Malaria	1.67
Euadenia trifoliata	Capparaceae	N'zo téké	Leaf	Decoction	Drink	Typhoid fever	1.67
Fagara xanthoxyloïdes	Rutaceae	Wo	Stem bark	Decoction	Drink	Malaria	2.91
Ficus mucuso	Moraceae	Gonan	Leaf Stem bark	Decoction	Drink Bain	Malaria	1.25
Glyphaea brevis	Malvaceae	Golglo-iri	Leaf	Decoction	Drink Bain	Malaria	1.25
Hoslundia opposita	Lamiaceae	Anomalliai	Leaf	Decoction	Drink	Malaria	23.75
Khaya senegalensis	Meliaceae	Djala	Stem bark Root	Decoction	Drink	Malaria Typhoid fever	29.17
Mangifera indica	Anacardiaceae	Manguier	Stem bark	Decoction	Drink Bain	Malaria	45.83
Morinda lucida	Rubiaceae	Jaune amère	Stem bark	Decoction	Drink	Malaria	7.08
Musa Sapientum	Musaceae	Bananier	Leaf	Decoction	Drink Bain	Malaria Typhoid fever	5
Nauclea latifolia	Rubiaceae	Gouinga	Leaf Root Stem bark	Decoction Maceration	Drink Bain Purge	Malaria Typhoid fever	30
Loesnera kalantha	Caesalpiniaceae	Souosébé	Leaf Root	Decoction	Drink Bain	Malaria Typhoid fever	1.25
Ocimum gratissimum	Lamiaceae	Aremangnirin	Leaf	Decoction	Purge	Malaria Typhoid fever	33.33
Ocimum canum	Lamiaceae	Alomagninrin	Leaf	Decoction Infusion	Bain	Malaria	3.75

Plant species	Family	Local name	Used part	Method of preparation	Method of Adminis tration	Pathology	FC (%)
Omphalogonus nigritanus	Apocynaceae	Ababa	Leaf	Decoction	Drink Bain	Malaria	1.25
Phoenix dactylifera	Arecaceae	Dattier	Leaf	Decoction	Drink	Malaria	2.08
Phyllanthus amarus	Euphorbiaceae	Mille maladies	Leaf	Decoction	Drink	Malaria Typhoid fever	41.67
Premna hispida	Verbenaceae	Wagné	Leaf	Decoction	Drink Bain	Malaria	0.83
Sarcocephalus esculentus	Rubiaceae	Bâti	Leaf Stem bark Root	Decoction Maceration	Drink Bain	Malaria	7.08
Tectonas grandis	Verbenaceae	Teck	Leaf	Decoction	Drink Bain	Malaria Typhoid fever	29.17
Uragoga peduncularis	Ulmaceae	Kiriba	Leaf	Decoction	Drink Bain	Typhoid fever	0.83
Xylia evansii	Mimosaceae	Bouho	Leaf Root	Decoction Maceration	Drink Bain Purge	Malaria	0.83

Table 3. Main phytochemical constituents of the medicinal plants most used in the treatment of malaria and typhoid fever.

Most cited species	Phytoconstituents	References
Ageratum conyzoides	Alkaloids, Flavonoids, Polyphenols, Saponins Sterols, Terpenoids.	Bidié *et al.*, 2011
Alchornea cordifolia	Alkaloids, Anthocyanins, Cardiac glycosides, Flavonoids, Polyphenols, Tannins.	Ngoupayo *et al.*, 2015
Azadirachta indica	Alkaloids, Flavonoids, Glycosides, Saponins, Reducing sugars, Tannins.	Dash *et al.*, 2017
Bambusa vulgaris	Glycosides, Saponins Coumarins.	Coffie *et al.*, 2014
Carica papaya	Alkaloids, Phenols, Proteins, Sugar.	Singh *et al.*, 2018
Citrus limon	Flavonoids, Glycosids, Reducing sugars, Tannins.	Pandey *et al.*, 2011
Hoslundia opposita	Alkaloids, Saponins, Tannins.	Okach *et al.*, 2013
Khaya senegalensis	Quinons, Sterols, Saponins	Yuan *et al.*, 2009
Mangifera indica	Alkaloids, Flavonoids, Phenols, Saponins, Tannins.	Okwu and Ezenagu, 2006
Nauclea latifolia	Alkaloids, Anthraquinones, Flavonoids, Glycosids, Saponins, Tannins.	Maitera *et al.*, 2011
Ocimum gratissimum	Alkaloids, Flavonoids, Polyphenols, Sterols, Tannins, Terpenoids.	N'guessan *et al.*, 2009
Phyllanthus amarus	Alkaloids, Flavonoids, Saponins, Tannins.	Dongock *et al.*, 2018
Tectonas grandis	Alkaloids, Anthraquinons, Carotenoids, Flavonoids, Polyphenols, Saponins, Tannins.	Ogunmefun *et al.*, 2017

Table 4. Antiplasmodial and antityphoid propreties of the medicinal plants most used.

Most cited species	IC50 (mg/ml)	References	MBC (mg/ml)	References	Pharmacological activities
Ageratum conyzoides	55	Madureira *et al.*, 2002			Antiplasmodial
Alchornea cordifolia	7.1 ± 1.5	Banzouzi *et al.*, 2002	100	Ngoupayo *et al.*, 2015	Antiplasmodial and Antityphoid
Azadirachta indica	5.8-8.5	El Tahir *et al.*, 1999			Antiplasmodial
Bambusa vulgaris			>80	Bolou *et al.*, 2011	Antityphoid
Carica papaya	15.19-18.09	Bhat and Surolia, 2001			Antiplasmodial
Citrus limon	5.7-7.92	Ruiz *et al.*, 2012			Antiplasmodial
Hoslundia opposita	5.99-12.1	Karamoko *et al.*, 2018			Antiplasmodial
Khaya senegalensis	47	El Tahir *et al.*, 1999			Antiplasmodial
Mangifera indica	>50	Zirihi *et al.*, 2005			Antiplasmodial
Nauclea latifolia	8.9 ± 2.5	Zirihi *et al.*, 2005	80	Bolou *et al.*, 2011	Antiplasmodial and Antityphoid
Ocimum gratissimum	6.0 ± 2.5	Mesia *et al.*, 2008			Antiplasmodial
Phyllanthus amarus	31.2-34.9	Appiah-Opong *et al.*, 2011	20	Bolou *et al.*, 2011	Antiplasmodial and Antityphoid
Tectonas grandis			20	Bolou *et al.*, 2011	Antityphoid

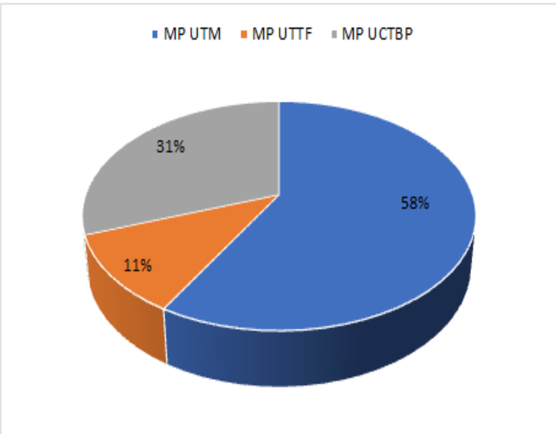

Fig. 2. Proportion of medicinal plants used in the treatment of both diseases

The active ingredients can be located in different parts of medicinal plants (leaves, flowers, roots, bark, fruits, stems, rhizomes ...). In our study the leaves are the most used parts of medicinal plants with a percentage of 55%, followed by 25% of bark and 19% of roots 1% for the fruits according to fig. 3. The ethnobotanical works carried out by Zerbo *et al.* (2011) 41%, N'Guessan (2009) 51.2% and Lakouéténé *et al.* (2009) 67% showed that the leaves represent the organ mainly used in various therapeutic preparations. There may be concern about excessive use of the leaves of herbal medicines, but studies by Poffenberger *et al.* (1992) have shown that removing 50% of a tree's leaves does not significantly affect its survival. Also, the high frequency of use of the leaves can be explained by the ease and speed of the harvest (Bitsindou, 1986) but also by the fact that they are the site of photosynthesis and storage of metabolites. Secondary responsible for the biological properties of the plant (Bigendako-Polygenis and Lejoly, 1990).

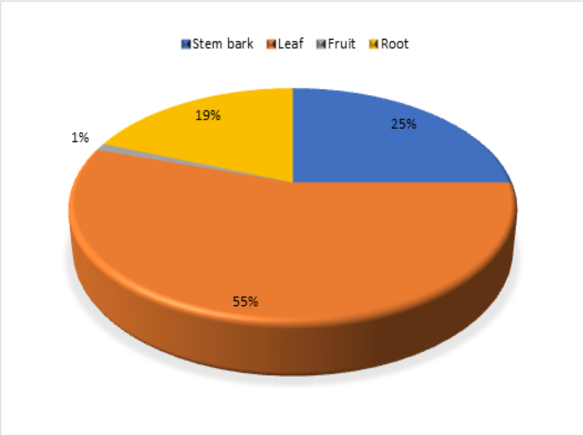

Fig. 3. Proportion of different plants parts used in the treatment of malaria and typhoid fever

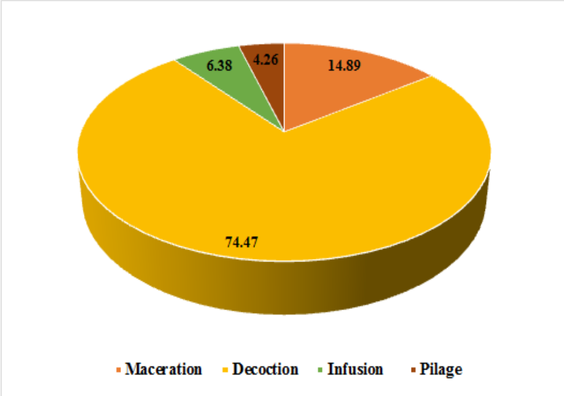

Fig. 4. Methods of preparation of remedies in the treatment of malaria and typhoid fever

The results show the percentage of use of the different preparation methods. The decoction with a percentage of 74.47% occupies the first place, it is followed by maceration with a percentage of 14.89%. Infusion with a percentage of 6.38% comes in third position and pounding with a percentage of 4.26% occupies the last place as shown in fig. 4. These results are in agreement with those obtained by Dongock *et al.* (2018) who showed that decoction was the most used method with a rate of 62%. According to Lahsissène *et al.* (2009) the interest shown by populations in the use of decoction, resided in the fact that it made it possible to increase the temperature in the organism. For Salhi *et al.* (2010), a decoction is the best preparation method to use to make the most of the active ingredient in medicinal plants and it also allows the most active ingredients to be collected and attenuates or cancels the toxic effect of certain recipes.

The results of this study show that the most used administration method is drink (oral) with 50%, followed by bathing with 36.36%, and finally 13.64% of the purge (Fig. 5). These results join those of N'Guessan *et al.* (2009) who place the drink at 46.98% and Bla *et al.* (2015) 57.69%. Bla *et al.* (2015) indicate that the decocte containing bio-active ingredients ingested orally requires a much faster and more efficient metabolic process than other techniques.

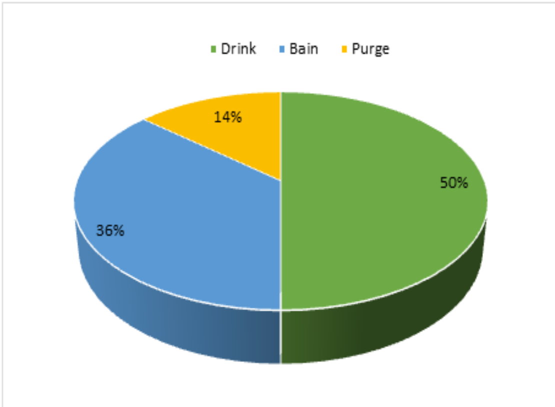

Fig. 5. Proportion of different modes of administration of herbal remedies in the treatment of malaria and typhoid fever

Surveys carried out in the town of Daloa allowed us to identify different species of medicinal plants used in local phytotherapy. Thus, we have 36 species belonging to thirty-five (23) botanical families. The list of the different families and species of medicinal plants in this study is presented in table 2 and fig. 6. We observe a slight predominance of Lamiaceae and Rubiaceae with three species per family; followed by Annonaceae, Apocynaceae, Caesalpiniaceae, Euphorbiaceae, Moraceae, Meliaceae, Moraceae, Mimosaceae, Rutaceae and Verbenaceae with two species. Then we have the ones that count a species (Fig. 6). These results join those of the work of several authors from West Africa (Koudouvo *et al.*, 2011; Yetein *et al.*, 2013; Traoré *et al.*, 2013; Klotoé *et al.*, 2018).

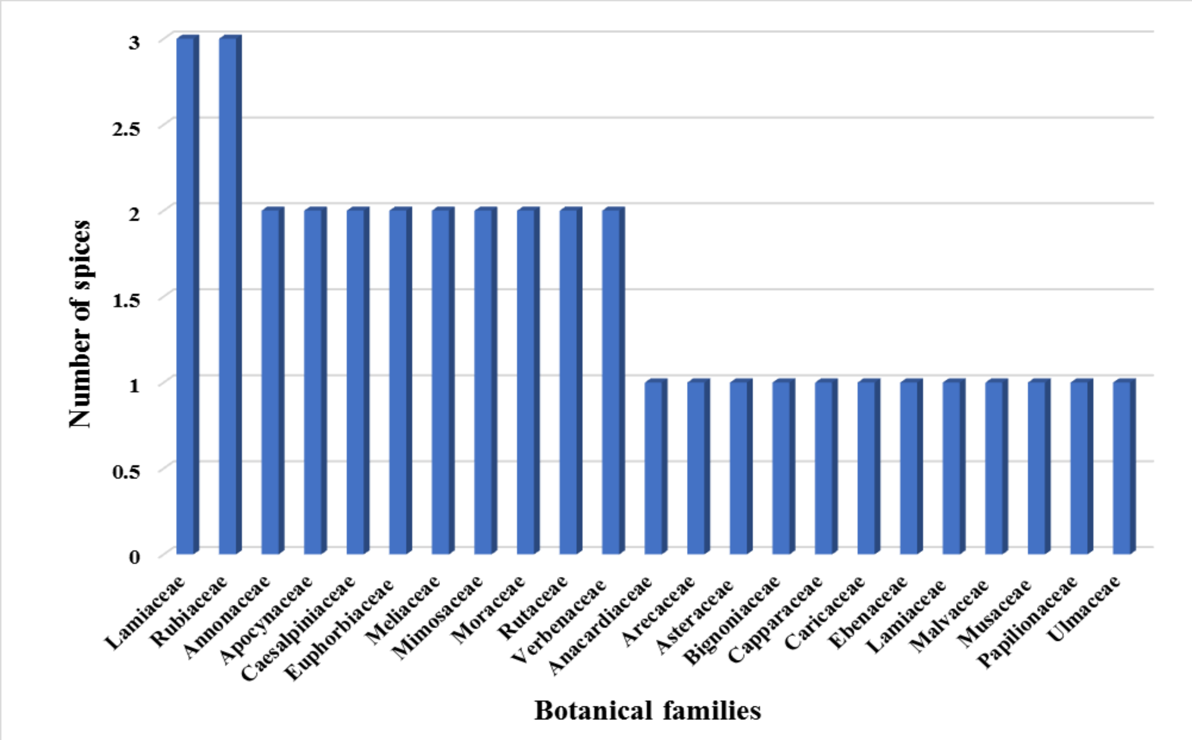

Fig. 6. Distribution of plant species by botanical family

Phytochemical and pharmacological characteristics of plants

The screening of plants for medicinal value has been carried out by numerous researchers with the help of preliminary phytochemical analysis (Ram, 2001; Mungole and Chaturvedi, 2011). Phytochemical screening test is of paramount importance in identifying new source of therapeutically and industrially valuable compound having medicinal significance, to make the best and judicious use of available natural wealth. A number of medicinal plants have been chemically investigated by several researchers (Ongoka *et al.*, 2006; Lopes-Lutz *et al.*, 2008; Ni *et al.*, 2012). Thus, the main plants used in this study for the treatment of malaria and typhoid fever are rich in secondary metabolites as several authors have shown (N'guessan *et al.*, 2009; Bidié *et al.*, 2011; Coffie *et al.*, 2014; Bla *et al.*, 2015; Tsobou *et al.*, 2015; Ngoupayo *et al.*, 2015; Dash *et al.*, 2017; Ogunmefun *et al.*, 2017; Dongock *et al.*, 2018; Singh *et al.*, 2018). These include alkaloids, polyphenols, saponins, sterols, terpenes, quinones. These secondary metabolites, also called phytochemicals, are responsible for the pharmacological properties of these plants. Similarly, the work of Zirihi *et al.* (2005), of Bolou *et al.* (2011), of Yetein *et al.* (2012), of Traoré *et al.* (2013), of Tsobou *et al.* (2015), de Klotoé *et al.* (2018) highlighted the antiplasmodial and antityphoid properties of the main plants used in the treatment of malaria and typhoid fever.

Conclusion

The medicinal plants occupy an important place in therapy, both in urban and rural areas. It is in this context that this study is part of the aim of identifying medicinal plants used in the treatment of malaria and typhoid fever. It emerges from this study that 36 medicinal plants belonging to 23 botanical families have been listed as being used in the treatment of these pathologies. However, 58% of these herbal medicines are used only for the treatment of malaria. The leaves are the most used organs, while the decoction represents the reference method of preparation and finally the drink the most recommended mode of administration. This study deserves to be continued with the aim of researching new drugs effective against these pathologies by scientific protocols.

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