

Full Length Research Paper

Medicinal plants used against malaria by traditional therapists in malaria endemic areas of the Ségou region, Mali

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West Africa is one of the regions in Africa with the highest levels of malaria transmission a descriptive study was carried out to inventorise the medicinal plants traditionally used against malaria by traditional therapists in five malaria endemic areas of the Ségou region, in Mali. Sixty-five traditional therapists were randomly selected to be part of the study. Questions were posed using semi-structured interviews, which solicited information on species used, plant organs used, as well as methods of preparation and routes of administration of decoctions. Results indicate that 69 species distributed over 27 families are used to treat malaria. The most represented families are Fabaceae (24.63%), Combretaceae (13.04%), Rubiaceae (7.24%) and Meliaceae (5.79%). The most cited species are *Argemone mexicana* (CF=0.78), *Combretum micranthum* (CF=0.84), *Conocarpus biocarpa* (CF=0.70), *Gardenia sokotensis* (CF=0.75) and *Mitragyna inermis* (CF=0.81). The recipe mostly involves leaves (82.43%), with the decoctions mainly taken orally.

Key words: Antimalarial plants, ethnobotanical survey, Ségou, Mali.

INTRODUCTION

Globally, the number of malaria cases is estimated at 228 million in 2018, against 251 million in 2010 and 231 million in 2017. Most cases (213 million or 93%) were recorded in 2018 in the African region (WHO, 2019). The

estimated number of malaria-related deaths was 405,000 in 2018. The Africa region alone accounted for 94% of malaria-related deaths worldwide in 2018. Children under 5 years are the most vulnerable to malaria. In addition,

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according to the 2018 Global Report, nearly 11 million pregnant women living in areas of moderate to high transmission in sub-Saharan Africa have been exposed to malaria infection (WHO, 2019).

Mali, like most countries in sub-Saharan Africa, has malaria as the leading cause of death and morbidity. In 2018, according to the health information system, 2,614,104 confirmed cases of malaria and 1,001 deaths were recorded. Malaria was the primary reason for consultation (39%) (Instat, 2018). This disease has socio-economic repercussions on the populations of the most affected countries, thereby slowing down the effective fight against the parasite (Instat, 2018; Diarra et al., 2015; Kodjovi et al., 2017).

In Africa, up to 80% of the population uses traditional medicine to meet their health care needs (WHO, 2002). The affordability of most traditional medicines makes them all the more attractive at a time when healthcare costs are skyrocketing and austerity is almost universal. In addition, in some countries traditional medicine is included in the university curriculum of medical students. For example, various universities in the Economic Community of West African States, South Africa, the Democratic Republic of the Congo and Tanzania are integrating traditional medicine into programs for pharmacy students and in medicine (WHO, 2013).

By 2030, woodfuel should still account for 80% of household energy consumption in sub-Saharan Africa (IEA, 2002). In addition to these destructive practices, there are drought, agricultural techniques and bad practices in the harvesting of medicinal plants, making it increasingly difficult to discover, exploit and safeguard the pharmaceutical potential of plant biodiversity. Faced with this observation, it is necessary to know whether among the plants used against malaria in Mali, some can be developed for a truly effective treatment.

With this in mind, an ethnobotanical study has been initiated in five malaria endemic areas in the Ségou region. Its purpose is to establish a preliminary list of plants likely to be active on malaria. In the African region, the knowledge and practices of traditional medicine have been passed down orally between traditional therapists for generations (WHO, 2013). This traditional knowledge could be translated into scientific knowledge in order to enhance it, conserve it and use it in a rational and sustainable manner.

MATERIALS AND METHODS

Study area

The region of Ségou is located in Mali between latitudes 12° 30' and 15° 30' North, and longitudes 4° and 7° West. Covering an area of 64,821 km², or 5% of the national territory, the population has increased by 40% since 1998, with an average annual growth rate of 3.1% between 1998 and 2009. The region's population is mainly made up of the Bambara ethnic group and secondarily of the Peul, Bobo, Mianka and even Bozo ethnic groups. The climate results in

a dry season (October to June) and a rainy season (July to September). It is limited to the north by the Republic of Mauritania and the region of Timbuktu, to the east by the region of Mopti, to the west and southwest by the region of Koulikoro, to the south by the region of Sikasso and finally to the southeast by the Republic of Burkina-Faso (Rouxel, 2002). Administratively, it is made up of 7 circles (Figure 1): these are the circles of Niono and Macina in the North, Ségou in the West, Baraouéli and Bla in the South and San and Tominian in the East. The region of Ségou has 16 classified forests covering an area of 78,860 ha. Regarding vegetation, several ecoclimatic zones can be distinguished according to a rainfall gradient and is located in the Sudano-Sahelian domain with tree-shrub savannah. The economy of Ségou is essentially based on breeding and agriculture; some people are engaged in hunting, fishing, potters. Few of them work as traditional therapists. The culture of cure based on the use of natural resources is an important element of public health in the Ségou region.

Study design

In order to identify the plants used by the malaria population in five malaria endemic areas (Ségou, Niono, Konobogou, San and Bla) in the Ségou region, an ethnobotanical survey was carried out; with 65 therapists including 33 men and 32 women over a period of 4 months (Table 1). The majority of traditional therapists had acquired the information through ancestral knowledge. The average age was 50 years (range 28 to 70 years).

All the therapists interviewed were informed about the objective of the study. The location of the various survey stations was determined by choosing the most popular markets in the five zones. The choice of traditional therapists was based on the size of their displays. The surveys were based on the Semi-Structured Interview method. Each interlocutor was met twice, at different times (in August 2018 and in November 2018), to answer the same questions. The approach of the interviewed herbalists was based on dialogue in the local language (Bamanankan), accompanied by the purchase of medicinal plants sold for the treatment of malaria. A digital camera, sachets, adhesive tape and markers were used as part of this study. The time spent on each interview was approximately 30 min to an hour. During each interview we collected all the information on the interviewee and the medicinal plants used, in particular the local names of the plants used to fight malaria, the way to diagnose malaria, the different parts used as drugs, the methods of preparation and drug administration.

Botanical identification

The taxonomic identification of the plants, harvested in the field, and the final determination of their botanical names were made by Seydou M. Dembélé working in the ethnobotanical and raw materials service of the Department of Traditional Medicine of Mali (DMT) and confirmed by the scientific nomenclature used by Lebrun and Stork (Arbonnier, 2009). Each sample was placed in the DMT Herbarium. The family names of the plants have been classified in alphabetical order on the basis of the APGIII system (Groupe Phylogénie angiospermes) (APG III, 2009) (the most important botanical classification today). Table 2 shows the general list of antimalarial species identified.

Data analysis

The data recorded on the survey forms were then processed and entered into Excel software. Data analysis used methods of descriptive statistics. The quantitative variables are described using the mean. Qualitative variables are described using counts and



Figure 1. Geographic location of the Ségou region in Mali.

Table 1. General information on the surveyed traditional therapists.

Zones	Traditional therapists (Number)	Number per sex		Age (years)
		Male	Female	
Ségou	22	12	10	40-72
Niono	15	10	5	30-68
Bla	10	3	7	28-60
San	8	2	6	54-60
Barouéli	10	6	4	32-66
Total	65	33	32	28-72

percentages.

Ethical considerations

A preliminary approach has been taken with traditional therapists to notify them of our survey and the date of our visit. The purpose of the study was explained in detail to the participants and all associated questions were answered before starting the interview. Participants agreed to be met at their premises and data were collected on the use of medicinal plants. Prior to starting the interview schedule, a written consent was obtained from each participants for the publication of this case report and accompanying images, as required by the University of Ségou ethics committee. Participants were told that they have the right to

withdraw from the interview at any time without penalty. Any information that participants believe should be kept confidential has not been included in this paper.

RESULTS AND DISCUSSION

Sixty-nine species of plants were identified, belonging to 58 genera and 27 families (Table 2).

Malaria diagnostic criteria

The diagnosis of malaria by traditional therapists is based

Table 2. List of antimalarial species and their modes of use.

Family	Number of species	Scientific name	Vernacular name (indicate language/dialect)	Part(s) \ used	Preparation / method of administration	Number of citations
Fabaceae	17	<i>Vachellia nilotica</i>	Bouana	Leaves	Decoction /oral	23
		<i>Senegalia senegal</i>	Patugu	Leaves	Decoction /oral	22
		<i>Afrormosia laxiflora</i>	Kolokolo	Leaves	Decoction /oral	13
		<i>Afzelia africana</i>	Lingué	Leaves	Decoction /oral	11
				Trunk/ bark	Maceration/ oral	
		<i>Bauhinia thonningii</i>	Niama ba	Leaves	Decoction /oral	21
		<i>Bauhinia rufescens</i>	Sifilejirini	Leaves	Decoction /oral	13
		<i>Cassia nigricans</i>	Niokoro dialani	Leaves	Decoction /oral	26
		<i>Cassia sieberiana</i>	Sinjan	Leaves	Decoction /oral	25
		<i>Detarium senegalense</i>	Tabakumba	Leaves	Decoction /oral	11
		<i>Entada africana</i>	Sama nère	Roots	Decoction /oral	29
		<i>Parkia biglobosa</i>	Nere	Trunk/ bark	Decoction /oral	14
		<i>Piliostigma reticulatum</i>	Niama	Leaves	Decoction /oral	22
		<i>Prosopis africana</i>	N'guele	Trunk/ bark	Maceration/ oral	16
		<i>Tamarindus indica</i>	N'tomi	Leaves	Decoction /oral	11
		<i>Senna occidentalis</i>	N'palanpalan	Leaves	Decoction /oral	25
		<i>Senna siamea</i>	Casia	Roots	Maceration/ oral	22
		<i>Stylosanthes mucronata</i>	Segu fali	Leaves	Decoction /oral	35
Combretaceae	9	<i>Combretum nigricans</i>	Dyirinible	Trunk/bark	Maceration/ oral	32
		<i>Conocarpus biocarpa</i>	N'galama	Leaves	Decoction /oral	46
				Roots	Maceration/ oral	32
		<i>Combretum velutinum</i>	N'ganiaka	Leaves	Decoction /oral	22
		<i>Combretum micranthum</i>	golobé	Leaves	Decoction /oral	55
		<i>Combretum glutinosum</i>	Tchangara blé	Leaves	Decoction /oral	32
		<i>Combretum collinum</i>	Tiagara diema	Leaves	Decoction /oral	22
		<i>Guiera senegalensis</i>	Kunje	Leaves	Decoction /oral	32
				Roots	Maceration/ oral	22
		<i>Terminalia macroptera</i>	Wolo	Roots	Maceration/ oral	22
Rubiaceae	5	<i>Pteleopsis suberosa</i>	Tèrèni	Leaves	Decoction /oral	31
		<i>Crossopteryx febrifuga</i>	Balembo	Leaves	Decoction /oral	22
		<i>Gardenia ternifolia</i>	Bledjé	Roots	Decoction /oral	22
		<i>Gardenia sokotensis</i>	Toucoroblen	Leaves	Decoction /oral	49
		<i>Mitragyna inermis</i>	Djun	Leaves	Decoction /oral	53
Meliaceae	4			Roots	Maceration/ oral	
		<i>Nauclea latifolia</i>	Bâti	Leaves	Decoction /oral	26
		<i>Pseudocedra kotschy</i>	Lombo	Leaves	Decoction /oral	23
		<i>Trichilia emetica</i>	Soulafinzan	Leaves	Decoction /oral	36
				Roots	Maceration/ oral	36
Apocynaceae	3	<i>Azadirachta indica</i>	Sayi jirini	Leaves	Decoction /oral	33
		<i>Khaya senegalensis</i>	Diala	Trunk/bark	Decoction /oral	21
		<i>Leptadenia hastata</i>	N'Sopen	Leaves	Decoction /oral	27
Lamiaceae	3	<i>Saba senegalensis</i>	Zaban	Leaves	Decoction /oral	32
		<i>Sarcostema viminalis</i>	woulouyolokoni	Leaves	Decoction /oral	2
		<i>Hyptis atrorubens</i>	Benefing	Leaves	Decoction /oral	11
		<i>Vitex chrysocarpa</i>	Koronifin	Leaves	Decoction /oral	21
		<i>Vitex cuneata</i>	Koroba	Leaves	Decoction /oral	11

Table 2. Contd.

Anacardiaceae	3	<i>Lannea velutina</i>	Bakoroni pegu	Leaves	Decoction /oral	13
		<i>Mangifera indica</i>	Mangoro	Leaves	Decoction /oral	28
		<i>Sclerocarya birrea</i>	Nkuna	Leaves	Decoction /oral	11
Asteraceae	3	<i>Centaurea alexandrina</i>	Niamey ouani	Leaves	Decoction /oral	7
		<i>Eclipta prostrata</i>	Musouni fing	Leaves	Decoction /oral	9
		<i>Vernonia Colorata</i>	Kossafoune	Leaves	Decoction /oral	29
Brassicaceae	1	<i>Boscia senegalensis</i>	M'bere	Leaves	Decoction /oral	9
	1	<i>Moringa oleifera</i>	Bassidjirini	Leaves	Decoction /oral	11
Poaceae	2	<i>Bambusa vulgaris</i>	Boh	Leaves	Decoction /oral	28
		<i>Sorghum vulgare</i>	Nio	Leaves	Decoction /oral	5
Sterculiaceae	2	<i>Sterculia setigera</i>	Nkouko sirani	Leaves	Decoction /oral	9
		<i>Dombeya senegalensis</i>	N'tefa	Leaves	Decoction /oral	7
Boraginaceae	1	<i>Heliotropium indicum</i>	Nôsiku	Leaves	Decoction /oral	18
Convolvulaceae	1	<i>Ipomoea fistulosa</i>	forokofaraka	Leaves	Decoction /oral	33
Caricaceae	1	<i>Carica papaya</i>	Madjié	Leaves	Decoction /oral	34
Cochlospermaceae	1	<i>Cochlopermum tinctorium</i>	Tiribara	Leaves	Decoction /oral	23
Sapotaceae	1	<i>Vitellaria paradoxa</i>	Chii	Leaves	Decoction /oral	11
Scrophulariaceae	1	<i>Scoparia dulcis</i>	dimidimini	Leaves	Decoction /oral	5
Olacaceae	1	<i>Ximenia americana</i>	Ntonkè	Leaves	Decoction /oral	9
Opiliaceae	1	<i>Opilia amentacea</i>	Korongoyi	Leaves	Decoction /oral	19
Costaceae	1	<i>Costus spectabilis</i>	Sama senba	Leaves	Decoction /oral	5
Papaveraceae	1	<i>Argemone mexicana</i>	Bozobo	Leaves	Decoction /oral/	51
Lauraceae	1	<i>Cassytha filiformis</i>	Ala jon	Leaves	Decoction /oral	7
Annonaceae	1	<i>Annona senegalensis</i>	Danga	Leaves	Decoction /oral	9
Rhamnaceae	1	<i>Ziziphus jujuba</i>	Tonomon	Leaves	Decoction /oral	7
Vitaceae	1	<i>Cissus quadrangularis</i>	Djinenofon	Leaves	Decoction /oral	4
Rutaceae	1	<i>Citrus Limon</i>	Lemourou koumouni	Leaves	Decoction /oral	8
Myrtaceae	1	<i>Psidium guajava</i>	Guyagi	Leaves	Decoction /oral	6

solely on the symptoms. In general, they recognize the patients who suffer from it by the following signs: fever accompanied by headache, general pain, palpitations and chills.

Plant organs used

The organs used are the leaves (82.43%), the roots (10.82%) and the bark of the trunk (6.75%). Our study showed that the recipes were monospecific. The predominance of monospecific recipes is confirmed by Diarra et al. (2015). This preponderance is to the benefit of the patients. In fact, associations of plants, poorly matched, are sometimes dangerous. The frequent use of the leaves is justified by the abundance of antimalarial chemical groups they contain (Mangambu et al., 2014). The prevalence of leaves in recipes for the treatment of

malaria has been reported by other authors such as Diarra et al. (2015, 2016).

Methods of preparation and routes of administration of recipes

The methods of preparation used by traditional therapists are decoction (87.83%) and maceration (12.16%). This is due to the fact that a decoction collects the most active ingredients and attenuates or cancels the toxic effect of certain recipes (Salhi et al., 2010). Most of the preparations are administered orally as a drink, sometimes using the external route by bath (Table 2). Our results corroborate those of some studies (Diarra et al., 2016, 2015; Diallo et al., 2007) who found that antimalarial plants are mainly prepared by decoction and administered orally.

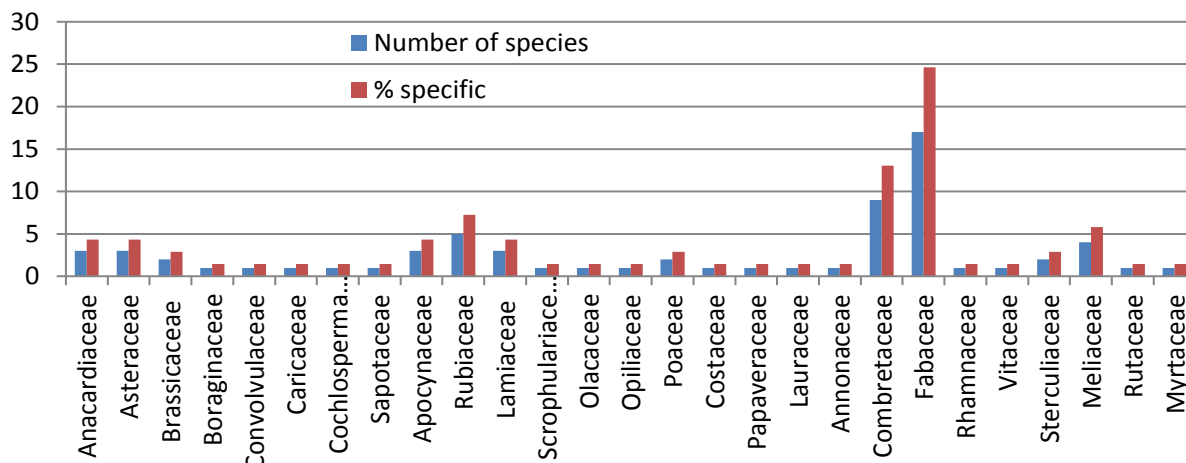


Figure 2. Nature and specific richness of plant families.

Diversity of taxa

From the data collected, 69 species of plants belonging to 27 botanical families were identified. Most of them are the Fabaceae (17 species or 24.63%). Others are the Combretaceae (nine species or 13.04%), the Rubiaceae (five species or 7.24%) and the Meliaceae (four species or 5.79%). These results show some similarities with Dénou et al. (2017); Diarra et al. (2015; 2016) and Diallo et al. (2007). However, there is variability in the number of individuals identified from one study to another (Dénou et al., 2017; Diarra et al., 2015; 2016; Diallo et al., 2007). This variability would be due to variations in the methods of investigation; it could in particular be explained by the differences in localities and vegetation. The Anacardiaceae, the Lamiaceae and the Asteraceae were represented by three species each (Figure 2). Three other families were represented by two species each and 16 represented by one species each.

DISCUSSION

Several studies have shown the antimalarial activity of the plants most cited in our study. *Combretum micranthum* is an important medicinal plant in West Africa known for the moderate antiplasmodial activity of its leaves (Karou et al., 2003; Ancolio et al., 2002; Benoit et al., 1996). In clinical trials, the efficacy of a decoction of the leaves of *Argemone mexicana* has been confirmed in the management of malaria (Saroj et al., 2015; Goutam et al., 2013; Willcox et al., 2007). *A. mexicana* contains the alkaloids berberine, protopine and allocryptopine; these compounds showed *in vitro* antimalarial activity (Avello, 2009). Few works on the toxicity and safety evaluation of *A. mexicana* are reported. Ibrahim and Ibrahim (2009) showed that the plant extract exhibits acute toxicity in mice with LD₅₀ value of 400 mg/kg.

Extracts from leaves of *Mitragyna inermis* have been tested *in vitro* against Chloroquine resistant strain (K1) and chloroquine-sensitive strain (3D7) of *Plasmodium falciparum*. Aqueous extracts exhibited the best results against K1 with the 50% inhibitory concentration (IC₅₀) values of 0.54±0.18, 1.72±0.99, 1.54±0.04 µg/ml. Hydroethanolic extract from the leaves of *M. inermis* gave also IC₅₀ value of 0.87 ± 0.10 g/ml with 3D7. As for the hydroacetone extract of the roots, the IC₅₀ values recorded with *P. falciparum* K1 are 1.82 ± 1.50 µg/ml (Zongo et al., 2011; Traore-Keita et al., 2000). The acute general toxicity assessed by Ouedraogo in Burkina Faso, classified the *M. inermis* extracts in the category of weakly toxic substances with an LD₅₀ = 810.7468 mg / kg (Ouedraogo et al., 2001). *Gardenia sokotensis* was also reported to exhibit *in vivo* antiplasmodial activity, extract dichloromethane-methanol (7/3v/v) showed a promising *in vivo* antiplasmodial activity with 50% effective dose of 17.59 mg/kg and 115 mg/kg respectively (Traoré et al., 2006). Few bibliographic data are available of phytochemical and pharmacological of *Conocarpus biocarpa*. These results show a correlation with the frequency of citation of the species with the exception of the antiplasmodial activity of *C. biocarpa* which has not been reported in the literature, to our knowledge. In the search for new active substances against Plasmodium, the unexplored flora of the countries of the South constitutes a privileged potential source of new drugs (Jansen et al., 2008).

Even if an exhaustive list could not be established, it appears that several medicinal plants mentioned during our investigation are increasingly imported from other regions of Mali. However, traditional imported medicines are far too expensive compared to local purchasing capacity and are not always available in rural areas. The traditional therapists interviewed also revealed that most of the natural plants used for the treatment of malaria grow less and less because of the wild harvesting of the

leaves and the brutal uprooting of the feet. Indeed, uprooting, delimbing, felling and debarking which are reported harvesting methods turn out to be harmful because these harvesting methods prevent the plant from flowering, induce infections and are harmful origin of the threat of extinction of species (Anoma and Aké-Assi, 1989). This overexploitation leads to a local disappearance of useful plants around large cities. To support the sustainable harvest of good quality medicinal plants in ways that respect and promote the conservation of medicinal plants and the environment in general, our study suggests the establishment of a support program for traditional therapists.

Conclusion

The present study reveals the great knowledge of antimalarial medicinal plants by traditional therapists and the botanical richness of this region. These results can be considered as a source of information for scientific research in the field of phytochemistry and pharmacology. The conventional use of these plants can be rationalized, because of their richness in active components, in order to find new anti-malarial substances. In order to improve the quality, harmlessness and efficacy of finished products for plant origin in the Ségou region, this work suggests the implementation of a program for supervising the associations of traditional therapists on good practices, harvesting, processing, drying, transport, storage and preservation of medicinal plant materials. This program will help encourage traditional therapists to improve their practices for achieving rigorous botanical identification, precise dosing, better hygiene, development of dosage forms and packaging. In perspective, our work concerns the phytochemistry, acute toxicity and the evaluation of the antiplasmodial activity of *C. biocarpa*.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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