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To cite this version:

Léa Nadège Bonkian, Rakiswendé S Yerbanga, Maminata Traoré Coulibaly, Thierry Lefèvre, Ibrahim Sangaré, et al.. Plants against Malaria and Mosquitoes in Sahel region of Burkina Faso: An Ethno-botanical survey. International Journal of Herbal Medicine, 2017, 5. hal-02411013

HAL Id: hal-02411013

https://hal.science/hal-02411013

Submitted on 14 Dec 2019

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International Journal of Herbal Medicine
Available online at www.florajournal.com

E-ISSN: 2321-2187
P-ISSN: 2394-0514
IJHM 2017; 5(3): 82-87
Received: 11-03-2017
Accepted: 10-04-2017

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Plants against Malaria and Mosquitoes in Sahel region of Burkina Faso: An Ethno-botanical survey

Léa Nadège Bonkian, Rakiswendé Serge Yerbanga, Maminata Traoré/ Coulibaly, Thierry Lefevre, Ibrahim Sangaré, Théophile Ouédraogo, Ousmane Traoré, Jean Bosco Ouédraogo, Tinga Robert Guiguemdé and Kounbobr Roch Dabiré

Abstract
Artemisinin-based Combination Therapy is recommended for the treatment of malaria in Burkina Faso but, most people in this country prefer to use herbal medicine because of its low cost and high availability. The aim of the study was to identify plants used by traditional healers from Sahel region of Burkina Faso in the prevention and the treatment of malaria. An ethno-botanical survey was carried out among traditional healers in the Sahel region of Burkina Faso. Questionnaires were administrated to people willing to participate in the survey and the plants used for prevention and treatment of malaria were recorded. A total of 80 traditional healers were interviewed. Forty two plants were identified as being commonly used in the treatment of malaria and 16 in repelling mosquitoes. The use of plants in the treatment and protection against malaria is widespread in the Sahel region of Burkina Faso.

Keywords: Ethno-botanical survey, malaria, plant, Repellents, Sahel, Burkina Faso

1. Introduction
Malaria is responsible for 61.50% of hospitalizations in health centers and 30.50% of deaths in Burkina Faso [1]. Children under five years and pregnant women are at the most risk of the disease [1].The control of malaria in Burkina Faso, as in all malaria endemic countries, is based mainly on the use of impregnated bed nets, intermittent preventive treatment for pregnant women and infants and early and adequate treatment of cases with Artemisinin-based Combination Therapies (ACTs). Despite all these strategies in place, Burkina Faso continues to face treatment challenges because of accessibility and adherence to ACTs [2]. Many patients delay treatment by health centers in favor of using herbal medicine for self-treatment [2]. One of the reasons is because traditional medicines are easily available and affordable for them. In Burkina Faso, traditional healers are seen as specialists in traditional medicine and are classified officially by their recognized associations. The pharmacists within the regional health districts supervise their multiple activities.
Desmodium velutinum (Willd) DC, *Combretum sericeum* G. Don, *Combretum molle* R.Br ex G. Don, *Bidens engleri* O.E. Schulz, *Cucumis metuliferus* E. Mey. ex Naudin, *Cassia podocarpa* Guill. et Perr. and *Opilia celtidifolia* Guill. & Perr. were identified from previous investigations carried out in the west region of Burkina Faso and tested against *Plasmodium falciparum* [3, 4]. *Hyptis suaveolens* and *Hyptis spicigera* also used in the west region of Burkina Faso against mosquitoes were tested for repellency [3]. Despite the importance of herbal medicine in Burkina Faso, there is a lack of published data on plants used against malaria especially in the Sahel region. That region is dry and it is believed that plants used in that area will be different from those from more humid areas, which are more studied up to now. The aim of this study was to conduct an ethno-botanical survey among traditional healers from Sahel region of Burkina Faso to identify possible anti-malarial and anti-mosquito plants but also how these plants are used.

2. Material and methods
2.1. Study area
The study was carried out in the northern Sahel region of Burkina Faso, which covers4 provinces, namely Séno, Soum, Oudalan and Yagha provinces (Figure 1). The population is estimated to1 121 764 inhabitants [5]. The main ethnics groups are: Fulani, Kel Tamashek, Sonrhai, Gourma, Mossi, Foulse and Zarma [6]. The Sahel region is characterized bya rainy season from July to September and a dry season from October to June.

The annual average rainfall is between 300 and 600 millimeters/year. The temperatures oscillates between 10 °C to more than 43 °C with a high daily and annual thermal amplitude [7]. The Niger River and other small rivers such as Béli, Goudébo, Gorouol, Sirba and Yali irrigate the region. There are also many natural ponds irrigating the Sahel region. The vegetation type is the steppe with herbs and trees, mostly thorny trees [7] (Figure1). Malaria is endemic in the region and transmission occurs during the rainy season and the highest level of malaria cases is observed in September [8]. In 2014, 503 976 cases of uncomplicated malaria, 29 224 cases of severe malaria and 423 deaths due to malaria were recorded in the region [9]. For their care and protection, the rural tribal populations from the region use in first line of care, the recipes of traditional medicine (Yelkouni, personal communication).

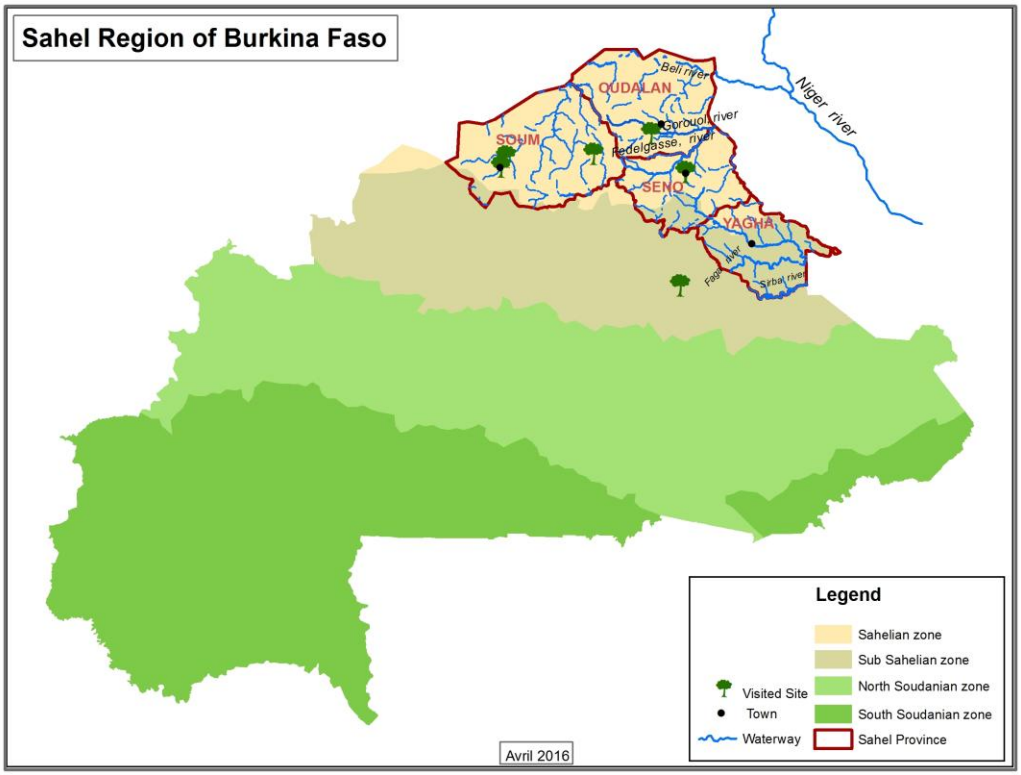

Fig 1: Study site

2.2. Study design and procedures

An ethno-botanical survey was conducted in February 2014. The inclusion criteria in the study were

To be a traditional healer or an herbalist resident in the Sahel region

- Having recipes or knowledge on plants used for treating malaria or for protecting against mosquitoes
- Consent to participate in the study.

The survey was conducted with the aid of the pharmacists of the region. After a documented informed consent, questionnaires were administrated to participants in local language. The socio-demographic data, the cause and treatment of malaria, plants used against malaria and mosquitoes, their mode of preparation and administration were asked in the questionnaires. The participants gave the vernacular names of the plants. After the interview, plants were collected with the assistance of traditional healers. The identification of the plants and their scientific names were later on given by a botanist of the "Institut de l'Environnement et de Recherches Agricoles" (INERA) in Farakoba/ Bobo-Dioulasso. The data collected were entered and analyzed with Epi-data program.

2.3. Ethical considerations

The institutional ethic review board of "Centre MURAZ" approved the protocol of the study (ref: A 005-2014/CE-CM). A written prior free informed consent from each traditional healer was obtained before the commencement of the study. The confidentiality of the participants and the data were protected throughout the study.

3. Results

3.1. Socio-demographic data

In total, 80 traditional healers were interviewed, 20 in the province of Oudalanas in the Séno and 40 were interviewed in the Soum. No consent was received from traditional healers from Yagha province and as a result, none of them took part in the study. The participants aged between 20 and 99years, with an average of 54.14± 13.06; 48. 75 ± 11.49 years for women and 56.44± 13.22 years for men. The sex ratio (M/F) was 2.3 (56/24). The average duration in traditional practice was 18.4±12.4 years for the 71 participants with 09 not disclosing their years of experience in practice. Only, 12participants (15%), including 02 women (8% of women) had certificates issued by the authorities to practice traditional medicine (Table 1).

Table 1: Socio- demographic characteristics of participants (n=80)

Characteristics	Frequency
Ethnicity	
Bella	02
Bissa	01
Foulse	07
Haoussa	01
Malebe	10
Marinse	03
Mossi	29
Fulani	21

Sonrhai	04
Age	
20	1
21 to 30	3
31 to 40	4
41 to 50	21
51 to 60	25
61 to 70	18
71 to 80	7
81 to 90	0
91 to 100	1
Gender	
Male	56
Female	48
Experience as healer (Years)	
1 to 10	26
11 to 20	21
21 to 30	15
31 to 40	07
41 to 50	02
Unknown	09
Certificate of practice (traditional medicine)	
Yes	12
No	68
Member of the traditional healers association	
Yes	75
No	05
Healer of malaria	
Yes	79
No	01
Knowledge of plants used as mosquito repellent	
Yes	47
No	33

3.2. Knowledge of traditional healers on causes and treatment of malaria

All the 80 traditional healers were interviewed on the cause of malaria. Seventy three (91.2%) participants answered what they know about the cause of malaria, 6 (7.5%) participants had no idea about the cause of malaria, and 1(1.3%) participant gave no response.

According to participants, malaria transmission is caused by mosquito bites (61.3%), dirt (5%), sun (8.75%), rain (1.25%), fatigue (1.25%), humidity (1.25%), dirty water (1.25%), climate change (2.5%) constipation (2.5%), climate change (2.5%), fatty foods (11.25%), sweet foods (3.75%) and milk (11.25%).With regards to participants' understanding of malaria treatment, 98.8% of the mused herbs. They collect the plants, which are still growing in the region and, buy those that they cannot get in the region from herbalists.

3.3. Identification, preparation and administration of plants

- Plants used for the treatment of malaria

A total of52 plant species were cited in local languages (Fulani, Moore and Sonrhai) by the traditional healers as used for the treatment of malaria. Forty two plants were identified by the botanist and belong to25 families (Table 2) but the remaining 10 (Krakra, Tinguila, Kondontaabo, Kogomde, Baagom-baogom, Nogomtaaba, Toomgoum, Kega, Leago, Laouyi) could not be identified because of lack of samples due to the season (Tinguila, Laouyi) and transcription issues. Approximately 9.5% of the plants were imported from other regions. The most commonly used plants in the treatment of malaria belong to 7 families namely:

- Combretaceae: *Guiera senegalensis* J.F. Gmel. (40%), *Combretum micranthum* G. Don (32.5%)*;*
- Cucurbitaceae: *Momordica balsamina* L. (13.75 %)*;*
- Anacardiaceae: *Lannea velutina* A. Rich. (8.75%)*;*
- Fabaceae*: Cassia sieberiana* DC. (8.75%)*;*
- Rutaceae: *Citrus limon* (L.) Osbeck. (7.5 %);
- Fabaceae: *Bauhinia rufescens* Lam. (6.25%)*;*
- Meliaceae: *Azadirachta indica* A. Juss. (6.25%);
- Myrtaceae: *Eucalyptus camaldulensis* Dehnh. (6.25%).

The most commonly used parts of the plants are the leaves (57.1%), the roots and the stem bark (31%), the fruits and the whole plant (9.5%) and the least used being the wood (2.4%). The preparations were mainly water based, in decoctions (78.5%) or in macerations (9.5%), and without preference (12%). The preparations were administered by oral route, and sometimes with bath (47.6%).

Table 2: Plants used in the treatment of malaria

Name of plant		Family	Plant part	Preparation	Administration	Frequency
Botanicalname	**Local name**					
Lannea velutina A. Rich.	farfai, sabara	Anacardiaceae	Stem bark, leaves	decoction	oral, bath	7
Sclerocarya birrea (A. Rich.) Hochst.	Nobga	Anacardiaceae	Stem bark	decoction	oral, bath	1
Mangifera indica L.	Manguier	Anacardiaceae	leaves	decoction	oral	1
Leptadenialancifolia (Schumach. & Thonn.) Decne.	Lelongo	Apocynaceae	Roots	decoction	oral	1
Leptadeniapyrotechnica (Forssk.) Decne.	Pipeteeki	Apocynaceae	stem, roots	decoction	oral	1
Calotropisprocera (Aiton) Dryand.	Soompouga	Apocynaceae	Stem bark	decoction	oral	1
Gymnanthemumcoloratum (Willd.) H. Rob. &B.Kahn	ko safina	Asteraceae	leaves	decoction, maceration	oral, bath	3
*Bauhinia rufescens*Lam.	tipolga, namadi	Fabaceae	leaves, Stem bark, roots, fruits	decoction	oral	5
Ceibapentandra (L.) Gaertn.	gakongare	Bombacaceae	wood	decoction	oral	1
*Bosciaangustifolia*A.Rich.	zibrezika	Capparaceae	Stem bark	decoction	oral, bath	1
Boscia senegalensis (Pers.) Lam.	Lamboiga,	Capparaceae	leaves	decoction	oral	1
Caricapapaya L.	papayer	Caricaceae	leaves	decoction	oral, bath	3
Cassia sieberiana DC.	koumbre saka	Fabaceae	roots	decoction, maceration	oral, bath	7
Tamarindusindica L.	poussiga	Fabaceae	leaves, roots, fruits	maceration	oral, bath	4
Senna occidentalis (L.) Link	nagnirancolga	Fabaceae	leaves	decoction	oral	2
Cochlospermumplanchonii Hook. F.	sonse, djarombe	Bixaceae	Whole plant, roots	decoction	oral, bath	4
Bauhinia reticulata DC.	barkere	Fabaceae	leaves	decoction	oral, bath	1
Guiera senegalensis J.F. Gmel.	wilinwiga,yoloko	Combretaceae	leaves, roots, Stem bark	decoction, maceration	oral, bath	32
Combretummicranthum G. Don	randga,dooki	Combretaceae	leaves	decoction, maceration	oral, bath	26
Terminaliaavicennioides Guill. & perr.	kondre	Combretaceae	leaves, Stem bark	decoction	oral, bath	2
Combretumnigricans Lepr. ex Guill. &Perr.	ndocko	Combretaceae	leaves	decoction	oral	1
Anogeissusleiocarpus (DC) Guill. et Perr.	kodjoli	Combretaceae	leaves	decoction	oral	1

Momordica balsamina L.	Konbisabgatim,	Cucurbitaceae	Whole plant	decoction, maceration	oral, bath	11
Azadirachta indica A. juss.	Neem, Tourotia	Meliaceae	leaves	decoction	oral, bath	5
Trichiliaemetica Vahl	soula fisan, sisenlili	Meliaceae	roots	decoction	oral, bath	2
Khayasenegalensis (Desv.) A. Juss.	cailcédrat	Meliaceae	Stem bark	decoction	oral	1
Acacia nilotica (L.) Delile	gaoudi, a penega	Fabaceae	leaves, roots, Stem bark, fruits	decoction	oral	3
Acacia senegal (L.) Willd.	kolmiga	Fabaceae	leaves, Stem bark	decoction	oral	2
Acacia ataxacantha DC.	nawib sana	Fabaceae	leaves	decoction	oral, bath	1
Acacia sieberiana DC.	gorponsgo	Fabaceae	Stem bark	decoction	oral	1
Ficus gnaphalocarpa (Miq.) Steud. ex A. Rich.	figuier	Moraceae	roots	decoction	oral	1
*Eucalyptus camaldulensis*Dehnh.	Eucalyptus	Myrtaceae	leaves	decoction	oral, bath	5
Psidiumguajava L.	goyavier	Myrtaceae	leaves	decoction	oral	4
Ximenia americana L.	Leenga	Olacaceae	roots	maceration	oral	1
Securidacalongipedunculata Fresen.	Pelga	Polygalaceae	leaves, Stem bark	decoction	oral	1
Ziziphusjujuba Mill.	Mougounouga	Rhamnaceae	leaves, roots	decoction	oral, bath	2
GardeniaternifoliaSchumach. & Thonn.	Adinga	Rubiaceae	Whole plant	decoction	oral, bath	1
Citrus limon (L.) Osbeck.	citronnier	Rutaceae	leaves	decoction	oral, bath	6
Scopariadulcis L.	kafrmann	Plantaginaceae	Whole plant	decoction	oral	1
Capsicumannuum L.	piment	Solanaceae	fruits	maceration	oral	1
Cissusquadrangularis L.	pangnade	Vitaceae	leaves	decoction	oral	1
Balanites aegyptiaca (L.) Delile	keglga	Zygophyllaceae	roots	maceration	oral	3

➢ **Plants used as mosquito repellent**

Among the 80 participants included in the study, 47were aware about plants used against mosquitoes. Twenty two (22) plant species were cited as being used against mosquitoes among which, 16 species were identified and belong to14 families (Table 3)6 species (Mello, Dogma, Leguelounguai, Keoga, Kokoaka, Zinzodga) could not be collected for identification.

The most cited plants for use against mosquitoes belonged to 04 families:

- Meliaceae: *Azadirachta indica* A. Juss. (38.3%)*;*
- Poaceae: *Pennisetum glaucum* (L.) R. Br. (34%), *Sorghum bicolor* L. Moench (14.9%)*;*
- Lamiaceae*: Ocimum americanum* L. (6.4%)*;* and
- Capparaceae: *Boscia senegalensis* (Pers.) Lam. (4.3%).

Most of these plants were used in fumigation (88%), bathing (22%), hanging in houses (6%) and fresh extracts for skin coating (6%).

All these plant cited, as used against mosquitoes were available in Sahel region.

Table 3: Plants used as mosquito repellent

Name of plant		Family	Plant part	use	frequency
Botanicalname	**Local name**				
Calotropisprocera (Aiton) Dryand.	Soompouga	Apocynaceae	whole plant	fumigation	1
*Boscia senegalensis*Lam.	Lamboiga	Capparaceae	leaves, stem bark	apply the juice on the skin, fumigation	2
Combretummicranthum G. Don	randga,dooki	Combretaceae	stem	fumigation	1
Arachishypogaea L.	Nangouri	Fabaceae	shell	fumigation	1
Ocimum americanum L.	Youneyouga, Roumstiim	Lamiaceae	leaves, whole plant	put in the house	3
Azadirachta indica A. Juss	Neem, Tourotia	Meliaceae	leaves	take a bath with the decoction	18
Acacia nilotica (L.) Delile	gaoudi, a penega	Fabaceae	whole plant	fumigation	1
*Eucalyptus camaldulensis*Renhard	Eucalyptus	Myrtaceae	leaves	fumigation	1
Ximenia americana L.	Leenga	Olacaceae	leaves	fumigation	1
Sorghum bicolor (L.) Moench	Boutale	Poaceae	whole plant, cob	fumigation	7
Pennisetum glaucum (L.) R. Br.	Gnade	Poaceae	whole plant, cob	fumigation	16
Cymbopogon citratus (DC.) Stapf	Citronnelle	Poaceae	leaves	fumigation	1
*Securidacalongipedunculata*Fresen.	Pelga	Polygalaceae	Rootsbark	fumigation	1
GardeniaternifoliaSchumach. &Thonn.	Adinga	Rubiaceae	whole plant	fumigation	1
Citrus limon (L.) Osbeck.	Citronnier	Rutaceae	fruits bark	fumigation	1
Datura stramonium L.	Koungaloumga	Solanaceae	leaves	fumigation	1
RottenLeaves	Vampansga, Vamponsa		whole plant, leaves	fumigation	3

4. Discussion

4.1. Study population and knowledge on malaria transmission

All participants interviewed live within hamlets in the Sahel region of Burkina Faso, with poor access to modern health facilities and amenities. Their primary health recourse is to traditional healers and herbal medicine.

Among the traditional healers interviewed, men were mostly represented (M/F=2.3). This ratio was previously found [10].Only a few of the participants hada certificate from Ministry of Health authorizing them tolegal practice of traditional medicine. The low rate of traditional healers who had certificates could be attributed to their illiteracy, costs associated with obtaining certificate, accessibility to the authorities and lack of understanding of what is required of them. Obtaining the certificate of recognition requires proofs from regional health district for the effectiveness of treatments proposed.

The Department of Traditional Medicine and Pharmacopeia, which is within the Ministry of Health, is working to increase the number of certified traditional healers. Approximately 61.3% of participants were aware about the causes of transmission of malaria but a significant number (38.7%) did not know how malaria is transmitted. Similar studies conducted in Zimbabwe, Uganda and Kenya have found the same tendency [11]. Traditional healers in Burkina Faso benefit from time-to-time trainings organized by the Ministry of Health in all districts. It is clear from these results that traditional healers need more training in the treatment of diseases especially malaria.

4.2. Preparation and administration of remedies

Leaves are the most common plant parts used, followed by the roots, stem barks, fruits and whole plant. Similar results were found by Randrianarivelojosia *et al*. [12] however, in some other studies, roots are the most cited [13, 14]. Water based preparations are the commons forms used by the traditional healers but in research laboratories these forms are found less active on malaria parasites compared to organic extracts [15].

4.3. Plants used in the treatment of malaria

The survey revealed several plants used traditionally to treat malaria. *Eucalyptus camaldulensis*, *Bauhinia rufescens*, *Combretum micranthum*, *Guiera senegalensis*, *Cassia sieberiana* were previously found to be used against malariain the other regions of Burkina Faso [16-18].

Azadirachta indica, *Guiera senegalensis*, *Combretum micranthum*,

Gymnanthemum colaratum and *Ximeniaamericana* were tested on chloroquino- resistant and chloroquino-sensitive) *Plasmodium falciparum* [19]. The IC_{50} (µg/mL) against chloroquino resistant and chloroquino sensitive strain for each plant extract after 72 hours was respectively: 1.18±0.5and 0.88 ± 0.9 for *Combretum micranthum*, 1.83 ±1.2 and 0.6 ± 0.2 for *Ximenia Americana*, 2.35 ± 1.1 and 12.5 ± 0 for *Gymnanthemum coloratum*, 4.17 ± 1.8 and 2.35 ± 1.1 for *Azadira chtaindica*, 0.79 ± 0.6 and 7.03 ± 7.7 for *Guiera senegalensis*. Elsewhere, the leaf extract of *Cassia sieberiana* was successfully tested on *Plasmodium falciparum* [19] parasites isolated from patients [20]. In south Africa, the whole plant extract of *Momordica balsamina* showed an *in vitro* activity (IC_{50}=18 µg/mL) against *Plasmodium falciparum* [15].

Sahel region is characterized by dryness and some plant species have disappeared and the remaining ones have to adapt to the harsh climatic conditions including drought. During the study, it was found that some species used by traditional healers are imported from neighboring regions because the plants have disappeared from the Sahel region. It is known that plant metabolites may change in nature and proportion according to the environment, locality, soil and seasonal changes. This fact was also considered when carrying out this survey in Sahel Region, as the secondary aim of the research was to find new bioactive plant metabolites. Plants cited by traditional healers against malaria are also indicated for the treatment of other diseases. The multiple indications in medicinal plants are not unique as plant may contain many metabolites that may have different pharmacological activities.

4.4. Plants used as mosquito repellent

Traditional healers in Sahel region of Burkina Faso mentioned and identified many plants used as mosquito repellents for protection against mosquito bites. During fumigation of houses the plants are burned and the active volatile essential oils contained in plants are released in the environment and repel the mosquitoes causing malaria. Individuals may protect themselves against mosquito bite by applying the active principle, on the skin as ointments or by taking a bath with a decoction of the plant or by applying the fresh juice from plant material on the body. The leaves of *Azadirachta indica* and *Citrus limon* are also used in fumigation by the local population in Tanzania [21]. The mosquito repellency of *Azadirachta indica* [22], *Ocimum americanum* and *Cymbopogon citratus* has been previously reported [23-26, 21].The essential oil from *Citrus limon* peels, showed a high insecticidal activity against the vine mealybug with a LC_{50}= 2.7 mg/mL[CI: 1.8-3.6]) [27].The survey revealed a high frequency of utilization of *Sorghum bicolor* (14.9%), *Pennisetum glaucum* (34%) and *Boscia senegalensis* (4.3%), but no published data on their repellency was found.

5. Conclusion

In the light of this ethno-botanical survey, it appears that traditional healers from Sahel Region of Burkina Fasostill believe in plants and traditional medicine for their primary health care. However this observation could be biased as traditional healers would support what they do. Thus, it would be appropriate that patients or ordinary people be given the same interviews and their responses observed and confirmed with these findings.

Some species have disappeared from the Sahel region and are obtained from others regions. Some of the plants will be selected for laboratory investigation to justify their use in traditional medicine. As recommendation, the health district should continue to provide training for traditional healers in order to improve their knowledge and practices in health care.

6. Acknowledgments

Ourthanks go to all the persons and institutions that have supported the conduct of this ethno-botanical survey, particularly:

- The PACER 2/UEMOA project and the Eco health Sahel project (PEPS CNRS ECOSAN 2013) for financial support.
- The health District of Sahel region (Burkina Faso), the President of Sahel traditional healers association and all traditional healers who participated in the study.
- The "Institut de l'Environnement et de Recherches Agricoles" (INERA) for plants identification
- Professor Motlalepula G. Matsabisaand Miss Theresa Appiah for language support

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