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Ethnobotanical survey for potential anti-malarial plants in south-western Nigeria

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ABSTRACT

Aim of study: The ethnobotanical study surveyed the different types of medicinal plants used for the treatment of malaria in the south-western region of Nigeria.
Materials and methods: Information was collected by interviewing indigenous people, using a semi-structured questionnaire. Collected plant samples were identified and authenticated in Forestry Research Institute of Nigeria, Ibadan, Nigeria.
Results: A total of 151 respondents were interviewed of which 64% were females and 36% males. This population comprised of herbal medicine sellers (39%), traditional doctors (15%), housewives (24%) and farmers (22%). Twenty two plants species used in the treatment of malaria belonging to 18 families were identified and compiled detailing information such as common and vernacular names, parts used, methods of preparation and previous scientific reports. Of the plants identified during the survey, *Azadirachta indica* (12.9%), *Alstonia congensis* (11.9%) and *Cymbopogon citratus* (11.3%) showed the highest incidence of encounter whereas *Nauclea latifolia* recorded the lowest incidence of encounter (0.2%). The traditional usage of *Persea americana* and *Ludwigia peruviana* in the treatment of malaria is reported here for the first time.
Conclusion: Though a large number of traditionally used plants for the treatment of malaria were identified, scientific validation of the traditional claims of anti-malarial properties is imperative. This would establish their candidature for any possible future research for active principles and the possible development of new cheaper and more effective anti-malarial drugs, as well as in the conservation of this rich diversity of anti-malarial plants.

1. Introduction

Ethnobotany is the study of how communities of a particular region employ indigenous plants for food, clothing, medicine and other activities (Aiyeloja and Bello, 2006), the documentation of which is crucial for the conservation and utilization of biological resources (Muthu et al., 2006).

Plant materials have been a major source of natural therapeutic remedies and are used to treat various infectious diseases in many developing countries (Ody, 1993). Nowadays, natural products of plant sources have been the centre of focus as the main source of new, safer and more effective bioactive compounds with medicinal properties (Nitta et al., 2002).

A vast majority of prescription drugs used in the world contain compounds that are directly or indirectly, via semi-synthesis, derived from plants (Oksman-Caldentey and Inzé, 2004). Even the synthetic drugs and compounds used in modern times owe their active chemical compound to a bioactive compound in a plant, which has been identified and then copied (Rates, 2001). Thus, plants continue to be a very important resource for new medicines and beneficial compounds. African flora is greatly rich with a lot of medicinal plants, which indigenous people are familiar with and have used over time. Sofowora (1982) reported that Africa has as much as three hundred thousand medicinal plants. In African countries, approximately 80% of the population uses traditional medicine for the treatment of various diseases and ailments like malaria, typhoid, ulcers, skin diseases, diabetes, reproductive problems, aches and pains for various socio-cultural and economic reasons. Ethnobotanical surveys have shown that these traditional medicines have been found to be effective especially in the treatment of malaria which is of great concern to any African nation (WHO, 2002).

The constant evolution of the malaria parasite has rendered the cheapest and most widely available anti-malarial treatments ineffective—more so with the recent reports about the increasing resistance of *Plasmodium falciparum* to artemisinin-based compounds (Htut, 2009; Cui et al., 2012). Accordingly, there is deep concern that

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this parasite will soon develop total resistance to such orthodox treatments. Hence, the search for newer more effective malaria cures is a major thrust of global research today. Therefore, there is an urgent need to explore and utilize the naturally endowed rich biodiversity of indigenous communities through research that could translate to benefits for mankind. Such investigations on medicinal and beneficial plants could provide useful leads for the synthesis of important active compounds. Various studies have been documented with over 1200 plant species from 160 families used in the treatment of malaria or fever (Willcox and Bodeker, 2004). Similar investigations have been carried out in many African nations like Ethiopia (Bekalo et al., 2009), Kenya (Bussmann, 2006; Njoroge and Bussmann, 2006), Ghana (Asase et al., 2005), Cameroon (Titanji et al., 2008) and Nigeria (Odugbemi et al., 2007; Ajibesin et al., 2008; Olowokudejo et al., 2008; Idowu et al., 2009; Kayode et al., 2009). The cited studies in Nigeria were mostly restricted to single states in the federation. This may have posed some limitations on reach such as the exclusion of some potential candidates. The present study however covers the south-west regions of Nigeria with the intent of filling these gaps and identifying newer plants that are traditionally employed in the treatment of malaria across geopolitical boundaries.

Njoroge and Bussmann (2006) examined the utilization of traditional plant medicines in managing the malaria menace in Central Kenya. Their results showed a total of 58 species in 54 genera and 33 families to have been used in the treatment of malaria. Forty-one species belonging to 17 families were encountered during a study in Ghana. Of the 17 families studied, Leguminosae and Anacardiaceae predominated in terms of number of species used to treat malaria. Eight plant species namely, *Afraegle paniculata* (Rutaceae), *Haematostaphis barteri* (Anacardiaceae), *Indigoera pulchra* (Leguminosae), *Monanthotaxis* sp. (Annonaceae), *Ozoroa insignis* (Anacardiaceae), *Strychnos innocua* (Loganiaceae), *Strychnos spinosa* (Loganiaceae) and *Xeroderris stuhlmannii* (Leguminosae) which had not been previously documented for the treatment of malaria in Ghana were identified (Asase et al., 2005). *Azadirachta indica,* (Meliaceae), *Morinda lucida* (Rubiaceae) and *Nauclea latifolia* (Rubiaceae) – which were noted to have been utilised in the treatment of malaria in Ghana – were also identified to be used in the south-western regions of Nigeria (Ayitey-Smith, 1989; Abbiw, 1990; Mshana et al., 2001).

Thus, it is evident that the vast chemical diversity of plants in a bio-diverse region such as Nigeria is a promising source of novel lead compounds that is still relatively unexplored. Concomitantly, the use of ethnobotanical survey to cumulate the indigenous knowledge of traditional medicinal plants is envisioned as a valuable tool for targeting potentially active species from the wealth of anti-malarial plants. Though, studies have been conducted to identify plants traditionally used in the treatment of malaria, there is still a gamut of plants that are yet to be discovered. Therefore this study aimed at documenting ethnobotanical potentials, mainly anti-malarial activity of common herbs in the south-western region of Nigeria, and providing comprehensive details to back up their anti-malarial potential based on the information obtained during the survey such as frequency of usage, number of times the plant was mentioned, and previous literature on said plant.

2. Materials and methods

2.1. Study area

The study area covers south-western Nigeria, comprising of 5 states namely Delta, Edo, Ondo, Ogun, and Osun positioned between 7.08°N, 6.28°W and 3.05°N, 5.94°W (Fig. 1). The indigenes encountered in these regions were mainly farmers by occupation. Two main ethnic groups were encountered in these areas namely the Yoruba and Edo. The selected states were found to be malaria endemic states in the south-west regions with similar tropical climatic conditions. Their tropical climate is characterized by two distinct conditions of wet and dry seasons. These regions experience high rainfall and high humidity for most of the year with an average annual rainfall of 250 cm near the coastal area and 150 cm in the northern parts of the region.

2.2. Ethnobotanical survey

Large-scale studies investigating the potential of medicinal plants have reported a high correlation between the traditional

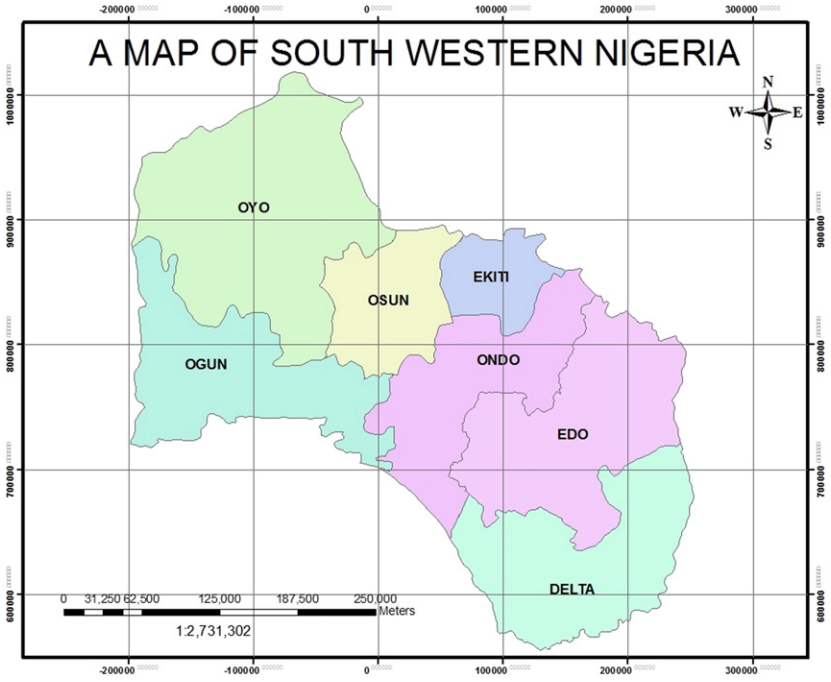

Fig. 1. Geographic location of area of study.

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use of plants and the presence of active compounds within the plant extract (McRae et al., 2007).

2.2.1. Questionnaire administration

Semi-structured questionnaires were used to interview the local population about their knowledge of plants used in the treatment of malaria (Table 1). Though the questionnaires had to be filled, direct questions were avoided. The basic information needed was collected through conversations, during the oral interviews. Respondents were chosen without distinction of gender. Individuals from all age groups (except children below 18 years) were to be interviewed on their knowledge of plants used in the treatment of malaria. However, most of the respondents were between the ages of 40–60 years and belong mainly to families which have a strong connection with traditional agricultural activities.

The random sampling technique was used and a total of 151 respondents were interviewed, of which 64% were females and 36% males. Information such as the demographic structure of the study population (age groups and sex of individuals) were generated and respondents were questioned on parts of plants employed in the treatment of malaria, mode of preparation, method of extraction, administration, other medicinal uses, accessibility and frequency of mention. The questionnaire was designed so as to meet all the criteria for an ethnobotanical survey so as to obtain a good ethnobotanical score (Willcox et al., 2011). The methods used for ethnobotanical data collection were semi structured interviews, field observation, preference ranking. The respondents often accompanied the investigators to the field to collect plant material. The plants encountered were photographed and herbarium specimens were collected and authenticated at the Forestry Research Institute of Nigeria (FRIN), Ibadan, Oyo State, Nigeria.

The survey was carried out from February to November 2009. Ethical clearance for the study was obtained from the ethical committee in Covenant University, Ota, Ogun State, Nigeria, and informed consent was obtained from all the participants prior to the administration of the questionnaire. The plants that were singly and most frequently used by traditional practitioners in the treatment of malaria were sought for during the ethnobotanical survey.

Table 1
Questionnaire employed to interview the local population about their knowledge of plants used in the treatment of malaria.

1	Date of interview and location	
2	Name of the participant	
3	Sex of the participant	Male Female
4	Age of the participant	18–29 30–39 40–49 50–59 60–69 70–79 79–89
5	Occupation of the participant	
6	Telephone and address of the participant	
7	Residence	Rural Urban
8	Type of plant employed (local name)	
9	Part(s) of the plant employed	Leaves Barks Root Fruit Seed Whole plant
10	Where do you collect the plant material from?	Wild Cultivated
11	Preparation method(s)	
12	Administration form(s)	
13	How do you confirm malaria before treatment?	
14	What other diseases do you use the plant to treat?	
15	How would you rank the plant in the treatment of malaria?	1- Slightly effective 2- Effective 3- Highly effective

2.3. Data analyses

The information obtained through the ethnobotanical interviews were analysed and expressed as percentage charts or tabulated based on the following parameters:

(i). Taxonomic diversity, growth forms, parts of the plant used to treat malaria.
(ii). The percentage of people who have knowledge about the use of a species in the treatment of malaria was evaluated using the formula (PPK): (number of people interviewed citing species/number of people interviewed) × 100.
(iii). Preference ranking (PR) method was employed. The plants were ranked according to their level of effectiveness in the treatment of malaria by the local people. Each rank is given an integer (1, 2 or 3) with the most effective plants assigned a value of 3 (Asase et al., 2005).
(iv). Availability of literature of previous studies on the plants identified e.g., anti-malarial or anti-plasmodial investigations, clinical trials, extraction solvents utilised and phytochemical isolated from them.

3. Results

3.1. Demographic data

The interviewed population comprised of herbal medicine sellers (39%), traditional doctors (15%), housewives (24%) and farmers (22%). Though individuals from all age groups (except children below 18 years) were to be interviewed on their knowledge of plants used in the treatment of malaria, most of the respondents were between the ages of 40–80 years and belonged mainly to families which have a strong connection with traditional agricultural activities. Majority of the respondents were females (65%) including herb sellers, farmers and housewives, some of whom were involved in farming while the males were mostly traditional doctors and farmers.

3.2. Plant information and taxonomic diversity

The investigations revealed that a total of 22 species namely *Anacardium occidentale* L., *Mangifera indica* L., *Allamanda cathartica* L., *Alstonia congensis* Engl., *Bixa orellana* L., *Dacryodes edulis* (G. Don.) H.J. Lam., *Canna indica* Linn., *Carica papaya* L., *Garcinia kola* Heckel, *Mormordica charantia* L., *Dioscorea dumetorum* Kunth, *Mallotus oppositifolius* Müll.Arg., *Persea americana* Mill., *Azadirachta indica* A. Juss., *Ficus exasperate* Vahl., *Psidium guajava* L., *Ludwigia peruviana* (L.) Hara., *Axonopus compressus* (Sw.) P. Beauv., *Cymbopogon citratus* (Dc) Stapf., *Morinda lucida* Benth., *Nauclea latifolia* Smith and *Musanga cecropioides* R.Br., distributed into 18 families (*Anacardiaceae*, *Apocynaceae*, *Bixaceae*, *Burseraceae*, *Cannaceae*, *Caricaceae*, *Clusiaceae*, *Cucurbitaceae*, *Dioscoreaceae*, *Euphorbiaceae, Lauraceae, Meliaceae, Moraceae, Myrtaceae, Onagraceae, Poaceae, Rubiaceae*, and *Urticaceae*), are used in the treatment of malaria in the south-western regions of Nigeria.

Data on the correct identification of these plants, which include the specific names, common names (English), their families, local names, plant parts used, percentage of people interviewed with knowledge (PPK) about their use to treat malaria, the preference ranking (PR) of the species, as well as other ailments treated are presented in Table 2.

Of the plants identified during the survey, *Azadirachta indica* (12.8%), *Alstonia congensis* (11.9%) and *Cymbopogon citratus* (11.3%) showed the highest incidence of encounter whereas *Nauclea latifolia* showed the lowest incidence of encounter (0.2%).

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Table 2
Indigenous medicinal plants used to treat malaria in south-western Nigeria and their preference ranking.

FAMILY	Plant name (voucher specimen no.)	Common names and plant form	Local names (Igbo, Yoruba, Hausa)	Parts used	Other medicinal value	PPK	PR
Anacardiaceae	[ab]*Anacardiumoccidentale* L. FHI 109445	Cashew tree	Sashu, Kaju, Kanju	Leaves, Bark	Amebicidal, antivenom, antioxidant and astringent properties. Used to treat gingivitis, syphilitic ulcers, Inflammation, diarrhoea, (Razalia et al., 2008 and Orwa *et al.,* 2009)	2.3	1
Anacardiaceae	[a]*Mangifera indica* L. FHI 109451	Mango tree	Mango Sawamsop, Mongora	Leaves, bark	Used to treat haemorrhoids, venereal diseases, pulmonary disorders, diarrhoea, dysentery. Employed as vermifuges, fabrifuges, pain-killers, antibiotic, antibacterial, antifungal, (Awe, 1998; Aiyeloja and Bello, 2006 and Kayode et al., 2009)	3.8	2
Apocynaceae	[b]*Allamanda cathartica* L. FHI 109463	Yellow allamanda, golden trumpet. Shurb	–	Leaves, root	Used to treat jaundice, dysentery, enlarged spleen, wound (Nayak et al., 2006)	0.8	2
Apocynaceae	[b]*Alstonia congensis* Engl. FHI 109449	Alstonia, cheesewood, stool wood, pattern wood tree	uburuocha, abo, gwandardaji	Leaves, bark	Used to treat gonorrhea, diarrhea, intestinal problems, rheumatic pain, ulcers, headache, scabies, cough (Majekodunmi et al., 2008 and Kayode et al., 2009)	11.9	3
Bixaceae	[ab]*Bixa orellana* L. FHI 109450	Lipstick tree, anatto	úhíé,machuku,úhíẹ́n kũọ̀ùnbúk	Leaves, seed	Used to treat diarrhea, dysentery, hypotensive, fevers, kidney diseases, skin diseases, wounds. Employed as insect repellant, antibacterials, anti-hemorrhagics (Terashima et al., 1991)	0.8	1
Burseraceae	[b]*Dacryodes edulis* (G. Don.) H.J. Lam. FH 109464	African native pear, African plum, bush butter tree	Ube,Elemi, oro,goron,bir	Leaves, bark	Anti-helmintics, astringent. Used to treat skin diseases,wounds, clearing pregnancy stretch marks, elephantiasis, diarrhea, dysentery, leprosy (Okwu and Nnamdi, 2008)	0.4	1
Cannaceae	*Canna indica* L. FHI 109452	wild canna lily Herb	aberekamw, ìdòrò, BààƙálééƙàlèBààƙálééƙàlè	Leaves, root	Used to treat diarrhea, dysentery; dropsy, swellings, oedema ,gout; kidneys, menstrual cycle disorder, jaundice, Venereal Disease, other Women's complaints (Choudhury et al., 2010)	0.4	1
Caricaceae	[a]*Carica papaya* L. FHI 109462	Papaya	Okworobeke/ojo, Ibepe, Gwanda	Leaves	Employed as purgative, lactation stimulants, diuretics, antidotes (venomous stings, bites), pain-killers, laxatives, vermifuges. Used to treat , liver disorders, cancer, febrifuges; kidneys disorders, venereal diseases, hemorrhoids, swellings, oedema, gout (Bhat and Surolia, 2001)	11.0	2
Clusiaceae	[a]*Garcinia kola* Heckel FHI 109460	Kola nut tree	Adu/aku-inu, Orogbo, Namijigoro	Leaves, fruit	Employed as genital stimulants, depressants, pain-killers, laxatives, antidotes for venomous stings and bites. Used to treat venereal diseases, nervous system disorders, diarrhea, dysentery (Iwu, 1993)	8.1	1
Cucurbitaceae	[b]*Mormordica charantia* L. FHI 109456	Bitter gourd, bitter melon Climber	dàgdágθ′, ejìnrìn, gàraàfúnií	Whole plant	Employed as antifungal, anti-inflammatory, anti-parasitic, antiseptic, digestive stimulant, febrifuge, lactagogue, menstrual stimulator, purgative, vermifuge, wound healer (Choudhury et al., 2010; Das et al., 2006; Khan and Omoloso 1998)	5.3	2
Dioscoreaceae	*Dioscorea dumetorum* Kunth FHI 109457	Wild yam, Bitter Yam Climber	Esuru, Gudugudu, Gursami	Leaves, Root	Employed as hypoglycaemic (Iwu et al., 1990)	0.4	1
Euphorbiaceae	*Mallotus oppositifolius*Müll. Arg. FHI 109455	Mallotus Shurb	Agukwu,Ijebu,káfàrmútúwaà	Leaves	To treat Leprosy, menstrual cycle disorders, small-pox, chicken-pox, measles, venereal diseases, diarrhea, dysentery, Kidneys problems, paralysis, epilepsy, convulsions, spasm; skin disorders. Used as diuretic, pain-killers, vermifuge (Iwu, 1993)	0.4	1
Lauraceae	*Persea americana* Mill. FHI 109444	Avacado tree	Ube-beke, Igba/apoka	Leaves	Employed as anti hypertension, antibacterial, antioxidant, antifungal, anti-helmintic, anti-diarrheal (Iwu, 1993)	0.8	1
Meliaceae	[ab]*Azadirachta indica* A. Juss. FHI 109461	Neem Tree	okwokwo- nwaosinake, imi-ewure, Dóógónyááròò	Leaves, bark, seed root	Employed as anti-helmintic (parasites and worms), Antipyretic, Antiseptic, Diuretic. Used to treat arthritis, Bronchitis, Cough, Diabetes, drowsiness Eczema, Fever, Jaundice , Leucorrhea, Lice, Nausea, Obesity, Rheumatism, Scrofula, Skin diseases, Syphilis, Tetanus, Thirst, Tumors, Vomiting, Chicken Pox, Acne (Alshawsh et al., 2009; Udeinya et al., 2006; Adesegun and Coker, 2001; Dhara et al., 1999 and Udeinya, 1993)	12.9	3
Moraceae	*Ficus exasperate* Vahl. FHI 109453	Fig tree	Ogbu, Oporo/opoto, Achedinnini	Leaves	Used to treat hemorrhoids; malnutrition, venereal diseases, naso-pharyngeal affections, fevers, typhoid, kidneys, arthritis, rheumatism, diarrhea, dysentery, swellings, oedema, gout; leprosy. Employed as diuretics; vermifuges, pain-killers, (Titanji et al., 2008)	9.1	2
Myrtaceae	[a]*Psidium guajava* L. FHI 109454	Guava tree	Ugova/ugwoba, Gurofa, Gwaabaa	Leaves, bark	Used to treat parasitic infection; menstrual cycle disorders; pulmonary troubles; small-pox, chicken-pox, measles, diarrhea, dysentery, stomach troubles, fever, typhoid, diabetes (Nundkumar and Ojewole, 2002 and Iwu, 1993).	10.6	2
Onagraceae	[b]*Ludwigia peruviana* (L.) Hara. FHI 109458	Primrose Willow Herb	–	Whole plant	Employed as anti-inflamatory, purgative (Wu et al., 2008)	0.4	1

Poaceae	[b]*Axonopus compressus* (Sw.) P. Beauv. FHI 109443	Broadleaf Carpet Grass	Idi	Whole plant	Used to treat asthma, breast swelling, diarrhea, fever, gingivitis, measles, nausea, rheumatism. Assists labor, lactation, (Wu et al., 2008)	3.4	2
Poaceae	[ab]*Cymbopogoncitratus* (Dc) Stapf. FHI 109448	Lemon grass	Ncheawula, Koriko-oba,agusi	Leaves	Used to treat cancer, Indigestion, Fever (Tchoumbougnang et al., 2005 and Bidla et al., 2004)	11.3	2
Rubiaceae	[b]*Morinda lucida* Benth FHI 109447	Brimstone tree	Ezeogu, Oruwo, idonzakara	Leaves, bark	Used to treat sores, abscesses, Leprosy, ringworm, fever, jaundice and dysentery (Odugbemi et al., 2007; Awe and Makinde, 1998 and Iwu., 1993)	5.3	2
Rubiaceae	[a]*Nauclea latifolia* Smith FHI 109446	African peach tree	uburu, egbesi, Marga	Leaves, bark	Used to treat yellow Fever, toothaches, dental caries, septic mouth and diarrhea, dysentery, Yellow fever, Low blood pressure (Benoit-Vicala et al., 1998)	0.2	1
Urticaceae	*Musanga cecropioides* R.Br. FHI 109459	Umbrella tree, Corkwood	únrì,agbàwò,Oro	Leaves, Bark	Used to treat dysentery, fevers, cough, naso-pharyngeal affections, oedema, gout, pain-killers, stomach troubles, paralysis, epilepsy, convulsions, heart; insanity, venereal diseases, arthritis, rheumatism, blood disorders; leprosy (Adeneye et al., 2006)	0.8	1

PPK: Percentage of people with knowledge of the anti-malarial usage of plant species.
[2]**PR:** Preference ranking of species used in treating malaria in the South-Western part of Nigeria.
[a] Plants species which have been scientifically previously investigated for anti-plasomodial/anti-malarial activity.
[b] Plants species which are singly used traditionally.

Among the families, *Anacardiaceae, Apocynaceae, Poaceae* and *Rubiaceae* provided the highest proportion of anti-malarial plants, making up 36% of the total plants collected. Of these four families plant species identified under the family of *Apocynaceae* and *Poaceae* namely *Alstonia congensis* and *Cymbopogon citratus* showed high PPK values of 42% and 40% and the corresponding PR values of 3 and 2, respectively.

The various groups of respondents provided information on the various plant species identified, of which the housewives (44%) and farmers (25%) provided more information on the various plant species identified than the other groups. This may be primarily due to the fact that the traditional doctors (13%) and herbal medicine sellers (18%) may have been reluctant to divulge information that pertains to their profession.

Plant species such as *Azadirachta indica* and *Cymbopogon citratus* were mentioned by all the 4 groups of respondents.

Of the 5 states surveyed, the highest number of respondents was interviewed in Ogun State and Edo State. It is however interesting to note that though Ogun was one of the states where the highest number of respondents were interviewed, obtained information on plants species that was identified by this study (as possible candidates for anti-malarial screening) mostly emanated from Edo State. This may be attributed to the fact that a large percentage of the respondents interviewed in Ogun were traditional doctors or herbal medicine sellers thus contributing to the low encounter of novel plant species or promising anti-malarial candidates.

It is exciting to note that these identified species were, in addition to their anti-malarial properties, found to possess various therapeutic characteristics and applications in the local communities—including antiseptic carminatives (*Azadirachta indica*, *Bixa orellana*., *Mormordica charantia)*, laxatives (*Garcinia kola*, *Carica papaya)*, purgative (*Carica papaya*), anticonvulsant (*Mallotus oppositifolius*, *Musanga cecropioides)*, anti-helmintic (*Musanga cecropioides*, *Azadirachta indica*, *Persea americana*, *Alstonia congensis)*, anti-bacterial (*Mangifera indica*, *Bixa orellana*, anti-fungal (*Persea americana*, *Mormordica charantia)*, and anti-oxidant properties (*Anacardium occidentale*, *Persea americana*).

Some plants were also employed in the treatment of diarrhea (*Anacardium occidentale*, *Mangifera indica*, *Alstonia congensis)*, leprosy (*Ficus exasperate*, *Morinda lucida*, *Musanga cecropioides)*, skin disorders (*Dacryodes edulis)* venereal diseases (*Canna indica)*, kidney disorders (*Bixa orellana*, *Carica papaya*, *Mangifera indica*), rheumatism (*Alstonia congensis*, *Bixa orellana*, *Axonopus compressus)* and insanity (*Musanga cecropioides.)*.

3.2.1. Growth forms and accessibility of the identified plants

Of the 22 plant species identified to have been used traditionally in the treatment of malaria, trees made up 59% of the identified population, shrubs 14%, climbers 9%, grasses 9% and herbs contributed 9%. Trees were found to be the most predominant plant form employed.

Six of these species (*Anacardium occidentale*, *Mangifera indica*, *Carica papaya*, *Azadirachta indica*, *Psidium guajava*, *Dacryodes edulis and Cymbopogon citratus*) were highly domesticated and 3 (*Allamanda cathartica, Canna indica and Bixa orellana*) were grown as ornamental plants. The remaining 13 species were found on farm lands (either grown for consumption or as weeds) or in the wild. *Mormordica charantia*, a creeper, was commonly found growing as a weed in farmlands whereas *Ludwigia peruviana* was only found in water-laden regions.

3.2.2. Herbal preparation and administration

Various methods of preparation and administration of the herbal remedies were recorded during the study. The most common method of preparation of these anti-malarial remedies

Table 3
Indigenous medicinal plants scientifically tested for anti-plasmodial/anti-malarial activity.

Name	Extracts tested	Phytochemicals isolated	Stage of validation	Ref.
[a]***Anacardium occidentale* L.**	Ethanol	Tannins	Ivt	Razalia et al., 2008 and Orwa et al., 2009
***Mangifera indica* L.**	Water	Glycosides, saponims, steroids and tannins	Ivt	Awe, 1998 and Aiyeloja and Bello, 2006
[a]***Alstonia congensis* Engl.**	Ethanol	15 alkaloids	*A related species Alstoniaboonei* has been tested and prepared as tablet	Majekodunmi et al., 2008 and Kayode et al., 2009
***Carica papaya* L.**	Water	–	ivt	Bhat and Surolia, 2001
***Garcinia kola* Heckel**	Water	The constituents include—biflavonoids, xanthones and benzophenones	ivt	Iwu, 1993 and Nundkumar, and Ojewole, 2002
***Azadirachta indica* A. Juss.**	Water, ethanol	More than 135 compounds have been isolated. The compounds have been divided into two major classes: isoprenoids and its derivatives – gedunin – possess anti-malarial properties	ivt,ivv	Alshawsh et al., 2009; Udeinya et al., 2006; Adesegun and Coker, 2001; Dhara et al., 1999 and Udeinya, 1993
***Psidium guajava* L.**	Water	flavonoids, carbohydrates and saponins	ivt	Nundkumar and Ojewole, 2002
[a]***Cymbopogon citratus* (Dc) Stapf.**	Chloroform/ethanol (1:1) extract.	Terpenoids, aldehydes	ivt, ivv	Tchoumbougnang et al., 2005 and Bidla et al., 2004
[a]***Morinda lucida* Benth.**	Petroleum ether extract	Danacanthal	ivt, ivv	Odugbemi et al., 2007; Awe and Makinde, 1998
***Nauclea latifolia* Smith**	Water	flavonoids, saponnin, terpenoids and tannin	ivt	Benoit-Vicala et al., 1998
[a]***Mormordica charantia* L.**	Ethanol	Three new cucurbitane-type triterpenoids, balsaminols C–E (1–3) isolated from a related species *M. balsamina*	ivt	Ueno et al., 1996; Ramalhete et al., 2010
***Ficus exasperate* Vahl.**	Ethanol	Tannins, saponins, flavonoids, steroids, anthraquinone glycosides, and reducing sugars	A related species *Ficus platyphylla* Del. has investigated—ivt	Shittu et al., 2011
[a]***Dacryodes edulis* (G. Don.) H.J. Lam.**	Methylene chloride/ methanol (1 : 1) mixture.	–	ivt	Zofou et al., 2011

ivt: *in vitro inhibition assays;* **ivv**: *in vivo using animal models*; **ct**: clinical trials.

[a] Plants species which are singly used traditionally.

was by preparing a decoction of the plant parts in either water or alcohol. Many respondents indicated that alcohol is the most preferred solvent of extraction; however water or carbonated drinks could be employed for non-alcoholic users. Additionally, a few are administered as infusions or crushed and swallowed raw. Some respondents indicated that plants could also be boiled down for about an hour, but others advised against it, as they believed this would diminish the efficacy of the plant material. Based on information gathered it was understood that the plant materials were either used fresh or air dried and stored for later use, especially during off season periods.

A few plants, namely, *Ludwigia peruviana*, *Axonopus compressus*, *Cymbopogon citratus*, *Morinda lucida*, *Azadirachta indica*, *Mormordica charantia*, *Alstonia congensis*, *Bixa orellana*, *Dacryodes edulis*, *Allamanda cathartica*, and *Anacardium occidentale*, identified in the survey, were said to have been singly used in the treatment of malaria; however most of the plants were said to be employed in combination with other plants or substances like "potash". It was believed that the potash would act as a detoxifier and aid in the removal of toxic substances from the plant material.

The data indicated that various plant parts at varying frequency were employed in the treatment of malaria. The plant parts employed were leaves (82%), barks (41%), fruits (9%), seeds (9%), roots (14%) and whole plants (14%), each of which showed various incidences of usage. The leaves and bark of these plants were the most commonly used parts for anti-malarial treatment, although all the parts of the plants may play prominent roles in the treatment of other illnesses.

3.2.3. Previous studies or documentation

Of the 22 identified plants, 13 (*Anacardium occidentale*, *Mangifera indica*, *Alstonia congensis*, *Carica papaya*, *Garcinia kola*, *Azadirachta indica*, *Psidium guajava*, *Cymbopogon citratus*, *Mormordica charantia*, *Dacryodes edulis*, *Ficus exasperate*, *Morinda lucida* and *Nauclea latifolia*) have been previously investigated for anti-malarial properties.

The status of scientific validation of the 13 identified plants, their phytochemicals and active compounds have been summarized in Table 3. Various plants showed the presence of various phytochemicals like tannins (*Anacardium occidentale*, *Azadirachta indica*, *Mangifera indica*, and *Nauclea latifolia*), alkaloids *(Alstonia congensis* and *Azadirachta indica*), saponins (*Psidium guajava* and *Mangifera indica)*, glycosides (*Nauclea latifolia* and *Mangifera indica*), terepenoids *(Cymbopogon citratus* and *Nauclea latifolia)* and flavonoids *(Psidium guajava* and *Nauclea latifolia).*

4. Discussion

To the best of available knowledge, none of the 13 previously investigated plants have passed the stages of orthodox clinical trials for their anti-malarial properties, but *in vitro* and *in vivo* analyses with significant anti-malarial activity have been reported. Thus, further studies that might lead to the identification of new and cheaper anti-malarial drugs will be required.

The other 9 plants have been traditionally used for the treatment of malaria, but no scientific study has been carried out to confirm their activity. *Alstonia congensis*, a plant that has been relatively uninvestigated for anti-malarial properties but, which has been frequently reported to have been used singly during the survey, could be considered a prime candidate for investigation, as it recorded a high PPK value of 42% and received the highest PR value of 3, as such could be considered to be highly preferable (based on its effectiveness) to all respondents who mentioned the plant. Studies on a related species *Alstonia boonei* have been carried out with significant anti-malarial activity and currently, herbal formulations (tablets) have been generated for the treatment of malaria in Nigeria (Majekodunmi et al., 2008).

Various ethnobotanical surveys have been conducted to identify plants indigenously used in the treatment of malaria. There are species, which were cited in this study, that are also known to be used as sources of anti-malarial remedies in other parts of Africa: *Azadirachta indica,* (Meliaceae), *Morinda lucida* (Rubiaceae) and *Nauclea latifolia* (Rubiaceae), which were noted to have been utilised in the treatment of malaria in Ghana were also notably employed in the south-western regions of Nigeria (Ayitey-Smith, 1989; Abbiw, 1990; Mshana et al., 2001). *Azadirachta indica* (Njoroge and Bussmann, 2006; Iwu, 1993) and *Momordica charantia* (Ueno et al., 1996) are also used for the management of malaria in Kenya. The ethnobotanical survey among traditional medicine practitioners by Oladele et al. (2011) in Osun State, south-west Nigeria also identified *Azadirachta indica, Khayasene galensis, Morinda lucida, Alstonia boonei, Rauwolfia vomitoria, Tetrapleura tetraptera* and *Croton zambesicus* as trees used in the treatment of malaria in this state. However the usage of *Rauwolfia vomitoria, Tetrapleura tetraptera* and *Croton zambesicus* were not encountered during this particular study.

Though various other plants (traditionally used in the treatment of malaria) have been identified by other ethnobotanical studies like Bussmann (2006), Njoroge and Bussmann (2006) in Kenya, Asase et al. (2005) in Ghana, Titanji et al. (2008) in Cameroon, and Idowu et al. (2009), Kayode et al. (2009), Olowokudejo et al. (2008), Ajibesin et al. (2008) and Odugbemi et al. (2007) in Nigeria, this is the first report on the traditional usage of *Persea americana* and *Ludwigia peruviana*. This could possibly translate to a relatively unexplored possibility and viable option for the treatment in malaria.

Studies from other regions of Africa also indicate that the family *Rubiaceae* has many species used in malaria management in different countries (Iwu, 1994). The current study revealed that the families, *Anacardiaceae, Apocynaceae, Poaceae* and *Rubiaceae* provided the highest proportion of anti-malarial plants, making up 36% of the total plants collected. Of these four families, plant species identified under the family of *Apocynaceae* and *Poaceae* namely *Alstonia congensis* and *Cymbopogon citratus* showed high PPK values of 42% and 40% and the corresponding PR values of 3 and 2, respectively, thus evincing more promising prospects in the treatment of malaria.

All the plants identified in the study were used traditionally in the treatment of malaria in the south-western region of Nigeria, and mostly consumed orally in the form of decoction. Plant species identified in the study were employed both singly and in combination with other anti-malarial plants; this may be due to the synergistic effect of these plants in the destruction of the plasmodium species. However, none of the respondents provided any information on the optimization and standardization of the administration of these remedies. This represents the major drawback of traditional medicine (Asase et al., 2005).

Of the plants identified during the survey, *Azadirachta indica* (12.9%), *Alstonia congensis* (11.9%) and *Cymbopogon citratus* (11.3%) showed the highest incidence of encounter. Thus, based on the results of the survey, these plants could be considered promising candidates for further scientific validation. Previous studies have indicated that *Azadirachta indica* contains phytochemicals such as alkaloids, flavonoids, terpenoids, saponins, tannins, phenols and cardiac glycosides (Ayeni and Yahaya, 2010). *Alstonia congensis* also manifests the presence of alkaloids and polyphenols such as flavonoids, tannins (Ogbonnia et al., 2008), saponins and terpenoids (Lumpu et al., 2012) and *Cymbopogon citratus* evidently contains alkaloids, saponins, tannins, anthraquinones, steroids, phenols and flavonoids (Asaolu et al., 2009). Each of these phytochemicals is known for various protective and therapeutic effects.

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Ludwigia peruviana, *Axonopus compressus*, *Cymbopogon citratus*, *Morinda lucida*, *Azadirachta indica*, *Mormordica charantia*, *Alstonia congensis*, *Bixa orellana*, *Dacryodes edulis*, *Allamanda cathartica*, and *Anacardium occidentale* were reported to have been singly employed in the treatment of malaria during this study. This may indicate that these eleven plants have high anti-malarial activity. Of these, 5 have been previously investigated (Table 3). Previous *in vitro* and *in vivo* studies show that *Cymbopogon citratus* (Tchoumbougnang et al., 2005), *Morinda lucida* (Awe and Makinde, 1998) and *Azadirachta indica* (Bidla et al., 2004), which are always used in combination, have significant anti-malarial activity. However, *Morinda lucida*, though found to be frequently employed traditionally, showed high *in vitro* cytotoxicity based on studies carried out by Ajaiyeoba et al. (2006), whereas *Cymbopogon citratus* showed insignificant cytotoxicity (Iwu, 1993).

In the face of growing unavailability of modern drugs, these medicinal plants-derived home-made remedies are not merely the first line treatment of choice for many caretakers in sub-Saharan Africa; even qualified physicians have been reported to prescribe herbal remedies (Raskin et al., 2002). However, as this study has revealed, only few clinical studies have been conducted to validate the efficacy of traditional anti-malarial treatments and to assess their safety. Thus, there is an urgent need to study the most commonly used remedies and plants implicated in their formulation to ascertain their capacity to reduce parasite densities and symptoms of malaria. More of such ethnobotanical studies could be conducted in different settings to gather available knowledge on preparation and toxicity risks. Extracts prepared strictly according to the practitioners recipes should be screened for anti-plasmodial activity and toxicity by *in vitro* and *in vivo* standard tests.

It is recommended that screening of all the above mentioned plants for anti-malarial activity be carried out to in order to justify their local usage. These studies might lead to the isolation (and possibly the identification) of potentially active compounds, which may be regarded as future promising phyto-therapeutics in the treatment of malaria.

Despite this promising prospect of harvesting potential anti-malarial compounds from the various plants identified, over-exploitation of the plant resources is a major concern, as the species are increasingly vulnerable. It is interesting to note that over the years great efforts have been put in place for the conservation of diverse fauna, yet this has overshadowed the relevance and critical need for plant conservation, especially that of medicinal plants (Dike and Obembe, 2012). The plants used the most as herbal remedies for malaria, such as *Alstonia congensis*, are often distressed due to over-harvesting of leaves and barks, with barks often completely stripped off. Hence there is compelling need for controlled harvesting of these most sought after species, as well as dedicated cultivation of these plants, in order to ensure continued growth and availability within the communities.

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