Vol. 13(16), pp. 370-383, September, 2019
DOI: 10.5897/JMPR2019.6779
Article Number: 1DB3E7661842
ISSN 1996-0875

http://www.academicjournals.org/JMPR

ACADEMIC JOURNALS
expand your knowledge

Journal of Medicinal Plants Research

Full Length Research Paper

Ethnobotanical studies of medicinal plants used in traditional treatment of malaria by some herbalists in Ghana

Tonny Asafo-Agyei*, Heron R. Blagogee, Susana Oteng Mintah, Mary-Ann Archer, Frederick Ayertey, Alexis Conrad Sapaty, Peter Atta-Adjei Jnr, Daniel Boamah, Jerry Asiedu-Larbi and Alfred Ampomah Appiah

Centre for Plant Medicine Research, P. O. Box 73, Mampong Akuapem, Ghana.

Received 6 May, 2019; Accepted 28 June, 2019

The use of medicinal plants for the treatment of diseases including malaria is a common practice in Ghanaian traditional medicine. The objective of this study is to document indigenous knowledge of medicinal plants used for the treatment of malaria through ethno-botanical studies to facilitate the discovery of new sources of drugs. The study was carried out in 2018 at the Centre for Plant Medicine Research (CPMR) among 36 registered herbalists of the Ghana Federation of Traditional and Alternative Medicine (GHAFTRAM). Data was collected based on oral interview with each of the 36 registered herbalists with the aid of a well-structured questionnaire. Only data from willing respondents were documented after obtaining their consent to participate in the study. 42 different plant species belonging to 27 families were identified as being used by GHAFTRAM herbalists in treating malaria. Among the various plant parts used, the leaves were the most reported (41%), and all of the medicinal preparations were decoctions prepared by boiling the plant parts. About 93% of the herbalists collected plants from the wild, whereas the 7% were collected from their immediate surroundings (within 100 m of their homes). Major threats to the continues availability of medicinal species of plants as indicated by the respondents included: farming activities (40%), bushfires (33%), over-harvesting (14%), and drought (13%). Majority (56%) of the herbalists reported uprooting whole plants as their method of collecting medicinal plant parts. The results of the study suggest a need for conservation and sustainable harvesting strategies to conserve plant wealth in Ghana.

Key words: antimalarial, conservation, medicinal plants, Ghana Federation of Traditional and Alternative Medicine (GHAFTRAM), traditional medicine

INTRODUCTION

The use of herbal medicine is on the increase globally (Asiimwe et al., 2014; Joshi and Joshi, 2000; Kamatenesi-Mugisha, 2005). In Africa, the situation is not different, over 80% of the population particularly in developing

*Corresponding author. E-mail: asafoagyeitonny18@gmail.com.

countries depend directly on plants for their primary healthcare requirements (Senthilkumar et al., 2013). In Ghana, where malaria is a major developmental and socioeconomic issue, many indigenes especially in rural communities rely on medicinal plants, solely and sometimes in combination with orthodox antimalarial drugs, for the treatment of the disease (Abbiw, 1990; Mshana et al., 2000). The Ghana government has specifically boosted the use of herbal medicines by integrating it into the main health care system by establishing herbal units in most of the government hospitals across the country. This has been necessitated by the consequences of limited access to modern health services in most developing countries including Ghana, high cost of modern medicine compared to the indigenous herbal medicines and wide socio-cultural acceptance of traditional medicine (Kamatenesi-Mugisha et al., 2005; Oreagba et al., 2011; Van Andel and Carvalheiro, 2013).

Malaria is the single most important cause of death, ill health and poverty in sub-Saharan Africa (Sachs and Malaney, 2002). Estimates suggest as many as 300 million acute cases of malaria occurring worldwide each year, resulting in 1 million deaths. Approximately 90% of these deaths occur in sub-Saharan Africa, and most of the victims are children younger than 5 years of age (Murphy and Breman, 2001). The disease is caused by members of the parasitic protozoa of the *Plasmodium* genus, which are transmitted by the female *Anopheles* mosquito to the human host. The five species of *Plasmodium* that infect humans include the deadly *Plasmodium falciparum*, which causes malignant malaria responsible for the severe symptoms and death in humans. It is also the most common in sub-Saharan Africa. Others are *Plasmodium vivax, Plasmodium ovale, Plasmodium malariae* and *Plasmodium knowlesi* which cause the milder, benign malaria (WHO, 2010).

Currently, the World Health Organization (WHO) has adopted an integrated approach in the control of the disease, and this involves case management and disease prevention. Together, they work against the transmission of the parasite from the mosquito vector to humans, and the development of illness and severe disease (WHO, 2012). Case management, which involves treatment with antimalarial drugs, continues to be the most extensive approach to malaria control. Preventive measures encompass intermittent preventive treatment (IPT) and malaria vector control. IPT involves the administration of a full course of an effective antimalarial treatment at specified times, and targets a defined population at risk of malaria, e.g. pregnant women, regardless of whether the recipients are parasitaemic or not, with the objective to reduce the malaria burden in the target population (WHO, 2012). Despite the gains made in malaria control, there are some key challenges in the fight against malaria. A growing concern is the emerging parasites (*Plasmodium* sp.), developing resistance to the most widely available, affordable, and safest first-line treatments such as Chloroquine and Sulfadoxine and pyrimethamine (Khalid et al., 1989; Sarker et al., 2000) ; resistance to a wide range of insecticides rendering mosquito control programmes unsuccessful ; the widespread production and marketing of “new” ineffective antimalarial drugs, such as Artesunate blister packs that contain no active ingredients (Newton et al., 2006); and the unavailability of needed infrastructure and resources to manage malaria in many African countries (Murphy and Breman, 2001) .

In light of the foregoing, the call for new chemical entities, probably with new mechanisms of action, for the treatment of malaria or alternative approaches to malaria treatment remains a priority. Indeed, some medicinal plants with antiplasmodial activity have shown enhanced activity against the parasite when formulated as nanoparticles (Murugan et al., 2016; Rajakumar et al., 2015). WHO, in fact, has put in place a strategy (Traditional Medicine Strategy, 2014-2023) to support the promotion of safe and effective use of traditional and complementary medicine (WHO, 2013).

The first step in conservation and sustainable usage of medicinal plants is to document material traditionally used to treat an ailment (Hamilton, 2004; Ssegawa and Kasenene, 2007). A larger number of medicinal plants and indigenous uses have not yet been documented. The rich history of African cultures and their innovative utilisation of plants as a source of remedies have been passed down through generations largely by oral tradition (Soelberg et al., 2015). This knowledge is gradually being lost (Tabuti et al., 2012) as the custodians die before passing on information to the younger generations. Besides the gradual loss of ethnobotanical knowledge due to lack of documentation, overharvesting of medicinal materials from their natural habitat and destruction of habitats have been two of the major threats to traditional medicine. In order to conserve wild plant species, there is need for reliable data on their distribution and level of use (Ahrends et al., 2011). The documentation of indigenous knowledge through ethnobotanical studies is therefore important in conservation and utilization of biological resources (Munthu et al., 2006).

MATERIALS AND METHODS

Ethno-botanical data on plant species used for the treatment of malaria were collected during a two-week training course from 10th to 21st September 2018. This was achieved by interviewing 36 registered herbalists belonging to the Ghana Federation of Traditional and Alternative Medicine (GHAFTRAM). A well-structured questionnaire was used to obtain and document data during the training course organized by the Centre for Plant Medicine Research (CPMR), Mampong-Akuapem, Ghana. The purpose of the training was to educate the herbalists on best practices in cultivation of medicinal plants, sustainable harvesting or utilization of medicinal plants and best practices in the preparation of herbal medicines. Prior to conducting interviews, the objectives of the study were explained to the herbalists to obtain their consent

to participate. When asked, the herbalists associated malaria with a bite from a mosquito without knowledge of the specific species of mosquito that causes malaria. Symptoms of the disease they described included fevers, chills, and strong headaches. The questionnaires were pretested to 20 individuals randomly in the Mampong township and adjustments were made to validate it before detailed interviews were conducted. After being validated, the questionnaires were used to collect data on the socioeconomic status of the herbalists, common or vernacular names of plants, plant parts used, preparation methods, mode of administration, collection sites, and plant threats. The herbalists were interviewed individually by selected staff of CPMR who were trained purposely for this study. The herbalists were asked to present specimens of all plant species they reported from locations where they make collections for their malaria preparations. The reported local names of plants by the herbalists who mostly rely on sight as identification method, were confirmed using the Flora of West Tropical Africa (Hutchinson et al., 1963) and by comparison with herbarium vouchers at the herbarium of CPMR. The nomenclature of the species was confirmed using the International Plant Names Index (Croft et al., 1999) and Catalogue of Life (Bisby et al., 2009). Voucher specimens of all plant species reported were prepared and deposited in the CPMR's herbarium.

Data analysis

The variation in the knowledge (mean ± standard error) of medicinal plants used for the treatment of malaria due to gender of the respondents was compared using Student's t-test (p =0.3). A one-way analysis of variance (ANOVA) was used to compare differences within age groups, religious groups, educational background, and ethnic groups. The diversity of species used for the treatment of malaria was evaluated using the Shannon-Wiener index ($H = \sum_{i=1}^{S} pi \ln pi$) where s is the total number of species and p is the relative abundance of species (Macías et al., 2008). The relative abundance of each species was estimated from the total citations from among the total number of interviews. Frequency of citation (FC) of the species of plants being used for the treatment of malaria was evaluated using the formula: (number of times a particular species was cited/total number of citations of all species in the study) × 100%. The percentages of threats to medicinal plants, plant parts used, habits and sources of plant materials were also calculated.

RESULTS AND DISCUSSION

The treatment of malaria using plant materials was inquired into because in many parts of the world, including Ghana, the *Plasmodium* sp have developed resistance to frontline antimalarial drugs such as chloroquine, antifolates and recently artemisinin (Sebisubi and Tan, 2010). Resistance to these drugs has been reported to be as high as 40 to 60 percent in some African and Asian countries (Builders et al., 2011). There are also reported cases of debilitating adverse effects of the conventional antimalarial drugs (Builders et al., 2011). This calls for an urgent need to discover new active agents that can overcome these pitfalls. Although hundreds of plants species are being used as a folkloric remedy for malaria and fever, the vast majority have not yet been adequately evaluated. The Ghana Health Service have recently endorsed artesunate-amodiaquine combination drug for the treatment of malaria. However, amodiaquine (4-aminoquinoline) has been linked with hepatic toxicity, agranulocytosis, and other refutations (Asase and Asafo-Agyei, 2011). The combination drug is relatively high-priced, rendering the medication unobtainable to low income earners in endemic communities. The herbalists interviewed reported that most of the patients they treat, give account of how they use both the traditional medicines together with conventional medicine to treat themselves of malaria. This is similar to report of Vigneron et al. (2005). The probable complication of plant-drug interactions when conventional medicines are used together with traditional medicines may arise and ought to be researched into.

Sociodemographic impacts

Considering gender and the number of medicinal plants reported, there was no significant variation with a score of 13.06 ± 1.29 for males and 13.88 ± 2.29 for females. Most of the herbalists beyond 58 years (18.21 ± 1.73) reported on antimalarial uses of plants than within the age group 18 to 37 years (11.40 ± 2.77) and in the age group 38 to 57 years (11.36 ± 1.50) (Figure 1). The herbalists interviewed belonged to different religious groups and were considered knowledgeable in antimalarial uses of plants although the number of plant species mentioned differed. For Christians, 13.43 ± 1.28 plants were reported; for Muslims, 15.67 ± 2.03 plants were reported; for traditional spiritual believers, 12.75 ± 5.45 were reported (Figure 2).

Majority of the herbalists were well informed about antimalarial uses of plants and had university education (36.5± 1.6) or only primary education (19.9± 3.6), whereas only a few have had secondary (17.2± 1.8), no formal education (14.0± 2.9) and college education (12.0± 3.8) indicating differences in familiarity of antimalarial plants due to differences in the level of education achieved (Figure 3).

Religious background and gender did not have any significant impact on the knowledge and usage of herbal preparations for malaria treatment by the herbalists, although educational background influenced their perception of alternatives. The knowledge on traditional uses of plants was possessed by the older generation (beyond fifty-eight years), indicating the lack of cultural and conservational importance of the medicinal species.

Plant species identified from the herbalists' reports for the treatment of malaria

A total of 42 plant species belonging to 27 families were reported as being used for malaria treatment by Ghanaian herbalists (Table 1). Trees were the most dominant habit (47.6%) of plants used in the treatment of malaria. The other species of plants identified included

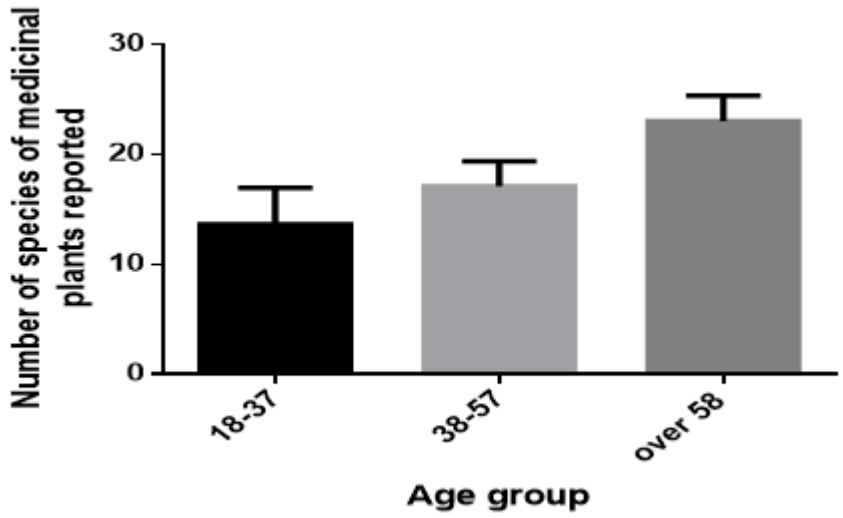

Figure 1. A distribution showing the difference in knowledge of medicinal plants used for the treatment of malaria due to age groups. Data are presented as means±S.E.M.

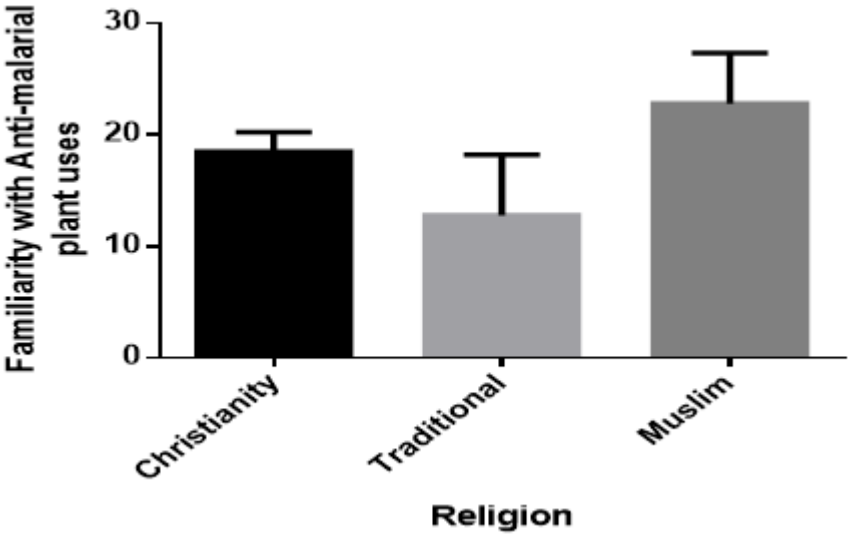

Figure 2. A distribution showing the familiarity with anti-medicinal uses of plants due religious affiliation. Data are presented as means±S.E.M.

shrubs (28.6%), herbs (16.7%), grasses (4.8%) and climbers (2.4%) (Figure 4). The findings of this study indicate that, a considerable high number (42 species) of medicinal plants are being used for treatment of malaria by Ghanaian herbalists. The dominance of tree species used for the treatment of malaria was also reported in Dike et al. (2012).

About 93% of the herbalists interviewed collected plant materials from the wild, whereas the remaining 7% collected plant materials from their immediate surroundings, that is, within 100 m from their homes. The frequency of collection was irregular, because plant parts were collected only when needed to treat malaria. According to the informants, farming activities pose a major (40%) threat to the survival of plant species although some informants also stated bush fires (33%), over-harvesting (14%), and drought (13%) as potential threats (Figure 5). Majority of the herbalists collected plant materials from the wild, similar to the results obtained by Boyom et al. (2011). Conservational strategies for sustainable utilization of medicinal plants are therefore needed in Ghana to protect plant wealth.

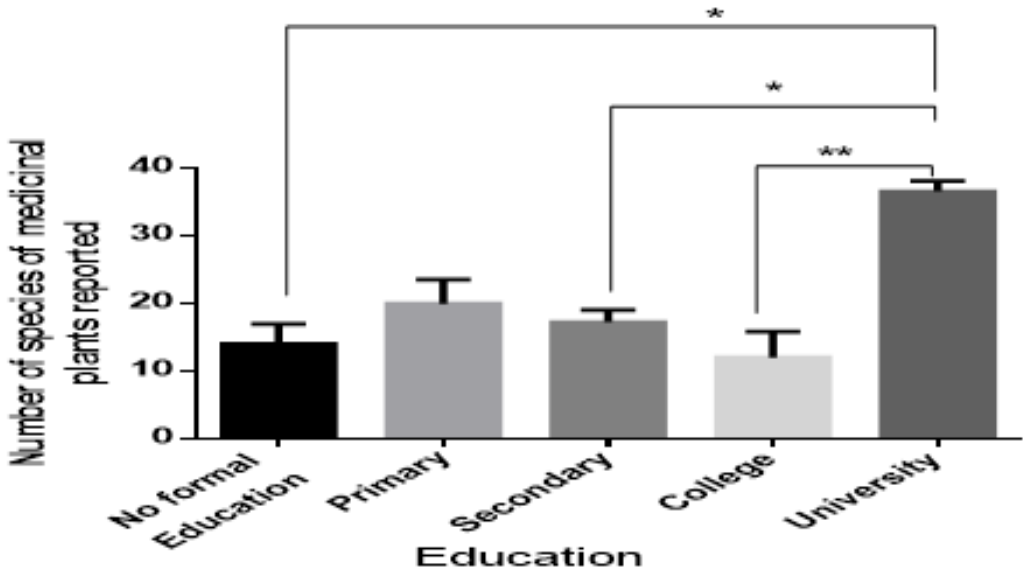

Figure 3. A distribution showing the difference in knowledge of medicinal plants used for the treatment of malaria due to educational background. Data are presented as means±S.E.M.*P<0.05, **P≤0.001.

Three (7.1%) species each belonged to the families Rutaceae, Meliaceae and Fabaceae. Two species each were identified for 9 families -Asteraceae, Cucurbitaceae, Euphorbiaceae, Lamiaceae, Rubiaceae, Zingiberaceae, Annonaceae, Longaniaceae and Poaceae. In contrast, 15 families-Caricaceae, Lauraceae, Meliaceae, Piperaceae, Malvaceae, Sterculiaceae, Bignoniaceae, Combretaceae, Moraceae, Myristicaceae, Sapindaceae, Myrtaceae, Mimosaceae, Amaranthaceae and Bromeliaceae-contributed with only one species to the total number of plant species reported (Table 1). The diversity of species used for malaria treatment by Ghanaian herbalists was high (Shannon-Wiener index = 3.5 ± 0.24). Most of the plants mentioned for the treatment of malaria, in this study, belonged to the families Rutaceae, Meliacea and Fabaceae. In contrast to this result, research from other parts of Africa showed that several species used for the treatment of malaria belonged to the family Rubiaceae (Asase et al., 2005; Iwu, 1994; Van Wyk et al., 2002). This shows that distinct groups of phytochemicals may account for the antimalarial properties possessed by plants being used traditionally for the treatment of malaria (Srisilam and Veersham, 2002). For instance, dissimilar phytochemical groups of compounds such as flavonoids (*Citrus aurantifolia* L.), phenols (*Phyllanthus niruri* L.) and terpenoids (*Momordica charantia* L.) (Berhow et al., 1994; Ishimaru et al., 1992; Chen et al., 2009) constituted different plant species belonging to different families such as Rutaceae, Euphorbiaceae and Cucurbitaceae respectively as reported by other works in Table 1. The most frequently cited plant was *Azadirachta indica* A. Juss (FC = 9.75). Other plant species commonly mentioned as being used for the treatment of malaria were *Nauclea latifolia* (FC=7.31) and *Occimum grattissimum* (FC = 6.09), whereas the least-cited plants were *Acacia nilotica*, *Ananas comosus*, *Alchornea cordifolia , Anthocleista nobilis, Bidens Pilosa, Cassia alata, Cleistopholis patens, Gossypium barbadense, Khaya senegalensis, Mezoneuron benthamianum , Paullinia pinnata, Psidium guajava, Pycnanthus angolensis, Solanum torvum, Occimum basilicum, Persea americana , Piper guineense, Theobroma cacao, Spathodea campanulata, Zanthoxylum zanthoxyloides, Polyalthia longifolia*, Alstonia boonei, *Xylopia aethiopica, Terminalia ivorensis* and *Milicia excelsa* with a FC= 1.21 each. The most frequently cited plant species by the respondents (Azadirachta indica A. Juss (FC = 9.75) could provide a guide for antiplasmodial testing and phytochemical analyses as to their effectiveness in the search for plant materials for the treatment of malaria (Heinrich, 2009). A frequently cited plant, nonetheless, does not indicate the plant's effectiveness for malaria treatment, but its use and frequent citation may be due to its abundance or availability.

Usage and application

The commonest plant parts used for the treatment of malaria were the leaves (40.7%), followed by roots (24.1%), stem bark (24.1%), seeds (5.6%), fruits (3.7%) and whole plant (1.9%) (Figure 6). This corresponds with the findings of Caraballo et al. (2004) conducted in South-eastern Venezuelan Amazon, where they proved

Table 1. Reported species of plants used for the treatment of malaria.

***Genus, species,* authority family Common names- Voucher specimen no.)**	**Growth Form**	**Parts used**	**Preparation**	**Reported phytochemical constituents and antiplasmodial activity**	**Dosage form**	**Frequency of citation (%)**
Acacia nilotica Delile Mimosaceae (Odanwoma- CPMR 4935)	Tree	Stem bark and roots	Boil roots and stem bark with roots of *Citrus aurantifolia* and roots of *Nauclea latifolia* and roots of *Alstonia boonie*and roots of *Butyrospemum parkii*	Antiplasmodial (EI-Tahir et al.1999)	Take two tablespoonsful once a day	1.21
Aframomum melegueta (Roscoe) K.Schum. Zingiberaceae (fam wusa- CPMR 4919)	Herb	Seeds	Boil roots with roots of *Nauclea latifolia* and rhizomes of *Theobroma cacao* and fruits of *Tetrapluera tetraptera*	Genus contains labdane (Duker-Eshun et al., 2006)	Take one ice cream cup three times daily	2.43
Alchornea cordifolia (Schumach.) Müll.Arg. Euphorbiaceae (Ogyama- CPMR 4908)	Shrub	Leaves	Boil leaves with leaves of *Morinda lucida*	Antiplasmodial activity (Valentin, 2000)	Drink three times daily with medium size cup	1.21
Alstonia boonei De Wild. Rutaceae (Nyamedua- CPMR 4924)	Tree	Root	Boil roots with roots of *Citrus aurantifolia* and roots of *Nauclea latifolia* and roots of *Acacia nilotica* and roots of *Butyrospemum parkii*	Terpenoids (Marini-Bettolo et al., 1983), Alkaloids (Oguakwa, 1984), Antiplasmodial (Zirihi et al., 2005a)	Take two tablespoonsful once a day	1.21
Amaranthus spinosus L. Amaranthaceae (Natwibini-CPMR 4938)	Herb	Stem bark and leaves	Boil leaves with leaves of *Cymbopogon citratus,Azadiracta indica and bidens pilosa*	B-cyananins and phenenols Antiplsmodial activities (Hilou et al, 2006)	Drink three times daily with medium size cup.	2.43
Ananas comosus (L.) Merr. Bromeliaceae (Abrobe-CPMR 4940)	Herb	Fruit	Boil fruit peel with fruit peel of *Aframomum melegueta* and stem of *Sacchurum officinale*	Phenols (Litaudon et al., 2009)	Drink one full cup three times daily	1.21
Anthocleista nobilis G.Don Loganiaceae (Owudifo k3t3- CPMR 4930)	Tree	Stem bark	Boil stem bark with stem bark of *Terminalia ivorensis* and stem bark of *Pycnanthus angolensis*	Alkaloids, Flavonoids (Ngwoke et al., 2015)	Take 50 ml three times daily	1.21
Azadirachta indica A.Juss Meliaceae (Nim-CPMR 4913)	Tree	Leaves, and roots	Boil roots with leaves of *Bidens pilosa*	Terpenoids (Siddiqui, et al. 2004)	Take four tablespoonful two times daily	9.75
Bambusa vulgaris Schrad. ex J.C.Wendl. Poaceae (Mpampuro-CPMR 4937)	Grass	Leaves	Boil leaves with leaves of *Alchornea cordifolia, Carica papaya,* and *Persea americana*	Alkaloids, Phenols (Goyal et al., 2010)	Drink decoction three times daily.	3.65
Bidens pilosa L. Asteraceae (Gyinantwi-CPMR 4936)	Herb	Leaves	Boil leaves with roots of *Azadirachta indica*	Antiplasmodial (Brandão et al, 1997)	Take 60 ml three times daily	1.21

Table 1. Contd.

Carica papaya L. Caricaceae (Brofre-CPMR 4906)	Tree	Leaves	Boil leaves and/or stem bark with leaves of *Xylopia aethiopica* and dry leaves of *Morinda lucida* and dry leaves of *Persea americana*	Phenols (Canini, 1994)	Take 150 ml two times daily	4.87
Cassia alata L. Fabaceae (Nsempii -CPMR 4941)	Shrub	Leaves	Biol leaves with leavesw of *Cleistophilis patens and Carica papaya*	Antiplasmodial activites (Zirihi et al., 2005b)	Drink three times daily with medium size cup	1.21
Cassia siamea Lam. Fabaceae (Accasia-CPMR 4945)	Tree	Leaves	Boil the leaves of *Cassia siamea* with the leaves of *Cymbopogon citratus*, *Azadirachta indica* and *Bambusa vulgaris.*	Alkaloids (Smith et al., 1996)	Drink half medium cup three times daily	2.43
Citrus aurantifolia (Christm.) Swingle Rutaceae (Ankaatwasie- CPMR 4917)	Tree	Roots and fruits	Boil roots with roots of *Alstonia boonei* and roots of *Nauclea latifolia* and roots of *Acacia nilotica* and roots of *Butyrospemum parkii*	Flavonoids (Rehm and Espig, 1991): Patil et al. 2010)	Take 150 ml two times daily	4.87
Cleistopholis patens Engl. and Diels Loganiaceae (Ngo ne Kyene- CPMR 4931)	Tree	Leaves and root	Boil leaves with leaves of Azadirachta indica, Spathodea campanulata, stem of Saccharum officinarum and fruits of Citrus aurantifolia.	Antiplasmodial (Addae-Kyereme, et al 2001) Alkaloids (Waterman and Muhammad,1985)	Take four tablespoonful two times daily	1..21
Cymbopogon citratus Stapf. Poaceae (Esre or nantwiwidie-CPMR 4915)	Grass	Leaves	Boil leaves with leaves of *Polyathia longifolia* and roots of *Nauclea latifolia*	Flavonoids (Tapia et al., 2007; Porspi, 1992)	Take decoction as directed	2.43
Gossypium barbadense L. Malvaceae (Asaaba-CPMR 4942)	Shrub	Leaves	Boil the leaves of *Gossypium barbadense* with the leaves of *Paullinia pinnata*, *Cassia alata*, *Psidium guajava* and *Ocimum gratissimum*	No information available	Take one medium cup three times daily	1.21
Khaya senegalensis A.Juss. Meliaceae (Mahogany-CPMR 4946)	Tree	Stem bark	Boil the leaves of *Khaya senegalensis* with the leaves of *Azadirachta indica,Alstonia boonei, Terminalia cartapa* and *Alchornea cordifolia*	Antimalarial (WAHP, 2013)	Take one medium cup three times daily	1.21
Lantana camara L. Cucurbitaceae (Ananse dokono- CPMR 4920)	Shrub	Leaves	Grind and boil with dry leaves of *Momordica charantia* and leaves of *Occimum gratissimum* and dry leaves of *Azadirachta indica*	Terpenoids (Litaudon et al., 2009: Begum et al., 2008a) Flavonoids (Begum et al., 2008b)	Take half a cup two times daily after meals.	2.43
Mezoneuron benthamianum Baill. Fabaceae (Akoobowre-CPMR 4944)	Shrub	Leaves	Boil roots of *Mezoneuron benthamianum* with leaves of T*ectonia grandis, Psidium guajava* and *Carica papaya* and the fruit of *Citrus aurantifolia.*	Antiplasmodial activities (Jansen, 2017)	Drink three times daily with medium size cup of decoction three times daily	1.21
Milicia excelsa C.C.Berg Moraceae (Odum- CPMR 4928)	Tree	Stem bark	Boil stem bark with dry leaves of *Alchornia cordifolia* and stem bark of *Terminalia ivorensis*	Antiplasmodial (Areola et al., 2016.)	Take 50 ml three times daily	1.21

Table 1. Contd.

Momordica charantia Descourt. Cucurbitaceae (Nyanya-CPMR 4907)	Herb	Leaves	Grind and boil with dry leaves of *Lantana camara* and leaves of *Occimum gratissimum* and dry leaves of *Azadirachta indica*	Terpenoids (Chen et al, 2009: Chen et al., 2008) and phenols (Kubola et al., 2008)	Take decoction as directed	2.43
Morinda lucida A.Gray Rubiaceae (Konkroma- CPMR 4916)	Tree	Leaves, and stem bark	Boil leaves and/or stem bark with leaves of *Xylopia aethiopica* and dry leaves of *Carica papaya* and dry leaves of *Persea americana*	Anthraquinones (Sittie et al., 1999); Antiplasmodial activity (Tona et al. 1999)	Take one medium cup three times daily	3.65
Nauclea latifolia Sm. Rubiaceae (Owintin- CPMR 4921)	Shrub	Stem and root	Boil leaves with dry leaves of *Carica papaya* and leaves of *Vernonia amygdalina* and leaves of *Solanum torvum* and roots of *Occimum gratissimum*	Antimalarial (Prance, 1987; Porspi, 1992)	Take 30 ml three to four times daily	7.31
Ocimum basilicum L. Lamiaceae (Akokomesa-CPMR 4910)	Herb	Leaves	Boil leaves with seeds of *Piper guineense* and leaves of *Azadirachta indica*	Flavonoids (Barua et al., 1978; Grayer et al., 2001), and essential oils (Grayer et al., 1996: Zhang et al., 2009)	Take three tablespoonful three times daily before meals	1.21
Ocimum gratissimum Forssk. Lamiaceae (Nunum- CPMR 4911)	Shrub	Leaves, and roots	Boil leaves with dry leaves of *Carica papaya* and leaves of *Vernonia amygdalina* and leaves of *Solanum torvum* and roots of *Nauclea latifolia*	Flavonoids (Grayer et al., 2001)	Take one medium cup three times daily	6.09
Paullinia pinnata Griseb. Sapindaceae (Toantini- CPMR 4933)	Shrub	Leaves and root	Boil dry leaves and roots with dry stem bark of *Perrsea Americana* and dry stem bark of *Morinda lucida*	Antiplasmodial (Gbeasor et al., 1989)	Take one medium cup three times daily	1.21
Persea americana Mill. Lauraceae (Pear- CPMR 4912)	Tree	Seeds, stem bark and roots	Boil leaves and/or stem bark with leaves of *Xylopia aethiopica* and dry leaves of *Carica papaya* and dry leaves of *Morinda lucida*	Carotenoids (Gross et al., 1973)	Take one medium cup three times daily	1.21
Phyllanthus niruri hort. ex Wall. Euphorbiaceae (Bomma gu makyi-CPMR 4909)	Herb	Whole plant	Boil whole plant	Phenols (Ishimaru, et al 1992) and terpenoids (Singh et al.,1989)	Take 60 ml three times	2.43
Piper guineense Thonn. Piperaceae (Esro wisa- CPMR 4914)	Climber	Seeds	Boil seeds with stem bark of *Zanthozylum xanthoziloids* and leaves of *Azadirachta indica* and seeds of *Aframomum maleggueta*	Alkaloids (Torto and Baxter 1976; Addae-Mensah, et al., 1977) Antiplasmodial activity (Bero et al., 2009)	Take 75 ml three times daily before meals	1.21
Polyalthia longifolia (sonn.) Hook.f. and Thomson Annonaceae (Polalthia- CPMR 4923)	Tree	Leaves	Boil leaves with leaves of *Cymbopogon citiratus* and roots of *Nauclea latifolia*	Diterpenoids (9), Alkaloids (Yang-Chang et al., 1990)	Take decoction as directed	1.21

Table 1. Contd.

Psidium guajava L. Myrtaceae (Guava- CPMR 4934)	Tree	Leaves	Boil leaves with water	Phenols, Flavonoids, Carotenoids, Terpenoids. (Gutiérrez et al., 2008)	Take five tablespoonful three times daily before meals	1.21
Pycnanthus angolensis (Welw.) Exell Myristicaceae (Otie/Otsil- CPMR 4929)	Tree	Stem bark	Boil stem bark with stem bark of *Terminalia ivorensis* and stem bark of *Anthocleista nobilis*	Antiplasmodial (Abrantes et al., 2008)	Take 50 ml three times daily	1.21
Solanum torvum Schltdl. Solanaceae (Konsusua-CPMR 4943)	Shrub	Leaves	Boil the fruits of Solanum *torvum* with leaves of *Morinda lucida* and stem bark of *Trichilia heudelotii*	Flavonoids and Alkaloids (Porspi, 1992)	Take one medium cup three times daily	1.21
Spathodea campanulata Buch.-Ham. ex DC. Bignoniaceae (Kokoanisuo- CPMR 4922)	Tree	Stem bark	Boil stem bark with stem bark of *Pycnanthus angolensis*	Antimalarial (Makinde et al., 1988)	Take 50 ml three times daily	1.21
Terminalia ivorensis A.Chev. Combretaceae (Embre- CPMR 4927)	Tree	Stem bark	Boil stem bark with dry leaves of *Alchornia cordifolia* and stem bark of *Milicia excelsia*	Terpenoids (Ponou et al., 2010)	Take 50ml three times daily	1.21
Theobroma cacao L. Sterculiaceae (Cocoa- CPMR 4918)	Tree	Roots	Boil roots with roots of *Nauclea latifolia* and rhizomes of *Zingiber officinale* and fruits of *Tetrapluera tetraptera*	Alkaloid (Ashihara et al., 2008), proanthocyandin, And polyphenols (Hatano et al., 2002; Vijayakumar et al., 2008)	Take 25 ml three times daily	1.21
Trichilia heudelotii Planch. ex Oliv. Meliaceae (Tanduro-CPMR 4939)	tree	Stem bark	Boil the bark of *Trichilia heudelotii* with the leaves of Persea Americana, Psidium guajava and the leaves and stem bark of *Amaranthus spinosus*	Alkaloids, Flavonoids (Bankole et al., 2016)	Take one medium cup three times daily	3.65
Vernonia amygdalina Delile Asteraceae (Anwonwono- CPMR 4905)	Shrub	Leaves, and Roots	Boil leaves with dry leaves of *Carica papaya* and leaves of *Nauclea latifolia* and leaves of *Solanum torvum* and roots of *Occimum gratissimum*	Antimalarial, Alkaloids, Flavonoids, Analgesia (WAHP, 2013)	Take one ice cream cup three times daily	3.65
Xylopia aethiopica A.Rich. Annonaceae (Hwenteaa-CPMR 4926)	Tree	Root	Boil leaves and/or stem bark with leaves of *Carica papaya* and dry leaves of *Morinda lucida* and dry leaves of *Persea Americana*	Terpenoids (Smith et al.,1996; Harrigan et al.,1994)	Take decoction as directed	1.21
Zanthoxylum zanthoxyloides (Lam.) B.Zepernick & Timler Rutaceae (Okantor- CPMR 4932)	Shrub	Stem bark	Boil bark with seeds of *Piper guineense* and leaves of *Azadirachta indica* and seeds of *Aframomum maleggueta*	Alkaloids (Tatsadjieu et al., 2003) Antispasmodic, Analgesia (Porspi, 1992)	Take one ice cream cup three times daily	1.21

Table 1. Contd.

Zingiber officinale Roscoe. Zingiberaceae (Ginger- CPMR 4925)	shrub	Rhizomes (roots)	Boil rhizomes with roots of *Nauclea latifolia* and roots of *Theobroma cacao* and fruits of *Tetrapluera tetraptera*	Analgesic ((Suekawa et al., 1984; Porspi, 1992)	Take five tablespoonful three times daily before meals	4.87

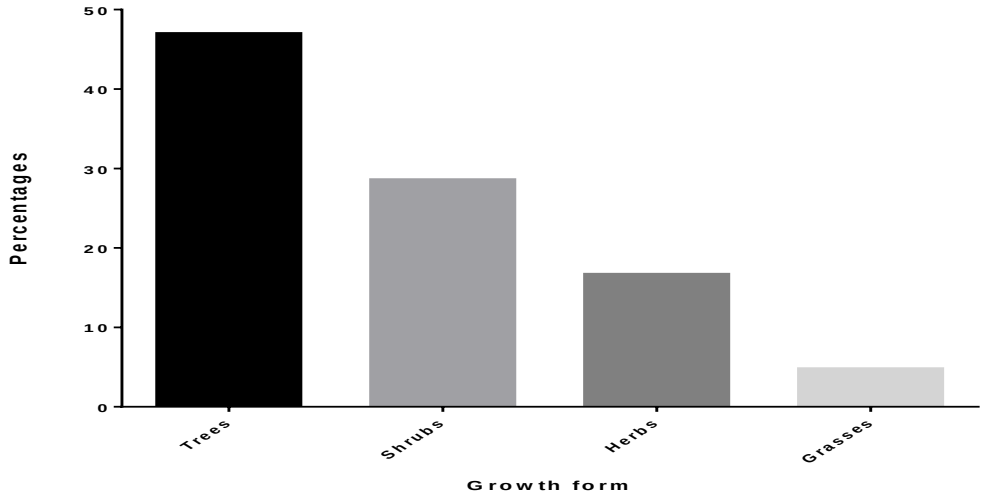

Figure 4. A distribution of growth forms and their percentage.

that the leaves constituted 70% of the parts used. It is likely that leaves are more available and accessible to people and contain highly effective antimalarial substances. The constant use of leaves could also be due to the fact that they are the site of the synthesis of organic substances and, therefore, antimalarial substances. Bhattarai et al. (2010) and Njoroge and Bussmann (2005). In all cases of preparation, the plant parts were boiled alone or together with parts of other plants. Almost all species reported (95.2%) were used as combination therapy with other plant species (Table 1). The mode of administration of the herbal preparations were all by drinking. Titanji et al. (2008) and Asase et al. (2005) by conducting similar studies have found forty-five preparation methods that combine more than one species of plants for the treatment of malaria with mode of preparation and administration being boiling and drinking the infusion respectively. Prescriptions were usually unspecific, and the intake of the herbal preparations continued until recovery. It became evident in this study that, the herbal preparations used by the herbalist's lack consistency and dosage instructions were indeterminate (Table 1). This means the quality of the herbal preparations may differ enormously amid prescriptions. This is not too different from observations reported elsewhere (Asase et al., 2005) and have been prominent also as a main drawback of traditional medicine (Evans-Anfom, 1986; Sofowora, 1993). The inclusion of certain plants, for instance *Citrus sinensis* fruits to herbal preparations might be to sweeten the decoction despite the fact that, *C. sinensis* has been mentioned in Bhat and Surolia (2001) as a

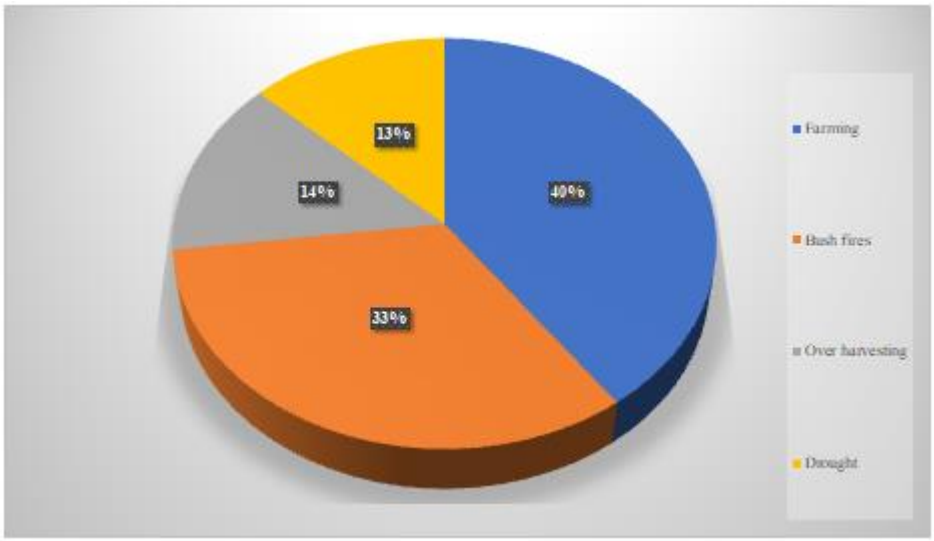

Figure 5. Proportions of different threats to medicinal plants being used by Ghanaian herbalists for the treatment of malaria.

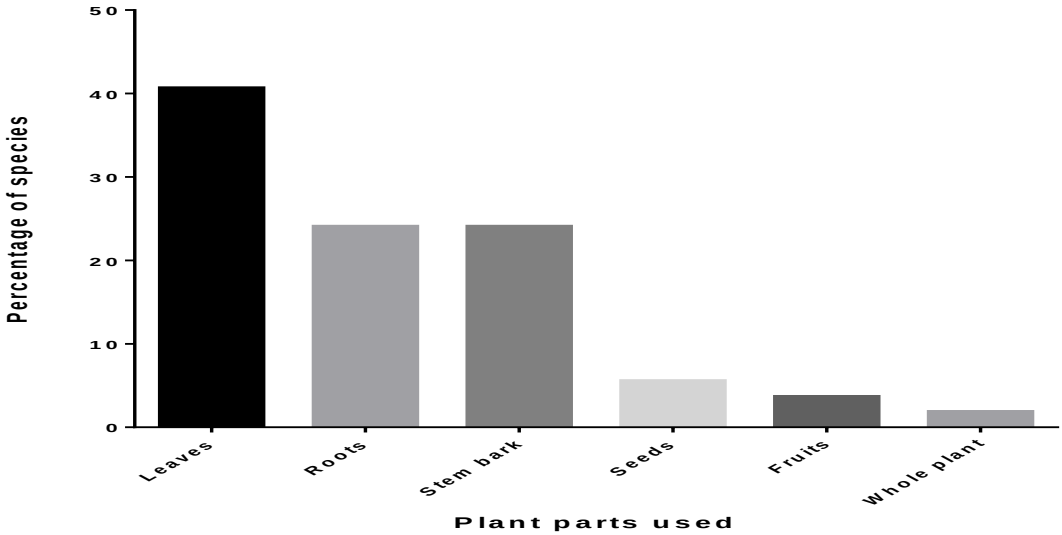

Figure 6. Distribution of plant parts used in the treatment of malaria and their percentages.

medicinal plant for the treatment of malaria itself. Again, C. sinensis may be used together with other plants as combination therapy because the antimalarial characteristics of medicines are contingent on synergy of the plant components. This renders identifying and characterizing the measure of bioactive compounds in herbal preparations very complex and poses immense challenges in coming up with quality control methods. However, WHO provides basic standards for quality of herbal preparations (WHO, 2007, 2011).

Antiplasmodial activity have been shown in some of the species used as sources of antimalarial preparations (Sendagire et al., 2005). For instance, in Ivory Coast, *Alchornea cordifolia* leaves are being used for the treatment of malaria, and an alcoholic concentrate of the leaves has clearly shown antiplasmodial activity at IC50 = 9.2 µg/ml (Okpekon et al., 2004). The leaves of *Alstonia boonei* are used for malaria treatment in Ghana and in Ivory Coast and Okpekon et al. (2004) accounted that the alkaloids extracted from this species possessed antiplasmodial activity at 8.4 µg/ml. In addition, methanol and methylenechloride extracts from root and stem bark

of *Morinda lucida* indicated antiplasmodial activity that may be linked to anthraquinones (Tona et al., 1999). It is worth noting that, the extraction solvent, locality of collection and time of harvesting influence the presence of phytochemical expression levels and the efficacy of extracts from plants (Prance, 1994).

CONCLUSIONS AND RECOMMENDATION

This study has emphasized the significance of plants in the treatment of malaria in Ghana. It has also contributed to the establishment of a complete database of traditional knowledge on medicinal plants used for the treatment of malaria in Ghana. In addition, this study provides useful information for new drug discovery, since it provides a list of plants amongst which an alternative phytochemical, that is more efficacious against the *Plasmodium* parasite could be discovered. More research should be conducted to find out the activities in the leaves of medicinal plants used for the treatment of malaria and other common diseases so that leaves can be used more than other plant parts such as roots and stem barks since harvesting of the roots and stem barks are more destructive and poses a greater threat to local plant populations, especially when whole plants are removed in some instances. The sourcing of plant materials from the wild by majority of the herbalists in this study, emphasizes the need to train them on sustainable cultivation and harvesting methods. Additional work can be done on the plants reported in this study to corroborate their antimalarial claim as well.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

REFERENCES

Abbiw DK (1990). Useful plants of Ghana. Richmond Intermediate Technology Publications and Royal Botanic Gardens Kew, London. S.154-157.

Abrantes M, Mil-Homens T, Duarte N, Lopes D, Cravo P, do Céu Madureira M, Ferreira MJU (2008). Antiplasmodial activity of lignans and extracts from Pycnanthus angolensis. Planta medica 74(11):1408-1412.

Addae-Kyereme J, Croft SL, Kendrick H, Wright CW (2001). Antiplasmodial activities of some Ghanaian plants traditionally used for fever/malaria treatment and of some alkaloids isolated from Pleiocarpa mutica: In vivo antimalarial activity of pleiocarpine. Journal of Ethnopharmacology 76:99-103.

Addae-Mensah I, Torto FG, Oppong IV, Baxter I, Sanders JK (1977). N-isobutyl-trans-2-trans-4-eicosadienamide and other alkaloids of fruits of Piper guineense. Phytochemistry 16(4):483-485.

Ahrends A, Rahbek C, Bulling M, Burgess ND, Platts PJ, Lovett JC, Kindemba V, Owen N, Sallu A, Marshall A, Mhoro EB, Fanning E, Marchant R (2011). Conservation and the Botanist effect. Biological Conservation 144:131-140.

Areola JO, Omisore NO, Babalola OO (2016). Antiplasmodial activity of stem-bark extract of Milicia excelsa (welw.) Cc berg against rodent malaria parasites (Plasmodium berghei) in mice. Life Journal of Science 18(4):905-911.

Asase A, Asafo-Agyei T (2011). Plants Used for Treatment of Malaria in Communities Around the Bobiri Forest Reserve in Ghana. Journal of Herbs, Spices and Medicinal Plants 17(2):85-106

Asase A, Oteng-Yeboah AA, Odamtten GT, Simmonds MSJ (2005). Ethnobotanical study of some Ghanaian anti-malarial plants. Journal of Ethnopharmacology 99:273-279.

Ashihara H, Sano H, Crozier A (2008). Caffeine and related purine alkaloids: Biosynthesis, catabolism, function and genetic engineering. Phytochemistry 69:841-856.

Asiimwe S, Namutebi A, Borg-Karlsson A, Kamatenesi-Mugisha M, Oryem-Origa H (2014). Documentation and Consensus of Indigenous knowledge on medicinal plants used by the local communities in Western Uganda. Journal of Natural Product and Plant Resource 4(1):34-42.

Bankole AE, Adekunle AA, Sowemimo AA, Umebese CE, Abiodun O, Gbotosho GO (2016). Phytochemical screening and in vivo antimalarial activity of extracts from three medicinal plants used in malaria treatment in Nigeria. Parasitology Research 115:299-305.

Barua RN, Sharma RP, Thyagarajan G, Hertz W (1978). Flavonoids of Chromolaena odorata. Phytochemistry 17:1807-1808.

Begum S, Wahab A, Siddiqui BS (2008a). Antimycobacterial activity of flavonoids from Lantana camara Linn. Natural Product Research, 22:467-470.

Begum S, Zehra SQ, Siddiqui BS, Fayyaz S, Ramzan M (2008b). Pentacyclic triterpenoids from the aerial parts of Lantana camara and their nematicidal activity. Chemistry and biodiversity 5(9):1856-1866.

Berhow MA, Bennett RD, Poling SM, Vannier S, Hidaka T, Omura M (1994). Acylated flavonoids in callus cultures of Citrus aurantifolia. Phytochemistry 36:1225-1227.

Bero J, Ganfon H, Jonville MC, Frédérich M, Gbaguidi F, DeMol P, Moudachirou M, Quetin-Leclercq J (2009). In vitro antiplasmodial activity of plants used in Benin in traditional medicine to treat malaria. Journal of Ethnopharmacology 122:439-444.

Bhat GP, Surolia N (2001). In vitro anti-malarial activity of extracts of three plants used in the traditional medicine of India. American Journal of Tropical Medicine and Hygiene 65:304-308.

Bhattarai S, Chaudhary RP, Quave CL (2010). The use of medicinal plants in the trans-himalayan arid zone of Mustang district. Nepal. Journal of Ethnobiology and Ethnomedicine 6(1):14.

Bisby FA, Roskov YR, Orrell TM, Nicolson D, Paglinawan LE, Bailly N, Kirk PM, Bourgoin T, Baillargeon G (2009). Species 2000 & ITIS Catalogue of Life: 2009 Annual Checklist Species 2000. Reading UK. Available at www.catalogueoflife.org/annual-checklist/2009.

Boyom FF, Ngouana V, Kemgne EAM, Zollo PHA, Menut C, Bessiere JM, Gut J, Rosenthal PJ (2011). Antiplasmodial volatile extracts from Cleistopholis patens Engler and Diels and Uvariastrum pierreanum Engl. (Engl. & Diels) (Annonaceae) growing in Cameroon. Parasitology Research 108(5):1211-1217.

Brandão MGL, Krettli AU, Soares LSR, Nery CGC, Marinuzzi HC (1997). Antimalarial activity of extracts and fractions from Bidens pilosa and other Bidens species (Asteraceae) correlated with the presence of acetylene and flavonoid compounds. Journal of Ethnopharmacology 57:131-138.

Builders M, Wannang N, Aguiyi J. (2011). Antiplasmodial activities of Parkia biglobosa leaves: *in vivo* and *in vitro* studies. Annals of Biological Research 2(4):8-20.

Canini A, Alesiani D, Arcangelo GD, Tagliatesta P (1994). Gas chromatography–mass spectrometry analysis of phenolic compounds from Carica papaya L. leaf. Phytochemistry 35:615-619.

Caraballo A, Caraballo B, Rodriguez-Acostca A (2004). Evaluations also preliminarde Conn antimalarial medicinal plants used in Southeast amazãnico Venezuela. Journal of the Brazilian Society of Tropical Medicine 37(2):186-188.

Chen J, Tian R, Qiu M, Lu L, Zheng Y, Zhang Z (2008). Trinorcucurbitane and cucurbitane triterpenoids from the roots of Momordica charantia. Phytochemistry 69:1043-1048.

Chen JC, Liu WQ, Lu L, Qiu MH, Zheng YT, Yang LM, Zhang XM, Zhou L, Li ZR (2009). Kuguacins F–S, cucurbitane triterpenoids from Momordica charantia. Phytochemistry 70:133-140.

Croft J, Cross N, Hinchcliffe S, Lughadha EN, Stevens PF, West JG,

Whitbread G (1999). Plant names for the 21st century: the International Plant Names Index, a distributed data source of general accessibility. Taxon pp. 317-324.
Dike IP, Obembe OO, Adebiyi FE (2012). Ethnobotanical survey for potential anti-malarial plants in south-western Nigeria. Journal of Ethnopharmacology 144(3):618-626.
Duker-Eshun G, Jaroszewski JW, Asomaning WA, Oppong-Boachie F, Olsen CE, Christensen SB (2006). Antiplasmodial activity of labdanes from Aframomum latifolium and Aframomum sceptrum. Planta Medica 68:642-644.
EI-Tahir A, Satti GMH, Khalid SA (1999). Antiplamodial activity of selected Sudanese medicinal plants with emphasis on Acacia nilotica. Phytotherapy Research 13(6):474-478.
Evans-Anfom E (1986). Traditional Medicine in Ghana: Practice, Problems and Prospects. Ghana Academy of Arts and Sciences, Commercial Associates Ltd., Accra, Ghana. 60 p.
Gbeasor M, Kassou Y, Amegbo K, De Souza C, Koumaglo K (1989). Antimalaria effects of eight African medicinal plants. Journal of Ethnopharmacology 25:115-118.
Goyal AK, Middha SK, Sen A (2010). Evaluation of the DPPH radical scavenging activity, total phenols and antioxidant activities in Indian wild Bambusa vulgaris "Vittata" methanolic leaf extract. Journal of Natural Pharmaceuticals 1(1):40-45.
Grayer RJ, Kite GC, Goldstone J, Bryan SE, Paton A, Putievsky E (1996). Infraspecific taxonomy and essential oil chemotypes in sweet basil, Ocimum basilicum. Phytochemistry 43:1033-1039
Grayer RJ, Veitch NC, Kite GC, Price AM, Kokubun T (2001). Distribution of 8-oxygenated leaf-surface flavones in the genus Ocimum. Phytochemistry 56:559-567.
Gross J, Gabai M, Lifshitz A, Sklarz B (1973). Carotenoid in pulp, peel and leaves of Persea americana. Phytochemistry 12:2259-263.
Gutiérrez RMP, Mitchell S, Solis RV (2008). *Psidium guajava*: A review of its traditional uses, phytochemistry and pharmacology. Journal of Ethnopharmacology 117:1-27.
Hamilton AC (2004). Medicinal plants, Conservation and Livelihoods. Biodiversity Conservation 13:1477-517
Harrigan GG, Gunatilaka AL, Kingston DG, Chan GW, Johnson RK (1994). Isolation of Bioactive and Other Oxoporphine Alkaloids from two Annonaceous Plants, Xylopia aethiopica and Miliusa banacea. Journal of Natural Products 57(1):68-73.
Hatano T, Miyatake H, Osakabe N, Takizawa T, Ito H, Yoshida T (2002). Proanthocyanidin glycosides and related polyphenols from Cacao liquor and their antioxidant effects. Phytochemistry 59:749-758.
Heinrich M, Edwards S, Moerman DE, Leonti M (2009). Ethnopharmacological field studies: A critical assessment of their conceptual basis and methods. Journal of Ethnopharmacology 124:1-17.
Hilou A, Nacoulma OG, Guiguemde TR (2006). In vivo antimalarial activities of extracts from *Amaranthus spinosus* L. and *Boerhaavia erecta* L. in mice. Jounal of Ethnopharmacology 103:236-240.
Hutchinson J, Dalziel JM, Hepper FN (1963). Flora of West Tropical Africa. Volume II. Flora of West Tropical Africa. Volume II., (2nd ed.(rev.) pp. 295-296.
Ishimaru K, Yoshimatsu K, Yamakawa T, Kamada H, Shimomura K (1992). Phenolic constituents in tissue cultures of *Phyllanthus niruri*. Phytochemistry 31:2015-2018.
Iwu M (1994). African Medicinal Plants in the Search for New Drugs Based on Ethnobotanical Leads. Ethnobotany and Search for New Drugs. Wiley, Chichester pp. 116-129.
Joshi AR, Joshi K (2000). Indigenous knowledge and uses of medicinal plants by local communities of the Kali Gandaki Watershed Area, Nepal. Journal of Ethnopharmacology 73:119-129.
Kamatenesi-Mugisha M, Oryem-Origa H (2005). Traditional herbal remedies used in the management of sexual impotence and erectile dysfunction in Western Uganda. African Health Sciences 5(1):40-49.
Khalid SA, Duddeck H, Gonzales-Sierra M (1989). Isolation and characterization of an antimalarial agent of the neem tree Azadirachta indica. Journal of Natural Product 52:922-927.
Kubola J, Siriamornpun S (2008). Phenolic contents and antioxidant activities of bitter gourd (*Momordica charantia* L.) leaf, stem and fruit fraction extracts in vitro. Journal of Food Chemistry 110:881-890.
Litaudon M, Jolly C, Le Callonecm C, Cuong DD, Retailleau P, Nosjean O, Nguyen VH, Pfeiffer B, Boutin JA, Guéritte F (2009). Cytotoxic pentacyclic triterpenoids from *Combretum sundaicum* and *Lantana camara* as inhibitors of Bcl-xL/BakBH3 domain peptide interaction. Journal of Natural Products 72(7):1314-1320.
Macías FA, Lacret R, Varela RM, Nogueiras C, Molinillo JM (2008). Bioactive apocarotenoids from Tectona grandis. Phytochemistry 69:2708-2715.
Makinde JM, Amusan OO, Adesogan EK (1988). The antimalarial activity of Spathodea campanulata stem bark extract on Plasmodium berghei on mice. Planta Medica 54(2):122-125.
Marini-Bettolo GB, Nicoletti M, Messana I, Patamia M, Galeffi C, Oguakwa JU, Portalone G, Vaciago A (1983). Research on African medicinal plants—IV: Boonein, A new C-9 terpenoid lactone from Alstonia boonei: A possible precursor in the indole alkaloid biogenesis. Tetrahedron 39(2):323-329.
Mshana RN, Abbiw DK, Addae-Mensah I, Adjanouhoun E, Ahyi MRA, Ekpere JA, Enow-Rock EG, Gbile ZO, Noamesi GK, Odei MA, Odunlami A, Oteng-Yeboah AA, Sarpong K, Sofowora A, Tackie AN (2001). Traditional Medicine and Pharmacopoeia; Contribution to the Revision of Ethno botanical and Floristic Studies in Ghana. Science and Technology Press, CSIR.
Munthu C, Ayyapar M, Raja N, Ignacimuthu S (2006). Medicinal plants used by traditional healers in Kancheepuran district of Tamil Nadu, India. Journal of Ethnobiology and Ethnomedicine 2:43.
Murphy SC, Breman JG (2001). Gaps in the childhood malaria burden in Africa: cerebral malaria, neurological sequelae, anemia, respiratory distress, hypoglycemia, and complications of pregnancy. The American Journal of Tropical Medicine and Hygiene 64(1):57-67.
Murugan K, Panneerselvam C, Samidoss CM, Madhiyazhagan P, Suresh U, Roni M, Chandramohan B, Subramaniam J, Dinesh D, Rajaganesh R, Paulpandi M, Wei H, Aziz AT, Alsalhi MS, Devanesan S, Nicoletti M, Pavela R, Canale A, Benelli G (2016). In vivo and in vitro effectiveness of Azadirachta indica-synthesized silver nanocrystals against *Plasmodium berghei* and *Plasmodium falciparum* and their potential against malaria mosquitoes. Research in Veterinary Science 106:14-22.
Newton PN, McGready R, Fernandez F, Green MD, Sunjio M, Bruneton C, Phanouvong S, Millet P, Whitty CJM, Talisuna AO, Proux S, Christophel EM, Malenga G, Singhasivanon P, Bojang K, Kaur H, Palmer K, Day NPJ, Greenwood BM, Nosten F, White NJ (2006). Manslaughter by fake artesunate in Asia: Will Africa be next? PLoS Medine 3:752-755.
Ngwoke KG, Anusi IA, Eze UM, Okezie PM, Abba CC, Abonyi DO (2015). Phytochemical and Antioxidant Properties of Stem Bark Extracts of Anthocleista nobilis. European Journal of Medicinal Plants 8(2):107-111.
Njoroge GN, Bussman RW (2005). Diversity and utilization of antimalarial ethnophytotherapeutic remedies among the Kikuyus (Central Kenya). Journal of Ethnobiology and Ethnomedicine 2:1-7.
Oguakwa JU (1984). N3-formylechitamidine, an alkaloid from Alstonia boonei. Phytochemistry 23(11):2708-2709.
Okpekon T, Yolou S, Gleye C, Roblot F, Loiseau F, Bories C, Grellier P, Frappier F, Laurens A, Hocquemiller R (2004). Antiparasitic activities of medicinal plants used in Ivory Coast. Journal of Ethnopharmacology 90:91-97.
Oreagba IA, Oshikoya KA, Amachree M (2011). Herbal medicine use among urban residents in Lagos, Nigeria. BioMed Central Complementary and Alternative Medicine 11:117-125.
Patil JR, Jayaprakasha GK, Murthy KNC, Chetti MB, Patil BS (2010). Characterisation of Citrus aurantifolia bioactive compounds and their Inhibition of Human Pancreatic Cells through Apoptosis. Microchemical Journal 94(2):108-117.
Ponou BK, Teponno RB, Ricciutelli M, Quassinti L, Bramucci M, Lupidi G, Barboni L, Tapondjou LA (2010). Dimeric antioxidant and cytotoxic triterpenoid saponins from Terminalia ivorensis A. Chev. Elsevier Phytochemistry 71(17-18):2108-2115.
Porspi A (1992). Ghana Herbal Pharmacopoeia. Policy Research and Strategic Planning Institute, Council for Scientific and Industrial Research, CSIR, Ghana pp . 59-61.
Prance GT (1994). Introduction. In Prance GT, Chadwick DJ, Marsh J (eds.), Ethnobotany and the Search for New Drugs. John Wiley and

Sons, Chichester, England pp. 57-90.
Prance GT (1987). Medicinal plants in tropical West Africa. By Bep Oliver-Bever. Brittonia, 39(1):9-19.
Rajakumar G, Rahuman AA, Chung IM, Kirthi AV, Marimuthu S, Anbarasan K (2015). Antiplasmodial activity of eco-friendly synthesized palladium nanoparticles using Eclipta prostrata extract against Plasmodium berghei in Swiss albino mice. Parasitology Research 114(4):1397-1406.
Rehm, S. and Espig, G., 1984. The cultivated plants of the tropics and subtropics: cultivation, economic value, utilization (No. 581.60913 R345). Margraf.).
Sachs J, Malaney P (2002). The economic and social burden of malaria. Nature 415:680-685.
Sarker SD, Bartholomew B, Nash RJ, Robinson N (2000). 5- O-methylhoslundin: An unusual flavonoid from Bidens pilosa (Asteraceae). Biochemical Systematics and Ecology 28:591-593.
Sebisubi FM, Tan GT (2010). Natural Products with Antimalarial Activity. Phytochemistry and Pharmacognosy pp. 1-10.
Sendagire H, Kaddumukasa M, Dorothy N, Aguttu C, Nassejje M, Pettersson M, Swedberg G, Kironde F (2005). Rapid increase in resistance of Plasmodium falciparum to chloroquine Fansidar in Uganda and the potential of amodiaquine-Fansidar as a better alternative. Acta Tropica 95:172-182.
Senthilkumar K, Aravindhan V, Rajendran A (2013). Ethnobotanical survey of medicinal plants used by Malayan Tribes in Yercaud Hills of Eastern India. Journal of Natural Remedies 13:119-132.
Siddiqui BS, Afshan F, Gulzar T, Hanif M (2004). Tetracyclic triterpenoids from the leaves of Azadirachta indica. Phytochemistry 65:2363-2367.
Singh B, Agrawal PK, Thakur RS (1989). An acyclic triterpene from Phyllanthus niruri. Phytochemistry 28:1980-1981.
Sittie AA, Lemmich E, Olsen CE, Hviid L, Kharazmi A, Nkrumah FK, Christensen SB (1999). Structure-activity studies: In vitro antileishmanial and antimalarial activities of Anthraquinones from Morinda lucida. Planta Medica 65:259-261.
Smith GC, Keen MC, Grivetti L (1996). Mineral values of selected pant foods common to southern Burkina Faso and to Niamey, Niger, West Africa. International Journal of Food Sciences and Nutrition 47:41-53.
Soelberg J, Asase A, Akwetey G, Jager AK (2015). Historical versus contemporary medicinal plant uses in Ghana. Journal of Ethnopharmacology 160:109-32.
Sofowora A (1993). Medicinal Plants and Traditional Medicine in Africa. Wiley, New York 289 p.
Srisilam K, Veersham C (2002). Antimalarials of plant origin. In Khan IA, Khanum A (eds). Role of Biotechnology in Medicinal and Aromatic Plants. Ukkaz Publications, Hyderabad, India 7:17-47.
Ssegawa P, Kasenene JM (2007). Medicinal plant diversity and uses in Sango bay area, Southern Uganda. Journal of Ethnopharmacology 113:521-540.
Suekawa M, Ishige A, Yuasa K, Sudo, K, Aburada M, Hosoya E (1984). Pharmacological studies on ginger. I. Pharmacological actions of pungent constituents (6)-gingerol and (6)-shogaol. Journal of Pharmacobio-dynamics 7:836-848.
Tabuti JRS, Kukunda CB, Kaweesi D, Kasilo OMJ (2012). Herbal medicine use in the districts of Nakapiripirit, Pallisa, Kanungu and Mukono in Uganda. Journal of Ethnobiology Ethnomedicine 8:35.
Tapia A, Cheel J, Theoduloz C, Rodríguez J, Schmeda-Hirschmann G, Gerth A, Wilken D, Jordan M, Jiménez-González E, Gomez-Kosky R, Mendoza EQ (2007). Free radical scavengers from Cymbopogon citratus (DC). Stapf plants cultivated in bioreactors by temporal immersion (TIS) principle. Zeitschrift für Naturforschung C 62(5-6):447-457.
Tatsadjieu LN, Nganga JJE, Ngassoum MB, Etoa FX (2003). Antibacterial and antifungal activity of Xylopia aethiopica, Monodora myristica, Zanthoxylum xanthoxyloides and Zanthoxylum leprieurii from Cameroon. Fitoterapia 74:469-472.
Titanji VPK, Zofou D, Ngemeneya MN (2008). The Antimalarial potential of medicinal plants used for the treatment of malaria in Cameroonian Folk Medicine. African Journal of Traditional, Complementary, and Alternative Medicines 5(3):302-321.
Tona L, Ngimbi NP, Tsakala M, Mesia K, Cimanga K, Apers S, de Bruyne T, Piters L, Totté J, Vlietinck AJ (1999). Antimalarial activity of 20 crude extracts from nine African medicinal plants used in Kinshasa, Congo. Journal of Ethnopharmacology 68:193-203.
Torto FG, Baxter I (1976). Wisanine, a novel alkaloid from the roots of Piper guineense. Tetrahedron Letters 17:3049-3050.
Valentin A, Benoit-Vical MF, Pélissier Y, Koné-Bamba D, Mallié M (2000). Antiplasmodial activity of plant extracts used in West African traditional medicine. Journal of Ethnopharmacology 73:145-151.
Van Andel T, Carvalheiro LG (2013). Why urban citizens in developing countries used traditional medicines: the case of Suriname. Evidence-Based Complementary and Alternative Medicine, 2013: pp13 http://dx.doi.org/10.1155/2013/687197.
Van Wyk BE, Van Oudtshoorn B, Gericke N (2002). Medicinal Plants of South Africa. Briza Publications, Pretoria, South Africa pp. 1-13.
Vigneron M, Deparis X, Deharo E, Bourdy G (2005). Anti-malarial remedies in French Guiana: A knowledge attitudes and practices study. Journal of Ethnopharmacology 98(3):351-360.
Vijayakumar S, Presannakumar G, Vijayalakshmi NR (2008). Antioxidant activity of banana flavonoids. Fitoterapia 79:279-282.
Waterman PG, Muhammad I (1985). Sesquiterpenes and alkaloids from Cleistopholis patens. Phytochemistry 24:523-527.
World Health Organization (WHO) (2007). Guidelines for assessing quality of herbal medicines with reference to contaminants and residues. ISBN 978 92 4 159444 8.
World Health Organization (WHO) (2010). Guidelines for the treatment of malaria, 2nd edn. WHO Press, Geneva.
World Health Organization (WHO) (2011). Quality control methods for medicinal plant materials ISBN 978 92 4 150073 9.
World Health Organization (WHO) (2012). World malaria report 2011. WHO Press, Geneva.
World Health Organization (WHO) (2013). WHO traditional medicine strategy 2014-2023. WHO Press, Geneva.
Yang-Chang W, Chang-Yih D, Shang-Kwei W, Keh-Shaw C, Tsang-Hsiung Y (1990). Two New Natural Azafluorene Alkaloids and a Cytotoxic Aporphine Alkaloid from Polyalthia longifolia. Journal of Natural Products 53(5):1327-1331.
Zhang JW, Li SK, Wu WJ (2009). The main chemical composition and in vitro antifungal activity of the essential oils of Ocimum basilicum Linn. var. pilosum (Willd.) Benth. Molecules 8(14):273-278.
Zirihi GN, Grellier P, Guédé-Guina F, Bodo B, Mambu L (2005a). Isolation, characterization, and antiplasmodial activity of steroidal alkaloids from Funtumia elastica (Preuss) Stapf. Bioorganic & medicinal chemistry letters 15(10):2637-2640.
Zirihi GN, Mambu L, Guédé-Guina F, Bodo B, Grellier P (2005b). In vitro antiplasmodial activity and cytotoxicity of 33 West African plants used for treatment of malaria. Journal of Ethnopharmacology 98:281-285.