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Ethnopharmacological use of herbal remedies for the treatment of malaria in the Dangme West District of Ghana

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ABSTRACT

Aim of study: Malaria is one of the most important diseases in the world. Because of the devastating nature of the disease there is an urgent need to develop new drugs or vaccines for the treatment, prevention and management of the disease. The objective of the present study was to collect and document information on herbal remedies traditionally used for the treatment of malaria in the Dangme West District of Ghana.
Methods: Data was collected from 67 indigenous households in ten communities in the district using a validated questionnaire.
Results: In total, 30 species of plants belonging to 28 genera in 20 families were reported to be used in the preparation of the herbal remedies. Mature leaves were the most (55%) common plant part used and 73.3% of the herbal remedies involved a single plant. Most of the herbal remedies were prepared by boiling and administered orally. The majority (47%) of the species of plants used were collected from their compounds or home gardens.
Conclusions: Knowledge about malaria and treatment practices exists in the study area. Herbal remedies were commonly used by people for the treatment of malaria because they were cost-effective. They are also more accessible. Many of the species of plants used have been documented for the treatment of malaria as well as investigated for their phytochemical and antimalarial and/or antiplasmodial activity confirming the results of previous studies as well as rationalization of their traditional use. Five species of plants used in the study area, namely, *Bambusa vulgaris* Schrad. ex J.C. Wendl. (Poaceae), *Deinbollia pinnata* Schum. &Thonn. (Sapindaceae), *Elaeis guineensis* Jacq. (Arecaceae), *Greenwayodendron* sp. (Annonaceae) and *Solanum torvum* Sw (Solanaceae), are documented for the first time for their use in the treatment of malaria. "The result of this study provides the basis for further pharmacological studies on the herbal remedies used".

1. Introduction

Malaria is estimated to cause 300–350 million clinical cases each year with a corresponding mortality rate of 2–3 million deaths worldwide (WHO, 2005). The disease is a major hindrance to socio-economic development in endemic countries especially in Africa. It constitutes 10% of Africa's total disease burden; 40% of its health expenditure and 30–50% of inpatient cases (WHO, 2001). In Ghana, malaria is hyper-endemic and continues to be the leading cause of morbidity and mortality in the country. In 2006 it accounted for 38.6% of out-patient attendance and over 18% of deaths at health facilities in Ghana (Ghana Health Service, 2007). Because of the devastating nature of malaria and the failure of the most affordable drugs such as Fansidar® and Maladrin® to treat the disease, there is an urgent need to develop new drugs or vaccines for the treatment, prevention and management of the disease (Kilama, 2005; Waako et al., 2005). Historically, the majority of conventional antimalarial drugs have been derived from plants or from structures modeled on plant-derived compounds (Klayman, 1985). Quinine and artemisinin were obtained directly from plants (Srisilam and Veersham, 2003). The use of herbal remedies is also important in urban areas of Ghana where conventional medicines are available (Asase and Oppong-Mensah, 2009).

Many communities in Africa have elaborate medicinal plant use knowledge (Sofowora, 1993). This knowledge is often transmitted from one generation to another usually via word-of-mouth, and as such the traditional uses of many species of plants have not been documented (Asase et al., 2008). There is danger of losing this precious knowledge due to the rapid degradation of natural habitats and ecosystems leading to loss of plant and cultural diversity. There is therefore the need to document traditional knowledge especially about medicinal plant diversity (Mshana et al., 2001; Van Wyk

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et al., 2002; Van Wyk and Wink, 2004). This documentation is of high priority in order to support the discoveries of drugs benefiting mankind in treating diseases such as malaria (Pieroni, 2000). It also contributes to achieving the U.N. Millennium Development Goal 6 of combating HIV/AIDS, malaria and other diseases. Some ethnobotanical studies have been accomplished in Ghana on herbal remedies used for the treatment of malaria in different communities and localities (e.g. Addae-Kyereme et al., 2001; Asase et al., 2005; Asase and Oppong-Mensah, 2009). To the best of our knowledge, however, there is no publication of studies that document traditional antimalarial herbal remedies in the Dangme West District of Ghana.

The aim of the present study was to collect and document information on herbal remedies traditionally used for the treatment of malaria by the indigenous people living in the Dangme West District of Ghana. Specifically, the study sought to document the species of plants used, methods of preparation and administration of the herbal remedies as well as the collection of the plants being used for the treatment of malaria. It is hoped that the result of this study will provide the basis for further pharmacological studies on the herbal remedies used.

2. Materials and methods

2.1. Study area

The study was carried out in ten communities, namely; Dodowa, Ayikuma, Agomeda, Salem, Numesi, Tandonya, Megbem, Manya Dosi, Manya Yiti and Media Agomeda in the Dangme West District of Ghana. The district is situated in the southeastern part of Ghana, between latitude 5°45′ South and 6°05′ North, and longitude 0°05′ East and 0°20′ West and covers a total land area of 1442 km^2. Temperatures are appreciably high for most parts of the year with the highest during the main dry season (November–March) and lowest during the short dry season (July–August). The absolute maximum temperature is 40 °C. The predominant vegetation type is coastal savanna which is made up of short grass savanna interspersed with shrubs and short trees. A large portion of vegetation remains dry for most parts of the year (Dangme West Assembly, 1996).

The population of the Dangme West District is estimated to be 120,000 people (Ghana Statistical Service, 2005). There are four traditional councils in the districts, namely, Se (Shai), Osudoku, Ningo and Prampram and the native language of the people is Adangbe. The major festivals celebrated by the people are Payami and Nymayem, which are performed in March and October, respectively. Puberty rites commonly called *Dipo* which marks the passage of girls into womanhood is performed by a section of the people in the district. The majority of the people are Christians and believers of traditional religion. Subsistence farming is the major occupation of the people living in the district. A number of people are involved in commercial farming of exotic banana and mango. Others engage in fishing and petty trading. Traditional medicine is important to the people because of the limited health facilities in the district (Dangme West Assembly, 1996).

Malaria transmission in the district is perennial with an estimated 20 infectious bites per person per year (Afari et al., 1995). In this study, we collected ethnopharmacological data on herbal remedies claimed to treat malaria as identified by members of households.

2.2. Methods

The study was conducted between August 2008 and June 2009. Data was collected from households using a validated questionnaire and prior informed consent was obtained before conducting interviews (Asase and Oppong-Mensah, 2009). The questionnaire was translated into Adanbge, the principal language spoken in the study area. Two research assistants who were natives and had grown up in the study area were trained in interview techniques and contracted to assist with the interviews. Several contacts with the leaders of the communities were made in order to gain their trust before the actual interviews were conducted.

In total, 67 households selected by consulting the leaders of the communities were interviewed using the questionnaire. Interview sessions usually involved 2–3 members of each household. Each household made the decision of persons to be interviewed. Sixty-five percent of the informants were females while 35% were male, and their ages range 18 to over 60 years. The group interviews were conducted in the mornings (8:30–10:30 GMT) and evenings (15:30–5:30 GMT) when most of the people were available. Members of each household were asked questions about knowledge of malaria and treatment practices, species of plants, plant parts used, mode of preparation and administration of herbal remedies as well as issues concerning the harvesting of the plants used. Interview sessions usually lasted between one to three hours including a field-walk to collect plant species. Repeat visits were made and this was very useful as interviewees recalled additional species and confirmed information.

Voucher specimens were collected with the aid of interviewees for all the species of plants and deposited at the Ghana Herbarium at the Department of Botany, University of Ghana. An experienced tree spotter who was conversant with the flora in the study area was part of the team and assisted with the identification of the plants. The voucher specimens collected were also compared with already identified specimens at the Ghana Herbarium to confirm the field plant identification. Data accumulated was entered into Microsoft Excel®, checked and edited for errors. The nomenclature of the species was checked using the International Plant Names Index (IPNI) (www.ipni.org).

3. Results and discussion

3.1. Knowledge about malaria and treatment practices

Malaria is locally known as asra/*atriidii*. Members of the households interviewed identified malaria based on signs and symptoms that included fevers (90%), headaches (70%), chills (90%), joint pains (64%), sweating (10%), bitter taste in the mouth (30%) and loss of appetite (45%); the percentage number of households are indicated in brackets. The mode of transmission of the disease was well known and indicated as being via the bites of infected *Anopheles* mosquito. Thus the people in the study area have very good knowledge about how to identify malaria (Agyepong, 1992).

All the households interviewed used herbal remedies for the treatment of malaria while about 20% used a combination of herbal remedies and Western medicine. The reasons for using herbal remedies were that they were cost-effective although a few of them felt that Western medicine was more effective. They were also more accessible. The use of a combination of herbal remedies and Western medicines for the treatment of malaria has been documented (Vigneron et al., 2005; Tabuti, 2008) and there could be potential problems associated with plant–drugs interactions. It is important to note that herbal remedies were used for only curative purposes in the study area different to the situation in some areas of French Guiana (Vigneron et al., 2005) where herbal remedies were used for curative purposes as well as preventive or for both purposes in the management of malaria.

3.2. Species of plants used

A total of 30 species of plants belonging to 28 genera in 20 families were reported being used in the preparation of herbal

Table 1
Species of plants used for the preparation of herbal remedies for the treatment of malaria in the Dangme West District of Ghana arranged according to plant families.

Family	Species (Voucher specimen number)	Local name (s) (Adangbe)	Growth form	Plant parts used	Methods of preparation and administration	Number of citations	Place of collection[a]	Cultivation status[b]
Anacardiaceae	*Mangifera indica* L. (GAA12)	Mango	Tree	Leaves	Boil leaves with cut fruits of *Citrus aurantifolia* for about one hour and drink one cupful of decoction three times daily until recovered.	4	Ev	SW
Annonaceae	*Greenwayodendron* sp. (GAA 007)		Tree	Leaves	Boil leaves and drink one cupful of decoction for adults and half a cupful for children three times daily until recovered.	10	Bu	W
Arecaceae	*Cocos nucifera* L. (GAA 005)	Akoshi	Tree	Root	Boil about 60 g of root material in one litre of water for approx. 45 minutes and drink decoction three times daily. Children should take half of the dosage.	2	Ev	C
Arecaceae	*Elaeis guineensis* Jacq. (GAA 27)	Abe, Ngbe	Tree	Root	Boil and drink decoction as required until recovered.	2	Ev	SW
Asteraceae	*Acanthospermun hispidus* L. (GAA 01)	Klagbe ngua	Herb	Whole plant	Wash whole plant, boil and drink one cupful of decoction three times daily for 3–5 days. Children should take half of the dosage.	8	Ev	We
Asteraceae	*Vernonia amygdalina* Delile. (GAA 26)	Shawka	Shrub	Leaves	Boil about 50 g of the fresh leaves in one litre of water and drink one cupful three times daily. Children should take half of the dosage. Alternatively, mash the leaves and drink the infusion as required.	9	Cp	SW
Bromeliaceae	*Ananas comosus* (L) Merr. (GAA 02)	Blefo Nmer	Herb	Fruit	Boil fruit peels with leaves of *Azadirchata indica* and drink one cupful of decoction thrice daily until recovered. Children should take half of the dosage.	4	Cp/Fl	C
Caricaceae	*Carica papaya* L. (GAA 03)	Adeba	Tree	Leaves	Boil dried leaves and drink one cupful of decoction twice daily.	8	Ev	SW
Euphorbiaceae	*Phyllanthus amarus* & Thonn. (GAA 16)	Ofobi okpabi	Herb	Whole plant	Boil about 50 g of plant in one litre of water and drink a cupful of decoction three times daily after meals until recovered. Children should take half of the dose. Sweeten with honey or sugar if desired. The decoction may cause dizziness.	4	Ev	We
Euphorbiaceae	*Securinega virosa* (Roxb. Ex Willd.) Baill. (GAA 16)	Asre	Shrub	Whole plant	Boil whole plants with leaves of *Morinda lucida* and drink decoction as desired until recovered.	5	Bu	SW
Fabaceae	*Senna alata* (L).Roxb. (GAA 20)	Asentin	Shrub	Leaves	Boil one leaf in one litre of water and drink one cupful of decoction only once. The decoction may cause frequent emptying of the stomach.	3	Cp	SW

Table 1(*Continued*)

Family	Species (Voucher specimen number)	Local name (s) (Adangbe)	Growth form	Plant parts used	Methods of preparation and administration	Number of citations	Place of collection[a]	Cultivation status[b]
Fabaceae	*Senna occidentalis* (L.) Link (GAA 21)	Nkorda brodia	Shrub	Seeds	Dry seeds, grind and boil about two teaspoonfuls in half a litre of water for 5 minutes and drink infusions twice daily until recovered.	3	Ev	We
Fabcaeae	*Senna siamea* (Lam.) H.S.Irwin & Barneby (GAA 22)	Zangara tsi	Tree	Stem bark	Boil and drink decoction as desired until recovered.	27	Cp	SW
Poaceae	*Bambusa vulgaris*Schrad ex J.C. Wendl. (GAA 28)	Pamplo	Grass	Leaves	Boil and drink decoction as desired until recovered.	1	Bu	W
Poaceae	*Cymbopogon citratus* Stapf. (GAA 06)	Tea ba	Grass	Leaves	Boil and drink one cupful of infusion twice daily until recovered.	4	Cp	C
Poaceae	*Saccharum officinarum* L. (GAA 18)		Grass	Stem	Boil with fruit peels of *Ananas comosus* and leaves of *Azadirachta indica* and drink one cupful of decoction thrice daily.	3	Cp/Cl	C
Lamiaceae	*Ocimum gratissimum* L. (GAA 15)	Su	Shrub	Leaves	Boil about 40–60 g of plant in one litre of water and drink decoction thrice daily until recovered.	3	Cp	SW
Meliaceae	*Azadirachta indica* A. Juss (GAA 03)	Kintsi, Kinsto	Tree	Leaves	Boil leaves and drink one cupful of decoction three times daily until recovered OR boil leaves with fruits of *Ananas comosus* and drink. Also mash leaves in water and drink.	32	Ev	SW
Meliaceae	*Khaya senegalensis* A. Juss. (GAA 08)	Mahogany	Tree	Stem bark	Boil and drink as required. Make alcohol extract of stem bark and drink one cupful before meals. Do not give alcohol extract to children.	8	Cp	SW
Moringaceae	*Moringa oleifera* Lam. (GAA 12)	Moringa	Tree	Leaves	Boil and drink one cupful of decoction thrice daily for 3–5 days OR mash leaves in water and drink thrice daily.	8	Cp	C
Musaceae	*Musa paradisiaca* L. (GAA 13)	Amadan	Tree	Root	Boil and drink as desired until recovered.	1	Cp/Fl	C
Myrtaceae	*Psidium guajava* L. (GAA 17)	Goa	Shrub	Leaves	Boil leaves with cut fruits of *Citrus aurantifolia* and drink one cupful of decoction twice daily.	5	Cp	C
Rutaceae	*Citrus aurantifolia* L. (GAA 04)	Abonua	Shrub	Leaves and fruits.	Boil fruits and or leaves with leaves of *Azadirachta indica* and drink cupfuls of decoction three times daily until recovered.	16	Cp	SW
Rubiaceae	*Morinda lucida* Benth. (GAA 11)	Dzadzaclahu	Tree	Leaves	Boil and drink decoction until recovered.	7	Bu	W
Rubiaceae	*Nauclea latifolia* Sm. (GAA 14)	Nyimo	Shrub	Root	Boil and drink decoction as desired until recovered.	14	Bu	W
Sapindaceae	*Deinbollia pinnata* Schum. & Thonn. (GAA 29)	Adon	Tree	Leaves	Boil and drink as desired until recovered.	6	Bu	W

Solanaceae	*Solanum torvum* Schtdl. (GAA 23)	Abedrow	Herb	Fruits	Boil fruits with leaves and drink a cupful of the decoction before meals.	1	Cp	C
Sterculiaceae	*Theobroma cacao* L. (GAA 25)	Cocoa	Tree	Leaves	Boil for about one hour and drink decoction as desired until recovered.	1	Cp	C
Verbanaceae	*Lippia multiflora* Moldenke. (GAA 26)	Nasu	Shrub	Leaves	Boil dried leaves for about 5 minutes and drink one cupful of infusion three times daily until recovery.	3	Bu	SW
Verbanaceae	*Tectona grandis* Lour. (GAA 30)	Polutsi, Poltso	Tree	Leaves	Boil dried leaves and drink decoction as desired until recovered.	3	Cp	SW

[a] Notes: Bu, Bush; Cp, Near compound/home garden; Ev, Everywhere; Fl, Farm/cropland.
[b] C, cultivated; SW, semi-wild; We, weed; W, wild.

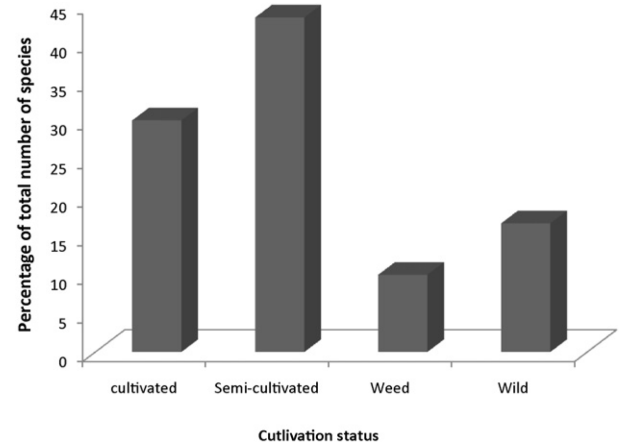

Fig. 1. Cultivation status of plants used in herbal remedies.

remedies for the treatment of malaria (Table 1). About 46.7% of the herbals were trees, 30% shrubs, 13.3% herbaceous plants and 10% were grasses. Most of the species of plants used were either semi-cultivated (43%) or cultivated (30%) (Fig. 1). This means that the plants being used in the study area have some form of protection through cultivation which is encouraging in terms of their conservation.

The majority (20%) of the herbal remedies contained species belonging to the families Fabaceae and Poaceae (Fig. 2). This result is similar to that of previous studies (Asase et al., 2005; Iwu, 1994) and thus indicating the importance of the families as possible sources of antimalarial drugs. A number of studies have also found that members of the Anacardiaceae, Meliaceae, Celastraceae, Rutaceae, Asteraceae and Combretaceae are commonly used for the treatment of malaria (Muthaura et al., 2007; Asase and Oppong-Mensah, 2009). Thus species from diverse families are used in the treatment of malaria (Asase et al., 2005).

The four most frequently cited species of plants were *Azadirachta indica* A. Juss., *Senna siamea* (Lam.) H.S. Irwin & Barneby, *Citrus aurantifolia* L., and *Nauclea latifolia* Sm. Species of plants most frequently cited used may be more effective and need to be subjected to further scientific investigations (Heinrich et al., 2009). For example, *A. indica* has been mostly mentioned as a treatment for malaria in other parts of Africa such as Togo (Gbeassor et al., 1996) and Kenya (Muthaura et al., 2007; Nguta et al., 2010) and found to have antiplasmodial activity (Kirira et al., 2006). In a recent study of antimalarial remedies in herbal markets in southern Ghana *N. latifolia* was one of the most frequently cited species of plants while *A. indica* was cited only once (Asase and Oppong-Mensah, 2009). In central west Cote D'ivoire, *N. latifolia* was among the most frequently cited species for the treatment of malaria (Zirihi et al., 2005). The species *Bambusa vulgaris* Schrad. ex J. C. Wendl., *Musa paradisiaca* L., *Solanum torvum* Schtdl., and *Theobroma cacao* L. were, however, cited only once in this study.

3.3. Plant parts used and mode of preparation of herbal remedies

Mature leaves were the most (55%) common plant part used in the preparation of the herbal remedies. Other plant parts used were roots, fruits, whole plant, stem bark and seeds (Fig. 3). Plant materials were mostly used in the fresh state with the exception of leaves of *Carica papaya* L., *Tectona grandis* L. f. and *Lippia multiflora* Moldenke., and seeds of *Senna occidentalis* (L.) Link that were dried before use. Similar to the results of this study, fresh leaves were the most common plant part used in herbal remedies for treatment of malaria in the Wechiau Community Hippopotamus Sanctuary in Ghana (Asase et al., 2005) and Msambweni District in Kenya (Nguta

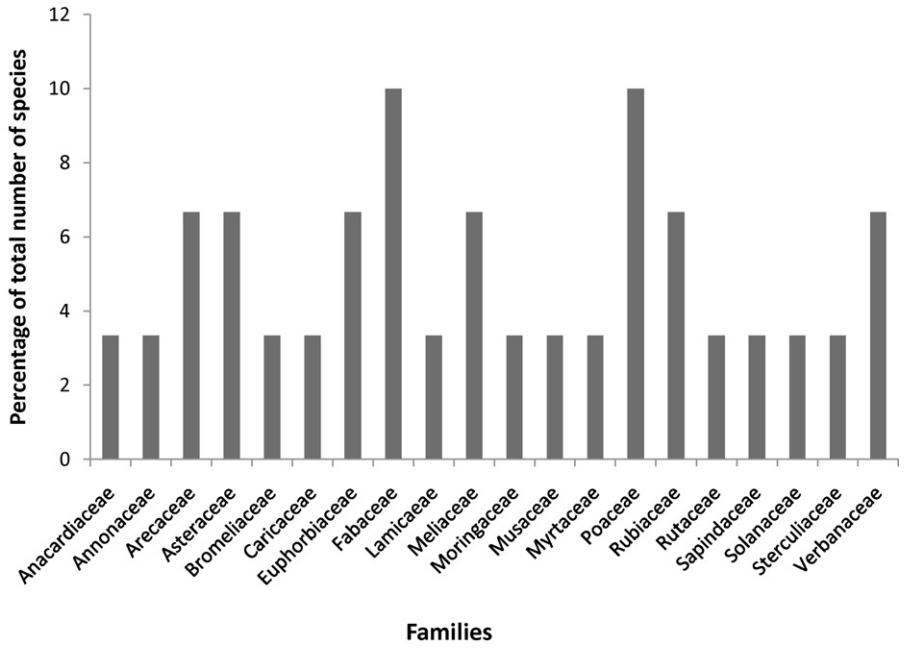

Fig. 2. Percentage number of species in different families of plants.

et al., 2010). Some studies have also reported root materials to be the most common plant part used (Gessler et al., 1995; Muthaura et al., 2007). The majority of the antimalarial remedies in herbal markets of southern Ghana are dried stem materials (Asase and Oppong-Mensah, 2009). It is important to note that harvesting of leaves for treatment of malaria will be less detrimental to populations of the plants compared to roots, stem materials and whole plants harvesting especially where there is no sustainable use strategy (Asase et al., 2005). The leaves of the plants should be used as an alternative if their chemical composition is not very different from that of the roots, stem materials or the whole plant.

About 73.3% of the herbal remedies involved the use of a single plant whilst about 26.7% involved a combination of two or more plants. For example, the leaves of *A. indica* and peels from the fruit of *Ananas comosus* (L.) Merr. were boiled together and the decoction consumed for treatment. The use of a combination of plants as well as individual plant species for the treatment of malaria has been reported (Asase et al., 2005; Vigneron et al., 2005). Most of the herbal remedies were prepared by boiling in water; about 60 g of plant materials in one litre of water. This situation is not different from what has been reported from other parts of Ghana (Asase et al., 2005; Asase and Oppong-Mensah, 2009). Boiling of plant materials was also the main method of preparation of herbal remedies for the treatment of malaria in the Budiope County of Uganda (Tabuti, 2008) and Msambweni District of Kenya (Nguta et al., 2010). In addition to boiling and drinking of decoctions, the leaves of *A. indica*, *Moringa oleifera* Lam., and *Vernonia amygdalina* Delile. were separately mashed in water and the infusion consumed for the treatment of malaria. The stem bark of *Khaya senegalensis* A Juss. was reportedly made into a tincture (local gin extracts) and consumed similar to the report of Asase and Oppong-Mensah (2009).

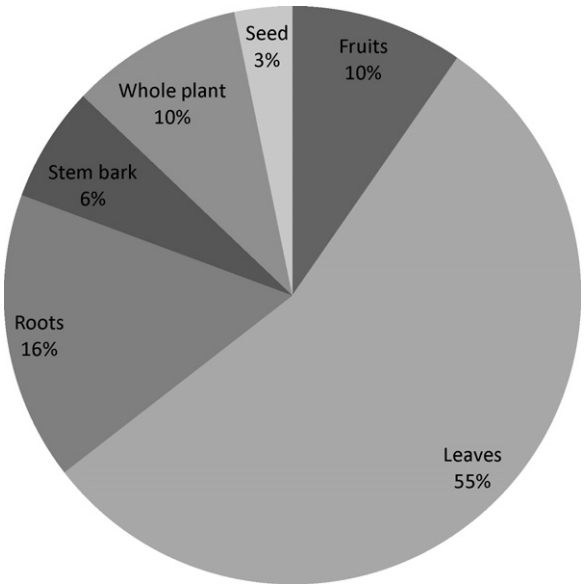

Fig. 3. Proportion of different plant parts used in herbal remedies.

3.4. Route of administration and dosage prescription of herbal remedies

Unlike the findings of some studies where other modes of administration of herbal remedies such as inhalations and steam baths have been reported (Asase et al., 2005; Muthaura et al., 2007), all the herbal remedies used in the study area were administered orally. Dosage prescriptions were adapted according to age where approximately a cupful (equivalent to 50 mL) or half a cupful thrice daily was prescribed for adults and children, respectively. Treatment was supposed to be continued until recovery. The problems associated with dosage prescription in the use of herbal remedies for the treatment of malaria has been highlighted by a number of authors (Asase et al., 2005; Muthaura et al., 2007; Tabuti, 2008; Nguta et al., 2010). Interviewees reported that their herbal remedies had no side effects but this was anticipated as most traditional healers do not, broadly speaking, know of the specific side effects of their herbal remedies. Similar observations have been made in the Budiope County in Uganda (Tabuti, 2008) and some districts in Tanzania (Gessler et al., 1995).

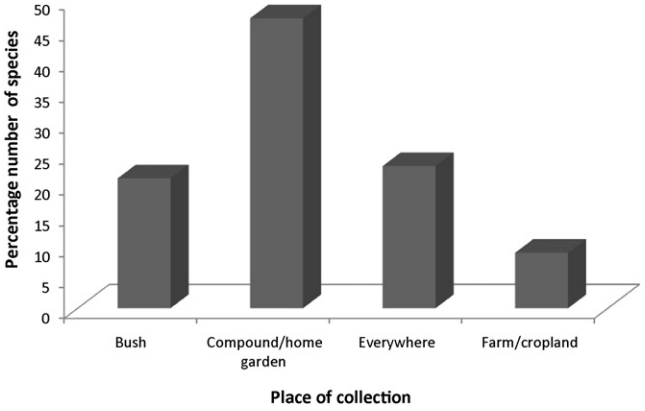

Fig. 4. Places of collection of species of plants used.

3.5. Place and frequency of collection of plants for treatment

The majority (47%) of the species of plants used were collected from their compounds or home gardens. Some of the species of plants were also collected from farms/croplands and in the bush while a few of the species were very common and could be collected from virtually everywhere in the district (Fig. 4). In the Wechiau Community Hippopotamus Sanctuary in northern Ghana plants were mostly collected from the vicinity of their habitation, in the forest reserve area and elsewhere in the bush for the treatment of malaria (Asase et al., 2005). Most of the plants collected for the treatment of malaria in Msambweni and Kwale Districts in Kenya were collected from community lands (Muthaura et al., 2007; Nguta et al., 2010). The plants used for the treatment of malaria in the Budiope County in Uganda were collected from similar places as found in this study (Tabuti, 2008). Whether plants are collected near homesteads, in forest reserves or elsewhere in the bush it is important that strategies are developed to ensure their sustainable use and conservation. It is worth noting that the plant parts of six of the species of plants used including fruits of *C. aurantifolia* and *A. comosus*, leaves of *M. oleifera* and stem of *Saccharum officinarum* could be obtained from the local markets.

None of the informants considered time of year and/or day as well as place of harvesting plants as an important factor. Plant parts were therefore harvested as and when needed using simple tools such as cutlass and hoes, and there was no specific time to collect. A similar observation was made in the Bodiope County in Uganda (Tabuti, 2008). Only the required amount of plant materials needed was usually collected for treatment and therefore the probability of overharvesting plant materials was insignificant. From studies in Ethiopia, it is known that harvesting time can be an important issue and some plants only have their full therapeutic effect if they are collected early in the morning or during a certain season (Abebe, 1984). Also, according to Prance (1994), the potency of herbal reme-

Table 2
Cross-reference in published literature on ethnopharmacological use and pharmacology (antiplasmodial activity and major phytochemical compounds) of antimalarial plants use in the Dangme West District of Ghana.

Species	References to similar ethnopharmacological use	Pharmacology
Acanthospermun hispidus	Mshana et al. (2001), Asase et al. (2005), Odugbemi et al. (2007), Bero et al. (2009)	Antiplasmodial activity (Zirihi et al., 2005; Bero et al., 2009)
Ananas comosus	Sanon et al. (2003), Odugbemi et al. (2007)	Phenols (Ma et al., 2007)
Azadirachta indica	Abbiw (1990), Asase et al. (2005), Asase and Oppong-Mensah (2009), Odugbemi et al. (2007), Fredros et al. (2007)	Antiplasmodial activity (Kirira et al., 2006); terpenoids (Siddiqui et al., 2004), limonoids (Siddiqui et al., 2009)
Carica papaya	Bhat and Surolia (2001), Asase et al. (2005), Odugbemi et al. (2007), Asase and Oppong-Mensah (2009)	Phenols (Canini et al., 2007)
Citrus aurantifolia	Odugbemi et al. (2007), Mshana et al. (2001)	Flavonoids (Berhow et al., 1994; Piccinelli et al., 2008)
Cocos nucifera	Juan Hernández et al. (2004)	Terpenoids (Akihisa et al., 2009)
Cymbopogon citratus	Abbiw (1990), Asase and Oppong-Mensah (2009)	Flavonoids (Figueirinha et al., 2008)
Greenwayodendron sp.	No report	Members of genus contain terpenoids (Yoo et al., 2005)
Khaya senegalensis	Mshana et al. (2001), Asase et al. (2005), Asase and Oppong-Mensah (2009)	Limonoids (Yuan et al., 2009)
Lippia multiflora	Valentin et al. (1995)	Antiplasmodial activity (Valetin et al. (1995); Essential oils (Mwangi et al., 1991)
Mangifera indica	Branch and Silva (1983), Asase et al. (2005), Odugbemi et al. (2007), Asase and Oppong-Mensah (2009)	Antiplasmodial activity (Zirihi et al., 2005), phenolics (Barreto et al., 2008)
Morinda lucida	Mshana et al. (2001), Odugbemi et al. (2007), Asase and Oppong-Mensah (2009)	Antiplasmodial activity and anthraquinones (Sittie et al., 1999; Tona et al., 1999)
Moringa oleifera	Tabuti (2008)	Flavonols (Sultana and Anwar, 2008)
Musa paradisiaca	Branch and Silva (1983), Asase and Oppong-Mensah (2009)	Flavonoids (Vijayakumar et al., 2008)
Nauclea latifolia	Odugbemi et al. (2007), Asase and Oppong-Mensah (2009)	Antiplasmodial activity (Zirihi et al., 2005)
Ocimum gratissimum	Odugbemi et al. (2007)	Flavonoids (Grayer et al., 2001)
Phyllanthus amarus	Asase and Oppong-Mensah (2009)	Amariinic acid and ellagitannins (Yeap Foo, 1995); alkaloids (Houghton et al., 1996)
Psidium guajava	Odugbemi et al. (2007), Asase and Oppong-Mensah (2009)	Phenols, flavonoids, carotenoids, terpenoids (Gutiérrez et al., 2008)
Saccharum officinarum	No report	Sterols (Bryce et al., 1967); terpenoids (Bryce et al., 1967; Deshmane and Dev, 1971); flavonoids (Colombo et al., 2006)
Securinega virosa	Abbiw (1990), Mshana et al. (2001)	Antiplasmodial activity (Kaou et al., 2008)
Senna alata	Zirihi et al. (2005)	Antiplasmodial activity (Zirihi et al., 2005)
Senna occidentalis	Asase et al. (2005)	Antiplasmodial activity (Zirihi et al., 2005; Kaou et al., 2008)
Senna siamea	Mbatchi et al. (2006)	Antiplasmodial activity (Mbatchi et al., 2006)
Solanum torvum	No report	Saponins (Lu et al., 2008)
Tectona grandis	No report	Quinones (Sumthong et al., 2006), carotenoids (Macías et al., 2008)
Theobroma cacao	Asase and Oppong-Mensah (2009)	Alkaloids (Ashihara et al., 2008), proathocyanidin, polyphenols (Hatano et al., 2002)
Vernonia amygdalina	Tona et al. (2004), Asase et al. (2005), Asase and Oppong-Mensah (2009), Odugbemi et al. (2007)	Antiplasmodial activity (Tona et al., 2004); terpenoids (Erasto et al., 2006; Abegaz et al., 1994); steroid glucoside (Jisaka et al., 1993); flavonoids (Ola et al., 2009)

dies could differ depending on method of extraction, place and time of harvesting of plant materials as well as other environmental factors. This means that the potency of antimalarial herbal remedies used in the study area could greatly vary depending on the time and place where the plant materials was harvested for use. This needs to be investigated.

3.6. Comparison of ethnopharmacological use with previous studies and pharmacology (antiplasmodial activity and phytochemical constituents)

To determine whether the species of plants used by the people in the Dangme West District of Ghana were already known for their use in the treatment of malaria, a literature search on ethnopharmacological use was performed and results listed in Table 2. The literature search showed that many of the species of plants were used to treat malaria in other parts of Africa. However, five species of plants, namely, *B. vulgaris* (Poaceae), *Deinbollia pinnata* Schum. & Thonn. (Sapindaceae), *Elaeis guineensis* Jacq. (Arecaceae), *Greenwayodendrum* sp. (Annonaceae) and *S. torvum* (Solanaceae), are documented for the first time for the treatment of malaria based on the literature search. The above species of plants occur in some of the areas of Ghana where previous studies on indigenous use of antimalarial plants have been done. It is also very important to note that there were species of plants such as *Hyptis spicigeria* Lam., *Ocimum canum* L., *Paullinia pinnata* L., *Jatropha curca* L., and *Jatropha gossypifolia* L., found in the Dangme West District of Ghana which have been documented for the treatment of malaria in our previous studies (Asase et al., 2005; Asase and Oppong-Mensah, 2009) but were not mentioned used as such in this study. Similarly, species such as *Tridax procumbens* L., and *Lantana camera* L., found in the study area and reported used for the treatment of malaria in Kenya (Muthaura et al., 2007; Nguta et al., 2010) and Uganda (Tabuti, 2008), respectively, were not mentioned used in this study. These differences in the use of plants for the treatment of malaria could be due to differences in the availability and efficacy of the plants as well as the cultural preferences of people. A recent study comparing the ethnobotany of two neighboring Amazonia people, (Shepard, 2004) showed how deeply varying cultural forces can shape significant differences in the use of essentially the same environment.

The antiplasmodial/antimalarial properties of many of the species of plants used have been investigated and found to be active against the *Plasmodium* parasite (Table 2). The phytochemical constituents of the plants have also been determined. However, the pharmacological properties of an individual plant can be significantly altered in the presence of other plant species in compound medicines. Further studies are very important because the *Plasmodium* parasite has developed resistance to most of the commonly used antimalarial drugs due to improper use (White, 2004). The phytochemical composition of medicinal plants is rarely constant which may be an advantage over chemically homogeneous drugs in reducing the livelihood of developing resistant *Plasmodium* strains. Nevertheless, knowledge of the pharmacological, phytochemical and toxicological properties of the herbal remedies used needs to be investigated in order to ensure the effective treatment for malaria as well as the safety of people.

4. Conclusions

The present study has shown that the people in the Dangme West District of Ghana have a very good knowledge to identify and treat malaria. Herbal remedies were commonly used for the treatment of malaria cases because they were cost-effective and easily accessible in their compounds.

This study has documented for the first time the species of plants used in the preparation of herbal remedies for the treatment of malaria in the study area. Many of the species of plants used in the study area have been previously documented for their use in the treatment of malaria and has been confirmed to have positive antimalarial/antiplasmodial activity, thus supporting rationalization for their continued use. Five species of plants are documented for the first time as used in the treatment of malaria. The pharmacological, phytochemical and toxicological properties of the herbal remedies used needs to be investigated with the geographical and temporal differences in the study area taken into consideration in order to ensure that people get effective treatment for malaria. This information will also assist in the proper selection of active plants for cultivation and subsequently their conservation in the study area.

The widespread and similar use of a number of species of plant for the treatment of malaria means that people in Africa are selecting plants specifically for the treatment of the disease. It also means that many communities in Africa still use plants for the treatment of malaria. Thus there is a case for the documentation of antimalarial herbal remedies used by different communities in order to better understand how different cultures use plants for their treatment of malaria cases for the benefit of present and future generations. This documentation will assist in the development of effective management strategies for malaria control especially in Africa where the burden of the disease is enormous.

The results of this study have implications, both health-wise and environmental beyond documentation for the sake of future potential new medicines. The importance of biodiversity conservation can be emphasized given the large number of medicinal plants collected from wild and semi-cultivated sites. There is also a direct link between access to wild and agro-biodiversity and human health when information on frequency of use and harvesting is available. Empirical evidence of this association is needed to support efforts in preserving traditional knowledge, cultural heritage, forest and agricultural resources, and biodiversity.

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