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Traditional antimalarial phytotherapy remedies in herbal markets in southern Ghana

Alex Asase*, Gloria Oppong-Mensah

Department of Botany, University of Ghana, P.O. Box LG 55, Legon, Ghana

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ABSTRACT

Ethnopharmacological relevance: Although traditional antimalarial plant remedies in herbal markets are a very important component of the health care system in Ghana this has not been previously studied to allow for the formulation of effective strategy for malaria control in Ghana.
Aim of study: The main objective of the present study was to collect and analyse data on the antimalarial plant remedies in herbal markets in southern Ghana.
Materials and methods: Herborists were interviewed using a validated questionnaire and species of plants were identified using a combination of field photo guides, local names and voucher specimens.
Results: A total of 71 herborists (95.8% female) were interviewed. There were potential correlations between different parameters and variables such as ethnic groups, type of vendor and age-groups. The study revealed 29 species of plants belonging to 22 families being sold for the treatment of malaria. The detailed use of these plants is documented. The most frequently mentioned species of plants were *Morinda lucida* Benth., *Indigofera* sp. and *Nauclea latifolia* Sm. The majority (82.8%) of the plant materials were sold in the dried state and 6.9% were sold in fresh state. About 76.2% of the herbal remedies were sold throughout the year while 23.8% were scarce in the dry season. The cost of treatment of malaria using the herbal remedies ranged from 1 to 2 United States Dollars (USD).
Conclusion: Standardization of names and authentication of plant materials using organoleptic, phytochemical and DNA barcoding techniques as well as further research on efficacy, safety and dosage prescriptions for both fresh and dried plant materials being sold for the treatment of malaria in southern Ghana are needed.

1. Introduction

Malaria is a disease caused by *Plasmodium* parasites and transmitted by the female *Anopheles* mosquito which acts as a host and a vector of the parasite. Symptoms of the disease include headache, fever, general body pains and gastrointestinal upset (Smyth, 1994). Malaria is arguably the most important disease in the world with an estimated 350–500 million clinical cases each year with a corresponding mortality rate of 2–3 million deaths each year (WHO, 2005). In Africa where malaria is endemic, access to conventional drug treatments is reduced in rural areas and cultural practices still remain important (WHO, 2008). Consequently, 80% of the population use traditional medicine for treating malaria (Phillipson, 1994; Marsh et al., 1995; Geoffrey and Kirby, 1996; WHO, 2008).

Many species of plant have been traditionally used for the treatment of malaria (Srisilam and Versham, 2003). Indigenous plants still play an important role in the treatment of a variety of diseases including malaria in Africa (Sofoworo, 1980; Phillipson, 1995; Omulokoli et al., 1997). In Ghana, there are many publications of studies on antimalarial uses of plants by communities (Irvine, 1961; Ampofo, 1983; Ayitey-Smith, 1989; Abbiw, 1990; ITC, 1990; PORSPI, 1992; Dokosi, 1998; Mshana et al., 2001; Asase et al., 2005). Herbal markets are important component of the health care system in Ghana (Falconer, 1992). To the best of our knowledge, however, there is no publication of studies on traditional antimalarial plant remedies available in herbal markets in Ghana. This information is needed for the development of strategies for the effective control of malaria in Ghana.

The objectives of the present study were to: (1) determine the socioeconomic status of herborists selling herbal remedies for the treatment of malaria in southern Ghana; (2) identify the species of plants being sold; (3) determine the condition of plant materials (i.e., dried or fresh state), modes of preparation and administration of the herbal remedies; and (4) determine the availability and cost of treatment of malaria using the herbal remedies.

* Corresponding author. Tel.: +233 244128800.
E-mail address: aasase@ug.edu.gh (A. Asase).

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2. Materials and methods

2.1. Study sites

Ghana is a country with a land area of 239,460 km^2. It is located on latitude 8° North and longitude 2° West and shares boundary with Cote D'iviore in the west, Togo in the east and Burkina Faso in the north and the Atlantic Ocean in the south. Administratively, Ghana is divided into ten political regions. The population of Ghana is estimated as 23,832,848 with an annual growth rate of 2.17%. About 70% of the estimated number of people lives in southern Ghana (Ghana Statistical Service, 2005).

The present study was conducted in seven herbal markets distributed across four political regions: namely, Greater Accra Region (Kaneshie and Agbogloshie/Accra Central Markets in Accra), Central Region (Kasoa and Mankessim Markets), Eastern Region (Koforidua Central Market) and Ashanti Region (Asafo Market and Kumasi Central Market in Kumasi) in southern Ghana. The location, climate and topography of the study sites in Ghana are presented in Fig. 1. The above markets were selected for the study because they are renowned for selling herbal products in Ghana (Falconer, 1992). The markets open daily at 8:30 am and close at about 5:30 pm.

The major ethnic groups in the study sites are Ga, Fante, Asante, Akyem and Assin, although there is a very high diversity of people from other ethnic groups due to rural–urban migration. Malaria is endemic in the study sites and in many other parts of Ghana but there are modern facilities for the treatment of the disease in the study sites. The people living in the study sites include government employees, businessmen and women, and petty traders.

2.2. Methods

The present study was conducted from August 2008 to February 2009. A total of 71 herborists were interviewed. The 71 herborists are a random selection for all the people selling such remedies in southern Ghana. Before the interviews were carried out the objectives of the study were thoroughly explained to the herborists. In most cases, the "queen mother" of the herborists was contacted first who then arranged for the interviews with members. Herborists were interviewed separately using a questionnaire. The questionnaire was designed to collect data on the socioeconomic status of the herborists, local names of the plants, plant parts used, condition of the plant material (dried or fresh), and modes of preparation and administration. Samples of the plant materials were obtained and stored in Ziploc bags as voucher specimens. The voucher specimens are deposited at the Ghana Herbarium, Department of Botany, University of Ghana.

In order to assist with identification of the plant materials each herborists was asked to go through a photo guide to the larger trees of Ghana's forest (Hawthorne and Gyakari, 2006) if they could recognize any of the plants that they mentioned. This guide contains coloured photographs, local names and other information on forest trees in Ghana and was useful in the identification of 70% of the plants mentioned. The identification of the plants was also carried out by matching the local names mentioned by the herborists with that in the available literature which does not contain coloured photographs of the plants (Irvine, 1961; Abbiw, 1990; PORSPI, 1992; Dokosi, 1998; Mshana et al., 2001). Twenty of the species were also identified by matching local names with that in literature as there were some overlaps in the identification of the species of plants using the different methods. The voucher plant materials collected were also used by the taxonomists at the Department of Botany, University of Ghana to confirm the identification of the plant materials based on their extensive experience on the flora of Ghana and by comparison with voucher specimens.

The nomenclature of the species of plants identified were updated using the International Plant Names Index (IPNI) (www.ipni.org) and Species 2000 & ITIS Catalogue of Life: 2009 Annual Checklist (www.catalogueoflife.org/annual-checklist/2009/).

2.3. Data analysis

In order to determine whether differences within and among age-groups, type of vendor and ethnic groups of herborists in the herbals markets and political regions were significantly different, multivariate analysis of variance (MANOVA) test was performed. The statistical software R version 2.6.0 (Crawley, 2007) was used to perform the MANOVA test. The assumption of normality was checked and met using the Shapiro–Wilk test (Crawley, 2007).

The diversity of species of plants sold for the treatment of malaria in the different markets was evaluated using the Shannon index ($H' = \sum_{i=1}^{s} pi \ln pi$), where s is the total number of species and p is the relative abundance of the i species (Magurran, 1988). The relative abundance of each species was estimated from the total citations out of the total number of interviews. The total citation of a species was assumed as a measure of the relative importance of each species of plant within the herbal market.

Hierarchical cluster analysis was used to classify herbal markets based on the composition of the species of plants being sold. Relative euclidean distance was used as a measure of similarity/dissimilarity between the markets and nearest neighbour linkage method was used. We used PC-ORD version 4.34 software for the cluster analysis (McCune and Mefford, 1999).

The frequency of citation (FC) of the species of plants being sold was evaluated using the formula: (number of times a particular species was mentioned/total number of times that all species were mentioned) × 100%.

3. Results

3.1. Socioeconomic characteristics of herborists

Of the 71 herborists interviewed 95.8% were female, while only three were males. The major occupation of the herborists was selling herbal remedies while a few of them (15.7%) traded other products, such as spices and vegetables. About 69% of the herborists sold their plant materials in permanent stalls while 30.9%

Table 1
Results of MANOVA test on socioeconomic characteristics of herborists dealing with herbal remedies for the treatment of malaria in southern Ghana.

Response variable	Explanatory variable	*F*-Value	*P*-Value
Age-group	Market	2.87	0.016
	Political region	1.20	0.12
Type of vendor	Market	5.21	0.00020
	Political region	4.73	0.0059
Ethnic group	Market	1.74	0.13
	Political region	2.96	0.038

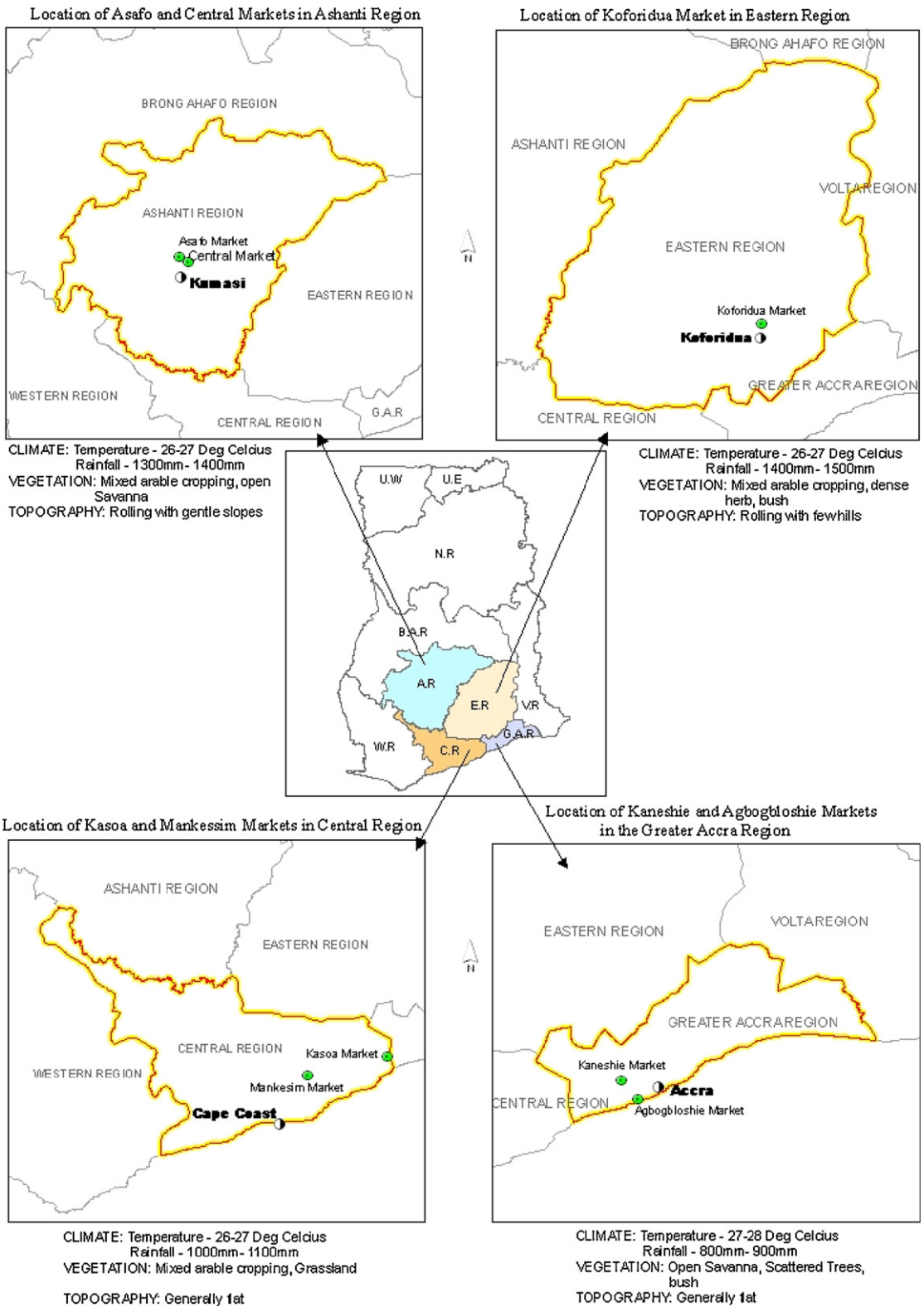

Fig. 1. The geographical location of the herbal markets surveyed in southern Ghana.

of them were ambulatory/hawkers. The herborists belonged to eleven Ghanaian ethnic groups: namely, Akuapem (5.6%), Akyem (9.9%), Asante (22.5%), Assin (23.9%), Brong (1.4%), Ewe (1.4%), Fante (15.5%), Hausa (9.9%), Kwahu (1.4%), Mamprusi (2.8%) and Wassa (1.4%). Three of the herborists interviewed were Nigerians. The ages of the herborists are presented in Fig. 2.

There were potential correlations between the different parameters and variables such as ethnic groups, type of vendor and age-group (Table 1). The type of vendor was significantly different among the herbal markets ($p < 0.001$) and political regions ($p < 0.001$). It was found that the percentages of herborists that sold their herbal remedies in permanent stalls differed in the political

Table 2
Species of plants in herbal markets for the treatment of malaria in southern Ghana with information on their local names, condition of plant materials sold, plant parts used, modes of preparation and administration, frequency of citation and average cost of treatment dose.

Family	Species (voucher specimen number)	Local name	Growth form	Plant parts used	Condition of plant material	Modes of preparation and route of administration	Frequency of citation (FC)	Average cost per treatment dose[a] (GH¢)
Anacardiaceae	*Mangifera indica* L. (GOM 29)	Mango	Tree	Stem	Dried	Boil in water and drink decoction as required	0.98	1.50
Annonaceae	*Cleistopholis patens* Engl. & Diels. (GOM 23)	Engo ni ntsini	Tree	Stem	Dried	Boil in water and drink	0.98	2.30
Apocynaceae	*Alstonia boonei* De.Wild. (GOM 14)	Nyamedua	Tree	Stem and root	Dried	Boil in water and drink	4.90	2.0
	Landolphia sp. (GOM 21)	Tintain, Gyamain	Tree	Stem	Dried	Boil in water and drink decoction as required	2.94	2.70
	Picralima nitida Th. & H.Dur. (GOM 5)	Akuama	Tree	Stem, root and fruit	Both	Boil in water and drink decoction	3.92	2.30
Asteraceae	*Vernonia amygdalina* Del. (GOM 26)	Awonoo	Herb	Leaves	Dried	Boil in water and drink decoction as required	0.98	1.50
Bignoniaceae	*Spathodea campanulata* Buch.-Ham.ex DC. (GOM 7)	Kookoo nisuo	Tree	Stem and root	Dried	Boil in water and drink decoction	1.96	2.30
Bombacaceae	*Bombax buonopozense* P. Beauv. (GOM 19)	Akatabena, Akata	Tree	Stem	Dried	Boil in water and drink	2.94	2.3
Caricaceae	*Carica papaya* L. (GOM 20)	Brofe	Tree	Leaves	Both	Boil in water and drink	0.98	1.5
Combretaceae	*Terminalia catapa* L. (GOM 28)	Abrofo-nkate	Tree	Stem	Dried	Boil in water and drink decoction as required	0.98	1.54
	Terminalia ivorensis A. Chev (GOM 8)	Amre, Emre	Tree	Stem	Dried	Boil in water and drink decoction as required	6.86	2.00
Cucurbitaceae	*Momordica charantia* L. (GOM 22)	Nyenya	Herb	Leaves	Dried	Mash and add to food	0.98	2.30
Euphorbiaceae	*Phyllanthus amarus* Schumach. & Thonn. (GOM 29)	Abom egu wakyi, Boma gu makyi	Climber	Whole plant	Dried	Boil in water and drink decoction	2.94	1.50
Fabaceae	*Indigofera* sp. (GOM 1)	Titto tea	Shrub	Leaves	Dried	Boil in water and drink decoction as required	9.80	2.00
	Tetrapleura tetraptera Taub. (GOM 33)	Prekese abena	Tree	Stem	Dried	Boil in water and drink decoction as required	0.98	2.50
Lecythidaceae	*Petersianthus macrocarpus* (P. Beauv.)Liben (GOM 13)	Esia	Tree	Stem	Dried	Boil in water and drink decoction	3.92	2.00
Loganiaceae	*Anthocleista nobilis* G. Don (GOM 6)	Odeefuor kete	Tree	Stem and root	Dried	Boil in water and drink	0.98	2.0
Meliaceae	*Azadirachta indica* A. Juss. (GOM 16)	Nim	Tree	Leaves	Fresh	Boil in water and drink	0.98	1.5
	Khaya senegalensis A. Juss. (GOM 17)	Mahogany	Tree	Stem and root	Dried	Boil in water and drink decoction or add alcohol and drink infusion	2.94	3.00
	Trichilia monadelpha (Thonn.) J.de Wilde (GOM 25)	Tandro	Tree	Stem	Dried	Boil in water and drink decoction as required	2.94	2.30
Musaceae	*Musa paradisiaca* L. (GOM 18)	Bode, Mpusae	Tree	Leaves	Dried	Mash and add to food	0.98	1.70
Myristicaceae	*Pycnanthus angolensis* (Welw.) Warb. (GOM 15)	Otie	Tree	Stem	Dried	Boil in water and drink decoction	4.90	2.0
Myrtaceae	*Psidium guajava* L. (GOM 28)	Guava	Tree	Leaves	Dried	Boil in water and drink decoction	0.98	1.55
Poaceae	*Cymbopogon citratus* Stapf. (GOM 30)	Tea leaf	Grass	Leaves	Fresh	Boil in water and drink decoction as required	0.98	1.50
Rubiaceae	*Morinda lucida* Benth. (GOM 2)	Konkroma, Yellow bitters, Okonkoma, Yellow fever	Tree	Stem and root	Dried	Boil in water or drink local gin infusions	17.64	3.00
	Nauclea latifolia Sm. (GOM 12)	Nimo, Tafeshia, Ogewu	Shrub	Stem	Dried	Soak in water or add porridge, and drink	8.82	1.50
Rutaceae	*Zanthoxylum zanthoxyloides* (Lam.) B. Zepernick & Timler (GOM 10)	Okanto	Tree	Stem	Dried	Boil in water and drink decoction as required	2.94	2.00
Sapindaceae	*Paullinia pinnata* L. (GOM 4)	Toa ntini	Climber	Roots	Dried	Boil in water and drink decoction	3.92	2.00
Steruliaceae	*Theombroma cacao* L. (GOM 31)	Cocoa	Tree	Leaves	Both	Boil in water and drink decoction as required	3.92	1.52

[a] One United States Dollar (USD) is equivalent to 1.5 Ghana Cedis (GH¢).

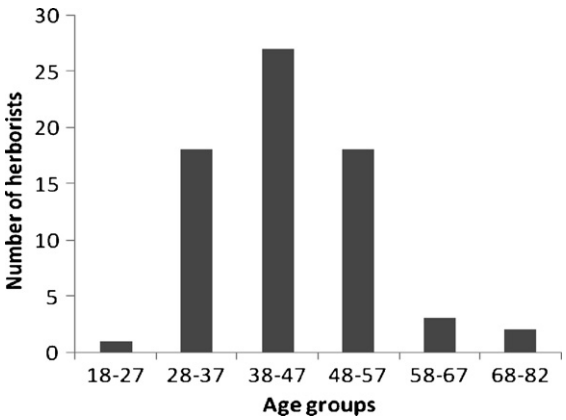

Fig. 2. Age-group distribution of the herborists interviewed.

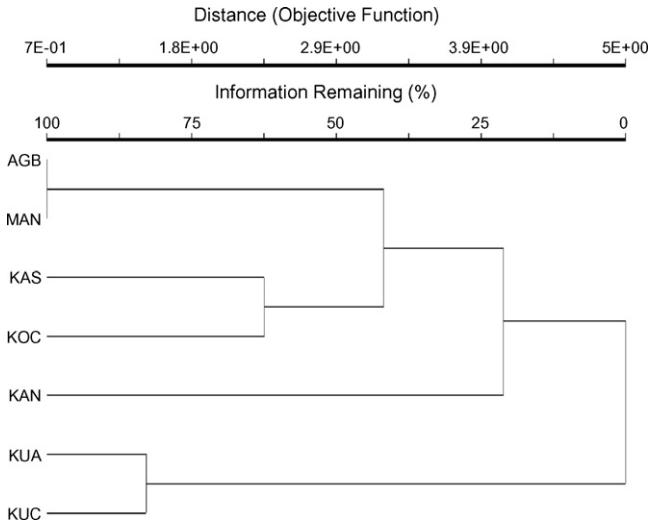

Fig. 3. Dendrogram of species of plants being sold in herbal markets in southern Ghana. Similarity measures are relative euclidean distance and the nearest neighbour joining method was used. AGB, Agbogloshie Market; MAN, Mankessim Market; KAS, Kasoa Market; KOC, Koforidua Central Market; KAN, Kaneshie Market; KUA, Kumasi Asafo Market; and KUC, Kumasi Central Market.

regions and were 100%, 91.7%, 60.6% and 46.7%, respectively, for Ashanti, Central, Greater Accra and Eastern Regions. Similarly, the percentages of herborists that sold their herbal remedies in permanent stalls were different for the herbal markets: 87.5% for Accra Central Market, 54.5% for Kaneshie Market, 83.3% for Kasoa Market, 46.7% for Koforidua Central Market, and 100% each for Asafo, Kumasi Central and Mankessim Markets.

There was significant difference ($p < 0.05$) in ethnic groups of the herborists in the different political regions. As expected the majority of herborists were Fantes (70%) in the Central Region, Asante (45.5%) in the Ashanti Region, and Akyem (54.5%) in the Eastern Region. The largest number of ethnic groups including Assin (46.9%), Asante (28.1%), Fante (9.4%), Akuapim (6.3%), Akyem (3.1%), Brong (3.1%) and Wassa (3.1%) of herborists was recorded in the Greater Accra Region. However, there was no significant ($p > 0.05$) difference in the ethnic groups of herborists in the different herbal markets.

The age-groups of herborists were found to be significantly ($p < 0.05$) different among the herbal markets but not political regions ($p > 0.05$). Herborists within the age-groups 38–47 years for Accra Central (37.5%), Kaneshie (47.1%) and Koforidua Central Markets (43.8), and 28–37 years for Kumasi Central Market (37.5%) were most common; the percentage number of herborists are indicated in brackets.

3.2. Species of plants being sold

This study revealed that 29 species of plants belonging to 22 families were being sold in the markets for the treatment of malaria. The species of plants, their growth form, families and frequency of citation (FC) are presented in Table 2. The species being used as herbals were trees (75.9%), herbs (6.9%), shrubs (6.9%), climbers (6.9%) and grasses (3.5%). Most plants (41.4%) being sold belonged to the Meliaceae, Fabaceae, Apocynaceae, Rubiaceae and Combretaceae. The rest of the 17 families being used were represented by one species per family (Table 2).

The mean Shannon diversity index of species of plants sold for the treatment of malaria in herbal markets in southern Ghana was 1.62 ± 0.63 (SD). There was a significant difference ($p > 0.01$) in the Shannon diversity index of species of plants sold in different political regions. Fig. 3 is a dendrogram based on a hierarchical cluster analysis of species of plants being sold in the herbal markets. Two

Table 3
Cross-referenced in published literature on antimalarial activity and major phytochemical constituents of the ten most frequently cited species of plants in herbal markets for the treatment of malaria in southern Ghana.

Species	Antimalarial activity	Major phytochemical constituents
Alstonia boonei De.Wild.	Zirihi et al. (2005)	Alkaloids (Oguakwa, 1984) and terpenoids (Faparusi and Bassir, 1972)
Indigofera sp.		Members of the genus contain flavonoid glycosides (Hasan et al., 1996)
Morinda lucida Benth.	Sittie et al. (1999), Tona et al. (1999)	Anthraquinones (Sittie et al., 1999; Tona et al., 1999)
Nauclea latifolia Sm.	Benoit-Vical et al. (1998), Traore et al. (2000), Zirihi et al. (2005)	Alkaloids (Traore et al., 2000)
Paullinia pinnata L.	Gbeassor et al. (1989)	Purine alkaloids (Weckerle et al., 2003), polyphenols (Zamble et al., 2006)
Petersianthus macrocarpus (P. Beauv.)Liben		Saponins (Massiot et al., 1992; Olugbade et al., 2000)
Picralima nitida Th. & H.Dur.	Iwu and Kiayman (1992), Okokon et al. (2007)	Alkaloids (Lewin et al., 1992)
Pycnanthus angolensis (Welw.) Warb.	Zirihi et al. (2005)	Lignans (Abrantes et al., 2008), terpenoids quinines (Wabo et al., 2007), isoflavonoids (Omobuwajo et al., 1992)
Terminalia ivorensis A. Chev		Member of the genus contain terpenoids (Idemudia, 1970)
Theombroma cacao L.		Alkaloid (Ashihara et al., 2008), proathocyanidin and polyphenols (Hatano et al., 2002)

major groups were revealed from the cluster analysis. The first group consisted of herbal markets located in the Ashanti Region of Ghana (Kumasi Central and Asafo markets) while the second group consisted of herbal markets located in the other regions (Greater Accra Region, Central Region and Eastern Region). This means that there is a clear difference in the species of plants sold for the treatment of malaria in the Ashanti Region and the other political regions in Ghana.The most frequently cited species of plants were *Morinda lucida* Benth. (FC = 17.65), *Indigofera* sp. (FC = 9.80) and *Nauclea latifolia* Sm. (FC = 8.82). The ten most frequently cited species of plants in the herbal markets are listed in Table 3. References to published literature on their antimalarial activity and main phytochemical constituents have been added to the table. In contrast, eight species, namely, *Anthocleista nobilis* G. Don., *Azadirachta indica* L., *Carica papaya* L., *Cleistopholis patens* Engl. & Diel., *Cymbopogon citratus* Stapft., *Mangifera indica* L., *Momordica charantia* L., *Musa paradisiaca* L., *Psidium guajava* L., *Terminalia catapa* and *Tetrapleura tetraptera* Taub. were cited only once throughout the study.

3.3. Plant parts, condition of plant materials, mode of preparation and administration

Stem material was the most commonly sold (73.2%) plant material for the treatment of malaria. Other plant parts being sold were leaves (17.3%), roots (5.5%), whole plant (2.2%) and fruits (1.5%). The majority (82.8%) of the herbal remedies were sold in the dried/preserved state and 6.9% were sold in fresh state. Leaves of three of the species of plants, namely, *Azadirachta indica*, *Picralima nitida* Th. & H.Dur. and *Theobroma cacao* L. were sold in both dried and fresh states.

Many (90.2%) of the herbal remedies were prepared by boiling. In most cases, the preparation of the herbal remedies involved the addition of other ingredients such as lemon (*Citrus aurantifolia* Swingle) and ginger (*Zingiber officinale* Roscoe). It is important to note that some of the herbal remedies were reported being used as infusions in either local gin (*Akpeteshie*) or water. Other herbal remedies were in the powdered form and were added to food such as porridge. Overall, most herbal preparations were taken orally (93.1%) but in a few cases (6.9%) the remedies were taken as food.

3.4. Availability and cost of herbal remedies

About 76.2% of the herbal remedies were sold throughout the year while 23.8% were scarce in the dry season. The frequency of selling herbal remedies to meet the need differed among herborists. The majority of the herborists sold their herbal remedies on weekly basis (70.5%). Some of the herborists (21.3%) also sold their herbal remedies on daily basis while a few (8.2%) of them sold only occasionally.

The average cost of a dosage for treatment of malaria with the herbal remedies ranged from 1.00 to 2.00 USD (Table 3). Most of the herborists (90.9%) claimed that their sales have increased in recent times due to increased patronage. However, few (9.1%) of the herborists indicated that their sales have gone down due to scarcity of the herbal materials.

4. Discussion

The present study showed that selling of herbal remedies for the treatment of malaria in southern Ghana is predominantly a female occupation. This is contrary to the results obtained from a recent study in Burkina Faso (Sanon et al., 2002) and Mali (Togola et al., 2005), which reported that more males engaged in this activity than females. In Ghana, retail trading is largely a female dominated occupation and this could explain why 96% of the herborists were females. Factors such as age-group, type of vendor and ethnic group as well as the composition of species of plants being sold differed among the herbal markets and political regions. Togola et al. (2005) also found age-group to be a very important factor in his study. The fact that the majority of the herborists sold their herbal remedies in permanent stalls means that it is possible to verify original claims of cure and dosage prescriptions which are very important issues in traditional health care system in Ghana (Mshana et al., 2001). It is possible for patients to come back to the same herborists to discuss their experiences with the clinical effects of the herbal remedies bought.

The major difficulty encountered during this study was the identification of the species of plants. Despite some advantages with the use of local names (Lawrence and Hawthorne, 2006), a number of disadvantages are often associated with its use in the identification of plants (Cunningham, 2001). For example, in this study different local names were mentioned for some of the species of plants such as *Bombax buonopozene* P. Beauv, *Phyllanthus amarus* Schumach & Thonn., *Nauclea latifolia* and *Morinda lucida*. This is a very common practice in Ghana as different local names for the same species of plants have been documented (e.g. Mshana et al., 2001; Asase et al., 2005). It is also important to note that the use of the coloured photo guide was very helpful in the identification of plants in this study compared to conventional taxonomic keys (Lawrence and Hawthorne, 2006). There were generally agreements in the identification of species of plants using the different techniques. Thus the combination of different identification techniques was very useful in addressing the problem of species identification in this study. Nevertheless, we recommend for the standardization of the names as well as authentication of herbal remedies use for the treatment of malaria in Ghana using organoleptic (morphology and anatomy), phytochemical and DNA barcoding techniques. This would assist accurate identification and reference to herbal remedies used for the treatment of malaria in Ghana. In particular, DNA barcoding technique has become a very useful tool for the identification of plant materials (Chen et al., 2007).

Most of the remedies in the herbal markets were found to be in the dried state. This was the main method used in the preservation of the plants materials. As water is the fundamental requirement in microbial growth (Cooke and Whips, 1993) the dried plant materials in either powdery or chopped form are better protected from microorganism infestations. However, if the active compounds in the plants are volatile compounds then the efficacy of the herbal remedies will be lost or reduced in the dried plant materials. In the present study, most of the herbal remedies were prepared by boiling and drinking the decoctions, which means that the active ingredients in most of the plants are not volatiles.

The majority of the species of plants identified were species used in other parts of Ghana and largely within Africa for the treatment of malaria. Some of these plants have shown positive antiplasmodial activity and their active compounds have been determined. For example, in both Ghana and Cote D'iviore the leaves of *Alstonia boonei* have been reported used for the treatment of malaria and the alkaloid extract of this species had antiplasmodial activity at 8.4 μg/ml (Okpekon et al., 2004). The extracts of *Morinda lucida* have antiplasmodial activity and the activity of the stem bark and root could be associated with anthraquinones (Tona et al., 1999). A study in Nigeria reported *Alstonia boonei* and *Picralima nitida* as being used for the treatment of malaria; it was revealed that the alkaloid alstonine is responsible for the antimalarial activity of *Alstonia boonei* and *Picralima nitida* (Elisabetsky and Costa-Campos, 2005). The leaves of *Mangifera indica* and *Azadirachta indica* have been identified for the treatment of malaria in Uganda (Tabuti, 2007). *Mangifera indica*, *Alstonia boonei*, *Pycnanthus angolensis* (Welw.) Warb and *Nauclea latifolia* have also been identified in Cote D'iviore for the treatment of malaria (Zirihi et al., 2005). *Spathodea campulanata* Buch-Ham ex DC. has been iden-

tified for the treatment of malaria (Amusan et al., 1996). In Togo the leaves of *Azadirachta indica*, *Picralima nitida* and *Alstonia boonei* have reported as being used to treat malaria cases (Gbeassor et al., 1996). This correspondence in use of the same species in different cultures over a long period suggests strongly that these species may be effective in the treatment of malaria (Orwa, 2002; van Wyk and Wink, 2004). It is also important to note that in some cases plants that were reported as being used for the treatment of malaria were found to have antipyretic properties and had no real antiplasmodial properties (Addae-Kyereme et al., 2001; Asase et al., 2006).

The study indicated that herbal medicine is important in the treatment of malaria in urban areas of Ghana where conventional drugs are easily available. The reason for using plants might be because the *Plasmodium* parasite has become resistant to many of the common drugs such as Chloroquine® and Fansidar® that are used for the treatment of the disease in Ghana. It is also because the average cost of treatment of malaria using the herbal remedies were far cheaper and easily available compared to conventional drugs which cost on average GH¢ 5.00 per treatment dose.

The results of this study show that there is a need for the standardization of the names as well as authentication of herbal remedies use for the treatment of malaria in Ghana. Further pharmacological and phytochemical investigations of the extracts being used need to be undertaken to confirm efficacy, safety and development of appropriate dosage prescriptions for both the fresh and dried states of the plants being used in the treatment of malaria in Ghana is also required. This would enable more standardization methods to be developed. Further information about the volume of plant material needed would assist in making strategic plans to conserve active and safe plants and ensure a sustainable supply of such species.

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