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Research paper

Ethnobotanical study of medicinal plants from Ghana; confirmation of ethnobotanical uses, and review of biological and toxicological studies on medicinal plants used in Apra Hills Sacred Grove

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ABSTRACT

The majority of human populations in developing countries rely on traditional medicines but the practice of traditional medicine is not the same across the world. In this study, the authors investigated traditional medicinal uses of plants by the communities living around Apra Hills Sacred Grove, in southern Ghana. A total of 75 households in three communities, namely, Akrampa, Apra and Loye, living in the study area were interviewed about the plants they used for the management of their common human ailments. Data collection was achieved after obtaining prior-informed consent, and using a semi-structured questionnaire. Botanical voucher specimens of the plants reported as being used were collected following standard ethnobotanical practice. A total of 31 species of plants belonging to16 families were reported as being used in the management and treatment of diseases. Approximately 65% of the plants were collected from degraded areas outside the protected area of the grove whereas 35% were obtained from inside the protected area of grove (wild). The majority (81%) of the plants reported were non-cultivated plants while 19% were semi-cultivated plants, and none were cultivated. Leaves formed a major component (57%) of the plant materials being used and most of the herbal remedies were prepared by boiling and the decoctions drunk. The results of the study have also confirmed the ethnobotanical uses of the plants as well as highlighted "new use reports". The study has confirmed importance of degraded areas as a source of medicinal plants for indigenous communities and that a high proportion of non-cultivated plants is used for such medicines. Plants in need of further investigations based on a survey of the available literature on their ethnobotanical use, biological activity and toxicological studies have been highlighted.

1. Introduction

Nature is the greatest source of remedies for many health problems as about 71% of new drugs that have been approved since 1981 have directly or indirectly been derived from natural products (Newman and Cragg, 2012). Plants have traditionally played a major role in the treatment and management of human diseases and ailments (Thirumalai et al., 2009). The use of traditional medicines, especially herbal medicine, as an alternative to conventional medicine is becoming increasingly more popular worldwide. It is estimated that about 80% of the human populations of developing countries depend upon traditional medicines (Calitox, 2005).

The term traditional medicine refers to the sum of the knowledge, skills and practices based on theories, beliefs and experiences indigenous to different cultures that are used to maintain and improve health, as well as to prevent, diagnose and treat physical and mental illnesses (WHO, 2008). In North America, Europe, and other developed regions over 50% of the populations have used traditional medicine at least once. The world market for herbal medicines in the year 2003 stood at over US$ 60 billion per year, and is growing steadily (WHO, 2003). Nevertheless, the practice of traditional medicine is not the same all over the world but varies from place to place as it depends on factors such as the history, philosophy and personal attitudes of the users (Togola, 2008). The Word Health Organization (WHO) has a keen interest in documenting the use of medicinal plants by indigenous people from different parts of the world (Buragohain, 2011).

The study of interactions between people and plants in their environment is termed ethnobotany (Martin, 1995). The interactions between people and plants are nowadays widely viewed as a useful tool for the preservation of traditional knowledge (Heinrich et al., 2006), and biodiversity conservation (e.g., see Boadu and Asase, 2017). Ethnobotany is also about the study of modern and indigenous societies

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view about the usage of plants as medicines (Balick and Cox, 1995). Many indigenous cultures possess a great store of knowledge regarding herbal medicines for the treatment and management of various human diseases and ailments but this knowledge has not yet been documented (Offiah et al., 2011). Information on indigenous use of plants through further research such as pharmacological, biochemical and phytochemical studies has the potential to lead to discovery of new bioactive agents for the treatment of ailments (Koné and Atindehou, 2008). The indigenous uses of plants as well as understanding of vegetation changes by such communities have also social and public health implications (McDade et al., 2007; Reyes-García et al., 2008), and as such it should be documented without delay. The documentation of scientific research on traditional medicines may help conserve an important component of indigenous peoples' cultural heritage for future generations (Mahwasane et al., 2013) as well as enhance conservation of biodiversity (Boadu and Asase, 2017).

In Ghana, ethnobotanical studies have been carried out among different cultures to explore the wealth of medicinal plant knowledge in the country (e.g., Agyare et al., 2014; Gyasi et al., 2015; Komlaga et al., 2015). There are reports on general surveys on ethnobotanical knowledge on Ghanaian plants including those used as medicines (Irvine, 1961; Abbiw, 1990; Dokosi, 1998; Mshana et al., 2001). However, there are still gaps in our knowledge about medicinal plants used by different cultures and geographical areas in Ghana, and broadly within the West African region. There is currently a paucity of detailed scientific knowledge about medicinal plant among many communities in West Africa.

In this contribution, we investigated medicinal uses of plants by communities living in a clearly defined geographical area, Apra Hills Sacred Grove, in southern Ghana. The objectives of the study were to: (1) analyze diversity of species of plants, and mode of use of medicinal plants; and (2) review the available literature on ethnobotanical uses, biological activities and toxicity of the plants reported being used. The authors hypothesized that a significant proportion of the plants used by the communities in the study area for management of their healthcare problems were obtained from degraded areas outside the protected areas of the grove. They further hypothesized that most of the plants used for medicines were non-cultivated plants. We aimed to specifically answer the following research questions: (1) What are the most preferred species of plants used for medicines? (2) Which plant families are commonly used for medicines? (3) Where are plants commonly used for medicines collected (wild vs. degraded areas of the grove)? (4) What proportion of the plants used are cultivated or non-cultivated plants? (5) What proportions of different plant parts are used for medicines? (6) Which uses of the species of plants recorded in our current study have been previously documented in the ethnobotanical literature? (7) Which species of plants recorded in our current study have been screened for their biological and toxicological activities?

2. Materials and methods

2.1. Study area

The Apra Hills Sacred Grove is located in the Awutu Effutu Senya District in the Central Region of Ghana. The study area lies between latitude 5° 35′ N and 5° 30′ N, and longitude 0° 30′ and 0° 35′ W, and covers a total land area of 226 ha (Fig. 1). The area is made up of two adjacent West and Eastern hills. Vegetation type in the study area falls within the Southern Marginal forest type of Hall and Swaine (1981) and the grove is one of best remaining patches of this forest type in Ghana. To the best of the authors knowledge, there are no previous reports or ethnobotanical studies about the communities living around the Apra Hills Sacred Grove. The Awutu people are the indigenous ethnic group living in the study area although other groups such as the Ewe can be found in the area (Forestry Section Report, 1989). The most common religious groups found in the area were Christians, Muslims and traditional believers. The traditional believers worship the Adoko, Wianda and Amaga gods, and they depend largely on traditional medicine for their primary health care needs.

2.2. Methods

The study was conducted in three major communities, namely, Akrampa, Apra and Loye, surrounding the Apra Hills Sacred Grove. Within each community several households were randomly selected for interviews. In total, 75 households were interviewed about medicinal plants being used in the management and treatment of common ailments and diseases. The Heads of the households were the primary focus of our interviews although any member of a household could contribute information during the interviews. A household usually consisted of members of a single family including house helps/servants, and on average three adults (≥18 years) constituted a household in the study area. Data collection from households started after initial interactions with communities, and after obtaining prior-informed consent of the family head following the guidelines of the Code of Ethics of the International Society of Ethnobiology (2008).

Data collection was carried out using a pre-tested and semi-structured questionnaire (Supplementary data) that was designed in accordance with standard ethnobotanical methods (Alexiades and Sheldon, 1996; Cunningham, 2001). The first author with the aid of an interpreter performed the interviews (Fig. 2). The interviews were conducted mostly on Mondays because it was a local taboo day, and as such communities living around the grove do not go to farms that day and thus were available to be interviewed. In addition to household interviews, field-based free-listing interviews were conducted with three forest guards from the Forestry Commission of Ghana, who manage the area. The interviews with the forest guards focused on medicinal uses of plants within nine inventoried 25 m x 25 m sample plots in the study area. The guards consulted among themselves to bring up the known traditional uses of plants that were encountered within the plots.

Botanical voucher specimens of the plants reported as being used were collected, and processed following standard procedure (Martin, 1995), and the specimens were deposited in the Ghana Herbarium (GC) at the Department of Plant and Environmental Biology, University of Ghana. Species of plants were identified in the field, and later confirmed using voucher specimens at the Ghana Herbarium. Nomenclature of the plants was updated following The Plant List (http://www.theplantlist.org; accessed 10/08/2016).

A review of the available literature on previously reported ethnobotanical uses, biological activities and toxicity studies on the plants identified being used in this study were undertaken. The search was conducted largely via PubMed, Science direct and Google Scholar as well as reviewing standard literature on medicinal plants in Ghana and elsewhere in the West African region.

3. Results and discussion

3.1. Diversity and uses of medicinal plants

A total of 31 species of plants were reported as being used in the treatment and management of diseases and ailments in the study area (Table 1). The most frequently mentioned plant by the communities was *Khaya senegalensis* followed by *Lecanioidiscus cupanioides*. Conversely, *Momordica charantia* was the least cited plant. The species of

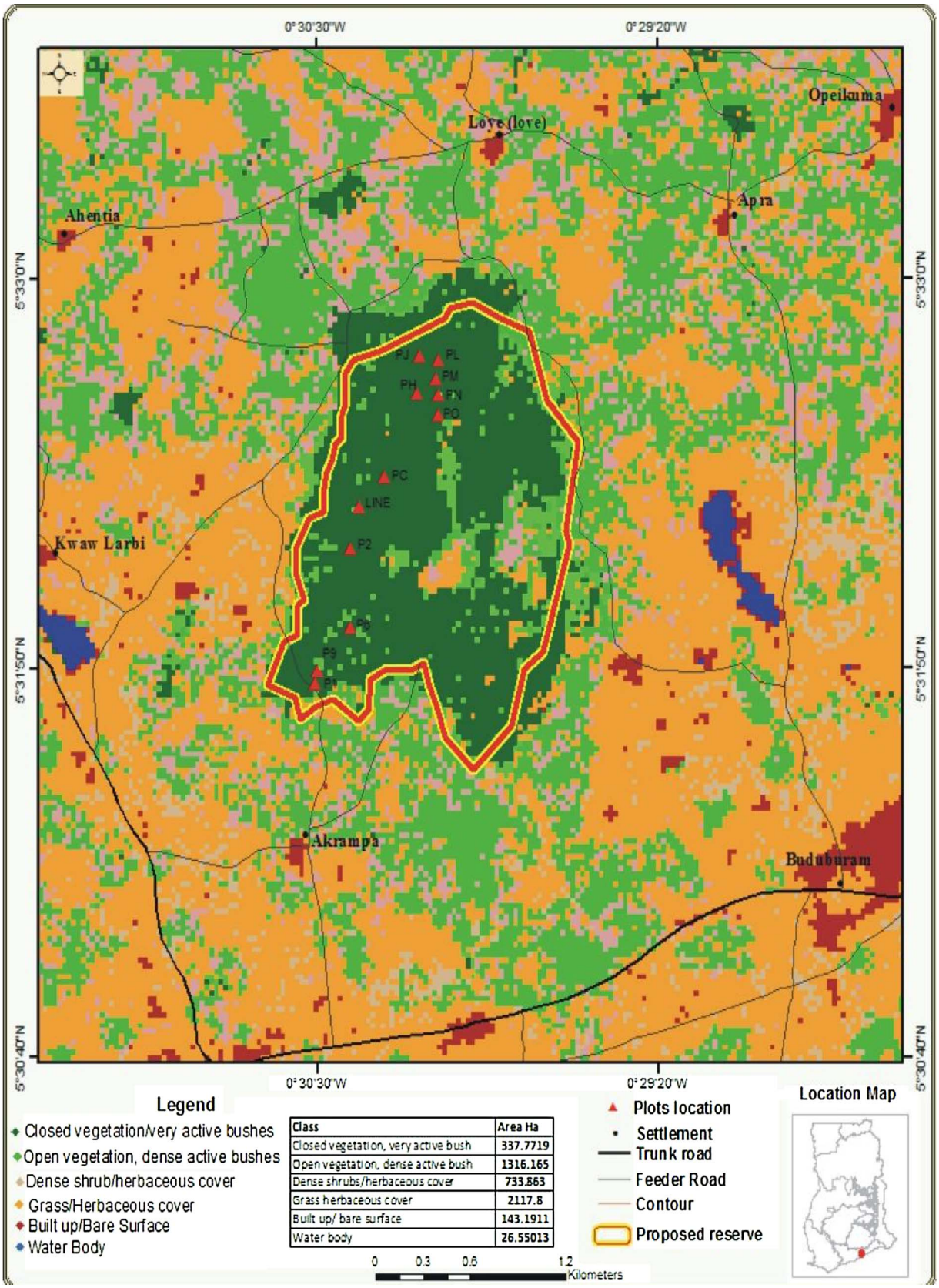

Fig. 1. Map of the study area (Apra Hills Sacred Grove, southern Ghana) showing location of sample plots.

plants mentioned as being used belong to 16 plant families and four of the families namely, Euphorbiaceae, Apocynaceae, Fabaceae and Rutaceae contributed the majority of the species reported (Fig. 3a). The dominance of species of the above families was not surprising as a recent floristic survey carried out in the study area showed that the largest families were Fabaceae (11 species), Apocynaceae (8 species),

Fig. 2. Ethnobotanical interview of a local informant by first author.

Euphorbiaceae (6 species), Sterculiaceae (6 species), and Rubiaceae (5 species) (Adeoye, 2015). Alternatively, the families Annonaceae, Curcubitaceae, Malvaceae, Menispermaceae, Rubiaceae and Verbanaceae contributed only one species each to the plants reported as being used and this could be due to their poor representation in the flora of the study area. The species being used included trees, shrubs, climbers and herbaceous plants- 39% of the plants reported were trees and 9% were climbers (Fig. 3b).

About 29% of the plants reported were collected only from the wild (within the protected area of the Apra Hills Sacred Grove), 65% of the plants were collected from the degraded areas only outside the protected area of the grove, whereas 6% were collected from both wild and degraded areas. Degraded areas included abandoned farmlands and other wastelands usually around the people's vicinity of habitation. The value of degraded habitats as sources of medicinal plants for local communities have been recognized (Towns et al., 2014) as old growth forests are becoming scarce and overexploited (Salick et al., 1995; Chazdon and Coe, 1999), and the results of this study provide further confirmation. Most (81%) of the plants used were non-cultivated plants, and 19% of them were semi-cultivated plants (Table 1). As the demand for medicinal plants is increasing rapidly due to growth of human populations and commercial trade, wild growing plants are being overexploited (Schippmann et al., 2002). Adequate protection of medicinal plants can be achieved through an increase in regulation and introduction of sustainable harvesting methods; however, a more viable long-term solution may involve the cultivation of medicinal plants (Schippmann et al., 2002; WHO et al., 1993). The cultivation of medicinal plants requires appropriate skills for intensive care and management. Other factors such as rates of growth, survival, reproduction, population structure and dynamics, as well as nutrient and organic dynamics should be taken into consideration in the selection of medicinal plants for cultivation (Ticktin, 2004).

Leaves, roots, stem barks, and fruits of the plants were the parts reported as being used in the preparation of herbal remedies (Fig. 4). Leaves formed the major component (57%) of the plant parts used while the least used plant part was fruits (2%). Our finding on the proportions of different plant parts used in this study agrees with most of the previous ethnobotanical studies that have indicated the predominance of leaves as being used in the preparation of herbal medicines (Adnan et al., 2014; Bernarba et al., 2015; Sher et al., 2015). Leaf materials are commonly used in local medicines because they are most easily accessible and constitute a key factor in the identification of plants. Also, harvesting of leaves has less detrimental impact on plants compared to harvesting of roots and stem barks especially where there are no sustainable harvesting strategies in place (Asase et al., 2005). The most commonly used methods for preparation and application of plant materials was boiling and drinking of the decoction. Over 70% of the herbal medicines reported in this study were prepared by boiling fresh plant material and the decoctions drunk, which was similar to that reported in previous ethnobotanical studies (Mahwasane and Boaduo, 2013; Bernarba et al., 2015). Some of the herbal remedies were also prepared in the form of infusions and administered topically.

3.2. Review of ethnobotanical use, biological and toxicological studies of medicinal plants

A review of the ethnobotanical uses of plants showed that all the species of plants identified in this study have all been previously documented as being used in herbal medicines in Ghana and widely elsewhere in West Africa. Some of the reported uses of plants are similar to those previously documented while other reported uses are "new reports". Knowledge of species of plants that are used in different areas can highlight those plants that are well known and well documented as well as those that need further studies. A total of 12 plants out of the 31 identified in this study were found to have similar uses in the available literature. These species of plants and their corresponding uses were: *Azadiracthta indica* for malaria in Ghana (Asase et al., 2005; and elsewhere Burkill, 1999); *Chassalia kolly* for management of typhoid and fevers in Nigeria (Onocha and Ali, 2010); *Chromolaena odorata* used for the treatment of a wide range of ailments including piles in Nigeria (Omokhua et al., 2016); *Lantana camara* for treatment of swollen eyes or inflammations of the eyes (Burkill, 2000; Abbiw, 1990); *Securinega virosa* for management of fatigue (Burkill, 1985; Mshana et al., 2001); and *Mallotus oppositifolius* for treatment of stomach aches (Christensen et al., 2015). Other similar uses were *Mangifera indica* for malaria (Asase et al., 2005); *Mormordica charantia* for treatment of stomach aches (Dokosi, 1998); *Senna siamea* for treatment of malaria (Komlaga et al., 2016); *Tiliacora dielsiana* to treat stomach aches; *Vernonia cinera* for inflammations; and *Zanthoxylum* zanthoxyloides for treatment of toothaches (Ogwal-Okeng et al., 2003).

New use reports included use of the leaves of *Afraegle paniculata* for the management of piles and back pain in this study while a previous study in Ghana reported the use of the plant for malaria in northwest of Ghana (Asase et al., 2005). Leaves and stem of *Baphia nitida* were reported as treatment of waist pain (used to describe any pain associated with this area of the body) in this study while in Nigeria the plant is used for management of diarrhoea (Adeyimne and Akindele, 2008), and inflamed and infected umbilical cords (Onwukaeme, 1995). *Capparis erythrocarpus* was reported for the treatment of piles and waist pains but used as aphrodisiac elsewhere (Singh et al., 2010). The use of *Gymnema sylvestres* for treatment of diabetes is well known (e.g. Kirtikar and Basu, 1975) but in this study the plant is reported for the treatment of measles. Other plants that have new use reports included *Holarrhena floribunda* for waist pain and malaria, *Jatropha gossypifolia* for fatigue, *Lecaniodiscus cupanioides* for treatment of bone fracture, *Mezoneuron benthamianum* for chest pain, *Paullinia pinnata* for waist pain and fatigue.

The biological activities of 29 of the species of plants encountered have been studied (Table 2). These plants have been screened for antimicrobial (10 plants), anti-inflammatory activity (9 plants), antioxidant activity (9 plants), antimalarial/anti-plasmodial (5 plants), anti-bacterial (3 plants), anti-mycobacteria (3 plants), anti-diarrhoeal activity (3 plants), anti-leishmanicidal (3 plants), anti-hypoglycemic (3 plants) and anti-depressant (4 plants) activities. Other species of plants have been screened for their biological activities such as antifertility, antiproliferative, anti-protozoan, anti-typhoid, analgesic/pyretic, antiviral, anti-helminthic, anticancer and muscle relaxant activities. The significant biological properties exhibited by extracts of the plants lead credence to their indigenous uses. There was, however, no information on biological activities of three of the plants, namely; *Ritchiea reflexa, Teclea verdooniana* and *Tiliacora dielsiana.*

Evaluation of toxicity caused by plants is of fundamental

Table 1
Species of medicinal plants with information on their families, local names, cultivation status, habitats, frequency of citation by households, plant parts, modes of preparation and how they are being used by households.

Species (Voucher number)	Family (Habit)	Local name	Cultivation status/ habitat	Number of citations per household	Plant parts	Uses	Modes of preparation/ administration
Afraegle paniculata (Schumach. & Thonn.) Engl. (APRA 01)	Rutaceae (Tree)	Atimpo	Wild/forest	38	Leaves	Treatment of piles and back pain.	Decoction/Oral
Azadirachta indica A. Juss. (Not collected)	Meliaceae (Tree)	Kolebu	Semi-cultivated/ degraded areas	8	Stem bark, leaves and roots	For treatment of malaria and fevers	Decoction/Oral
Baphia nitida Lodd. (APRA 02)	Fabaceae (Climber)	Joun	Wild/forest	15	Leaves and stem	For treatment of waist pain. Other use: Stem bark used for fuel wood and making handles of farm implements	Decoction/Oral
Capparis erythrocarpa Pierre ex. Gagnep (APRA 03)	Cappparaceae (Herb)	Peti-peti	Wild/degraded areas	19	Leaves and roots	For treatment of piles and back pain.	Decoction/Oral
Chassalia kolly (Schumach.) Hepper (APRA 04)	Rubiaceae (Shrub)	Ekodibe	Wild/forest	19	Leaves and roots	Treatment of fever	Decoction/Oral
Chromolaena odorata (L.) R. M. King & H. Rob. (APRA 05)	Asteraceae (Shrub)	Acheampong	Weed/degraded areas	8	Leaves	For treatment of fatigue, measles and stomach aches.	Decoction/Oral
Gymnema sylvestres (Retz.) R.Br. ex Sm. (APRA 10)	Apocynaceae (Herb)	Asamon	Wild/forest	38	Leaves and roots	To treat measles	Decoction/Oral
Holarrhena floribunda G. Don.) T. Durand & Schinz (APRA 11)	Apocynaceae (Tree)	Osese	Wild/forest	11	Leaves and roots	For treatment of waist pain, infertility in women. Other use: For making mortar and pestle	Decoction/Oral
Jatropha gossypifolia L. (APRA 09)	Euphorbiaceae (Tree)	Adatin	Semi-cultivated/ degraded areas	38	Leaves	For treatment of treat fatigue	Decoction/Oral
Khaya senegalensis. (Desr.) A. Jus (APRA 34)	Meliaceae (Tree)	Mahogany	Wild/forest	75	Fruits, stem bark and leaves	To treat fatigue	Decoction/Oral
Lantana camara L. (APRA 07)	Verbenaceae	Nbili-nbili	Wild/degraded area	38	Leaves	To treat swollen eyes	Infusion/Topical
Lecaniodiscus cupanioides Planch ex. Benth. (APRA 016)	Sapindaceae	Ojujumaba	Wild/forest	39	Leaves	For treatment of bone fracture	Decoction/Topical
Mallotus oppositifolius (Geiseler) Müll.Arg. (APRA 19)	Euphorbiaceae (Herb)	Satidua	Wild/degraded areas	8	Stem bark, roots and leaves	Treatment of menstrual pain and stomach aches	Decoction/Oral
Mangifera indica L. (not collected)	Anacardiaceae (Tree)	Mango	Semi-cultivated/ degraded areas	19	Stem bark and leaves	For treatment of measles and fever; Other use: fruits eaten as food	Decoction/Oral
Mezoneuron benthamianum Baill. (APRA 22)	Fabaceae (Herb)	Krokonso	Wild/forest	38	Leaves	For treatment of chest pain	Decoction/Oral/Massage
Momordica charantia L. (APRA 17)	Curcubitaceae (Herb)	Yenye	Weed/forest	4	Stem bark, roots and leaves	Treatment of fever and stomachache. Other use: Stem for use as frames for roofing of houses and general furniture	Decoction/Oral
Paullinia pinnata L. (APRA 23)	Sapindaceae (Herb)	Twiantin	Wild/degraded areas	11	Leaves and roots	For treatment of waist pain and fatigue	Decoction/Oral
Ricinus cumumnis L. (APRA 24)	Euphorbiaceae (Tree)	Adidankruma	Semi-cultivated/ degraded areas	19	Leaves	To treat hiccups and measles	Decoction/Oral
Ritchiea reflexa (Thonn.) Gilg & Gilg-Ben. (APRA 25)	Cappparaceae (Shrub)	Oputi nado	Wild/degraded areas	11	Leaves and roots	For headaches	Decoction/Oral
Securinega virosa (Roxb. Ex Willd.) Baill. (APRA 18)	Euphorbiaceae	Kokobro	Wild/forest	8	Leaves	For treatment of piles, back pain and fatigue	Decoction/Oral
Senna siamea (Lam.) H. S. Irwin & Barneby (APRA 28)	Fabaceae (Tree)	Cassia	Wild/degraded areas	8	Leaves and stem bark	To pile, back pain, swollen eyes and malaria	Decoction and Oral/Topical
Sida acuta (APRA 31)	Malvaceae (Herb)	Mofesan	Weed/degraded areas	8	Leaves and roots	For waist pain	Decoction/Oral
Solanum erianthum D. Don. (APRA 37)	Solanaceae (Shrub)	Boyun	Weed/degraded areas	38	Leaves and roots	For malaria	Decoction/Oral
Solanum torvum Sw. (APRA 39)	Solanaceae (Shrub)	Amajuradi	Semi-cultivated/ degraded areas	19	Roots, fruits and leaves	To treat measles and back pain	Decoction/Oral
Spondias mombin L. (APRA 32)	Anacardiaceae (Tree)	Afaba	Wild/Degraded areas	8	Leaves	To treat fatigue	Decoction/Oral
Strophanthus hispidus DC. (APRA 33)	Apocynaceae (Liana)	Edupeyin	Wild/forest	19	Leaves	For treatment of headache	Decoction/Oral
Teclea verdoorniana Exell & Mendonca (APRA 36)	Rutaceae (Tree)	Osu punapu	Wild/forest	19	Leaves and stem bark	For cold and fever	Decoction/Oral
Tiliacora dielsiana Hutch. & Dalziel (APRA 37)	Menispermaceae (Shrub)	Oprofe	Wild/forest	8	Root	To treat stomach ache	Decoction/Oral
Uvaria sp. (APRA 40)	Annonaceae (Shrub)	Apotompo	Wild/forest	19	Leaves	For waist pain	Decoction/Oral/Massage

(*continued on next page*)

Table 1 (*continued*)

Species (Voucher number)	Family (Habit)	Local name	Cultivation status/ habitat	Number of citations per household	Plant parts	Uses	Modes of preparation/ administration
Vernonia cinerea (L.) Less (APRA 41)	Asteraceae	–	Semi-cultivated/ degraded areas	37	Leaves	To treat swollen eyes	Decoction/Topical
Zanthoxylum xanthoxyloides (Lam.) Zepern & Timler (APRA 48)	Rutaceae (Shrub)	Kantum	Wild/degraded areas	11	Leaves, stem bark and roots	To treat headache	Decoction/Oral

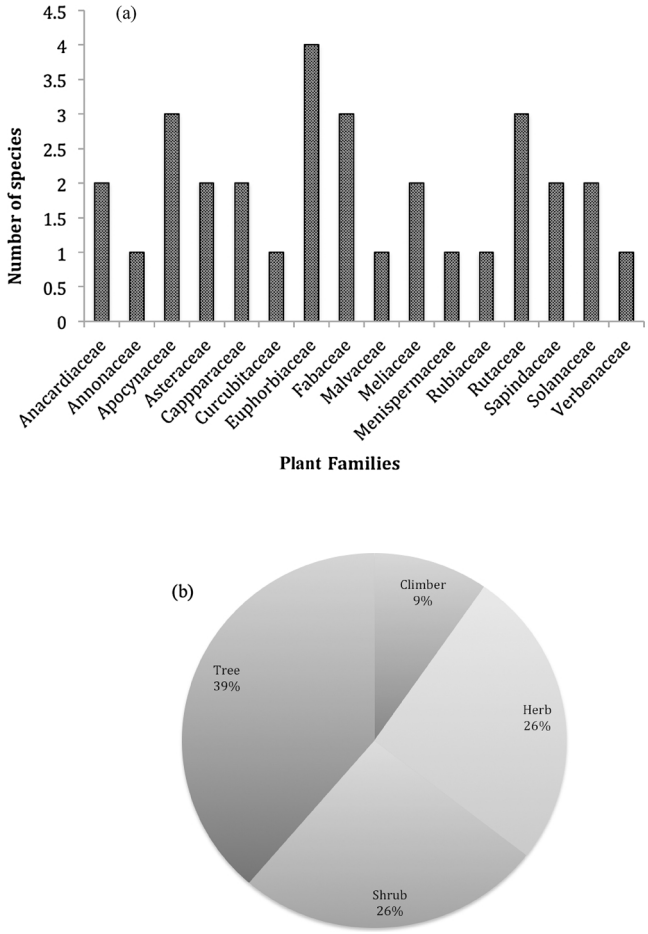

Fig. 3. Diversity of medicinal plants used in Apra Hills Sacred Grove in southern Ghana in terms of (a) plant families and (b) growth forms.

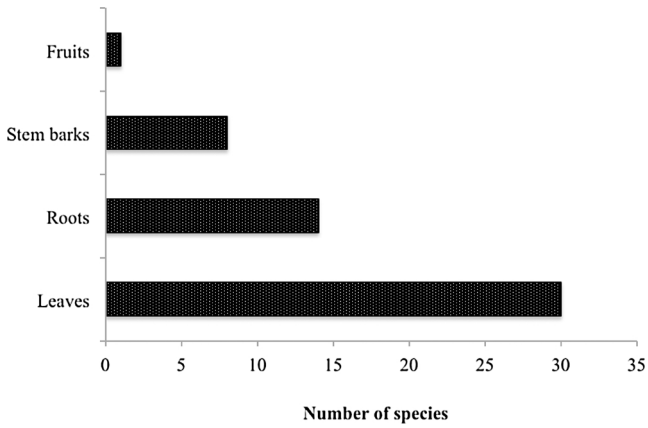

Fig. 4. Proportion of plant parts used for herbal medicines.

importance in minimizing the possible risks to people, especially when they are part of long-term treatment (Rodeiro et al., 2006). All the species of medicinal plants reported except four species (*Mallotus oppositifolius*, *Ritchiea reflexa, T. verdooniana and Tiliacora dielsiana*), have been evaluated for toxicity of their extracts. The plants have been evaluated for largely acute toxicity, cytotoxicity, mutagenicity or genotoxicity, and the extracts of most of them were safe, at least at lower doses. Few cases of toxicity have also been detected such as administration of high doses of *Gymnema sylvestres* will lead to side effects including hypoglycemia (Tiwari et al., 2014). Anti-mutagenic activities have been reported for *Holarrhena floribunda* and *Afraegle paniculata.*

Table 2
Summary of literature survey on reported ethnobotanical uses, biological activities and toxicological studies on species of plants reported as being used.

Species	Previously documented ethnobotanical uses	Biological activities	Toxicological studies
Afraegle paniculata	Malaria (Asase et al., 2005).	Antimicrobial activity (Tsassi et al., 2010); anti-inflammatory activity (Adjangba et al., 1975).	The plant is reported to possess mutagenic activity in Ames tester strains (Uwaifo, 1984).
Azadirachta indica	Malaria and fevers (Asase et al., 2005; Iyamah and Idu, 2015; Burkill, 1997; Mshana et al., 2001); and diabetes (Sujarwo et al., 2016).	Anti-oxidant activity (Gupta et al., 2016); antiviral activity (Younus et al., 2016); antihelminthic activity (Tomar and Preet, 2016) reported.	The ethanolic extract of *A. indica* stem bark at the doses of 50, 100, 200 and 300 mg/kg body weight may not be completely safe as an oral remedy and should be taken with caution if absolutely necessary (Ashafa et al., 2012).
Baphia nitida	For diarrhoea (Adeyemi and Akindele, 2008); and treatment of inflamed and infected umbilical cords (Onwukaeme, 1995).	Antidiarrhoeal activity (Adeyemi and Akindele, 2008); antiinflammatory activity (Onwukaeme, 1995); neurosedative and muscle-relaxant activities (Adeyemi et al., 2006).	Non-toxic on diazepam induced oxidative stress in rats (Akande et al., 2011).
Capparis erythrocarpus	It is used as aphrodisiac (Singh et al., 2010); and treatment of inflammatory and pain conditions (Danquah et al., 2011).	Possess antiarthritic (Danquah et al., 2011); and antinociceptive effects (Woode et al., 2009).	No organ specific toxicity was found associated with chronic administration of this plant in rats but its ability to reduce body weight may be useful for slimming in obese persons (Martey et al., 2013)
Chassalia kolly	For management of typhoid and fevers in Nigeria (Onocha and Ali, 2010).	Insecticidal and anti-microbial activity (Onocha and Ali, 2010).	Non-cytoxicity activity (Onocha and Ali, 2010).
Chromolaena odorata	Malaria (Afolayan et al., 2016); and for management of a wide variety of ailments including wounds, diarrhoea, skin infection, toothache, dysentery, stomach aches, sore throats, convulsions, piles, coughs and cold (Omokhua et al., 2016).	Have antioxidant and immunomodulatory properties (Boudjeko et al., 2015).	Acute and cytotoxicity studies of aqueous and ethanol leaf extracts confirmed non-toxic nature of the plants (Asomugha et al., 2015).
Gymnema sylvestres	The plant is reported used for treatment of diabetes and diseases related to phlegm (Kirtikar and Basu, 1975); jaundice, constipation, asthma, bronchitis, amenorrhoea, conjunctivitis, dyspepsia, (Anis et al., 2000).;	Antioxidant activity (Rahman et al., 2014); radio-protective activity (Sharma et al., 2009); antidiabetic, arthritic, antibiotic, antimicrobial, anti-inflammatory, anticancer and cytotoxic activity (Tiwari et al., 2014) has been reported.	High doses may lead to side effects including hypoglycemia, weakness, shakiness, excessive sweating, and muscular dystrophy (Tiwari et al., 2014); treatment of diabetic patients with *Gymnema sylvestre* has been shown to cause toxic hepatitis or drug-induced liver injury (Shiyovich et al., 2010).
Holarrhena floribunda	For management of Buruli ulcer (Yemoa et al., 2015), pain (Burkill, 1985) and malaria (Fotie et al., 2006).	The plant possesses antioxidant (Badmus et al., 2016); and antimycobacterial activities (Yemoa et al., 2015). Badmus et al. (2013) reported antioxidant, and lipid peroxidation inhibitory activities. Antibacterial activity (Bogne et al., 2007) and antimalarial activity (Fotie et al., 2006) have also been reported.	Anti-mutagenic activity has been reported (Badmus et al., 2013).
Jatropha gossypifolia	Diabetes (Granados et al., 2015) and malaria (Asase et al., 2005).	Hypoglycemic effects (Granados et al., 2015) and antifertility activity in rats (Jain et al., 2013) reported.	No report
Khaya senegalensis	Stem bark for treatment of convulsion, arthritis, hemorrhoids, malaria, boils, anemia and heat rash while leaves are used treat headache and loss of appetite (Mshana et al., 2001).	Anti-diarrhoeal (Nwosu et al., 2012); anti-proliferative and anti-inflammatory effect (Androulakis et al., 2006; Zhang et al., 2007); anti-hyperglycemic effect effects in rats (Kolawole et al., 2012; Funke and Melzig, 2006).	According to Nwosu et al. (2012), the aqueous extract of leaves of *Khaya senegalensis* is not toxic.
Lantana camara	Used in Uganda for treatment of respiratory tract infections (Kirimuhuyza et al., 2009) and inflammations of the eyes (Burkill, 2000; Abbiw, 1990).	Trypanocidal and leishmanicidal potential of the plants has been documented (Barros et al., 2016). Plant possesses active principle against antimycobacterial activity (Kirimuhuyza et al., 2009).	Toxic to NCTC929 fibroblasts at 500 µg/mL (IC50 = 301.42 µg/mL (Barros et al., 2016).
Lecaniodiscus cupanioides	The root decoction of the plant is used to control epilepsy and to enhance penile erection in Nigeria (Yemitan and Adeyemi, 2005).	Extracts of the plant showed antimalarial activity (Nafiu et al., 2013). Aqueous root extract of the plant exhibited CNS depressant activity (Yemitan and Adeyemi, 2005).	Acute oral toxicity test, up to 14 days, did not produce any visible signs of toxicity in mice. However acute (24 h) i.p toxicity test produced a dose-dependent mortality with LD_{50} of 455.2 mg/kg (Yemitan and Adeyemi, 2005)
Mallotus oppositifolius	Dysentery, diarrhoea and other stomach disorders (Christensen et al., 2015).	Antiprotozoan (Christensen et al., 2015); antiproliferative and antiplasmodial (Harinantenaina et al., 2013); and antidepressant effect in mice (Kukuia et al., 2016) has been reported.	No report
Mangifera indica	For management of malaria and fevers (Asase et al., 2005; Burkill, 1985) and wide range of ailments.	Extracts of the plants exhibited significant *in-vitro* antioxidant activity (Martínez et al., 2000). Antispasmodic analgesic, antipyretic and other effects of extracts from the plant (Coe and Anderson, 1996; Awe et al., 1998; Das et al., 1989) have been reported.	The acute toxicity test of mango leaves extract (MLE) at the maximal dose (18.4 g/kg) in ICR mice and showed no abnormalities (Zhang et al., 2014).
Mezoneuron benthamianum	The plant is used for treatment of erectile dysfunction (Zamblé et al., 2008).	Anti-microbial, activities (Dickson et al., 2006), and, antidiarrhoeal activity (Mbagwu and Adeyemi, 2008) have been reported.	Administration of the aqueous extract up to 2 g/kg (orally) did not produce any toxic effect in the acute toxicity in mice (Mbagwu and Adeyemi, 2008).
Momordica charantia			

(*continued on next page*)

Table 2 (*continued*)

Species	Previously documented ethnobotanical uses	Biological activities	Toxicological studies
	Diabetes (Nkambo et al., 2013) and stomachaches (Burkill, 1985; Mshana et al., 2001; Dokosi, 1998).	The plant has been reported to possess antiglycation and antioxidant properties (Aljohi et al., 2016); *in vivo* hypoglycemic effect of methanolic fruit extract (Nkambo et al., 2013); and *in vitro* anti-microbial activity (Mwambete, 2009).	Teratogenic effect of the water extract on the Sprague Dawley Rats (Uche-Nwachi and McEwen, 2009) has been reported.
Paullinia pinnata	Typhoid fever (Lunga et al., 2014a, 2014b); Helminthic (2014); and treatment of fatigue (Burkill, 2000).	Plant possesses anti-typhoid and radical scavenging properties (Lunga et al., 2014a, 2014b); antimicrobial activity (Lunga et al., 2014a, 2014b); antihelminthic activity (Agyare et al., 2014).	The methanol leaf extract of *Paullinia pinnata* is well tolerated when orally administered at a dose of 200 mg/kg body weight but toxic at higher doses (Adeyemo-Salami and Makinde, 2013).
Ricinus cumumnis	The plant is used in treatment of malaria (Asase et al., 2005).	The plant possesses leishmanicidal activity and cytotoxicity (Jumba et al., 2015).	Ricin toxicity has been reported for this plant (Moshiri et al., 2016).
Ritchiea reflexa	The plants is reported used for treatment of migraine and nasal disorders in Ghana (Serfor-Armah et al., 2002)	No report	No report
Securinega virosa	For management of epilepsy and mental illness (Magaji et al., 2012). The leaves are used in many parts of Africa in the treatment of fever, body pain; stomach- ache rheumatism, diarrhoea, pneumonia and epilepsy (Neuwinger, 1996a, 1996b) and fatigue Burkill, 1985; Mshana et al., 2001).	Antimicrobial, antioxidant and free radical scavenging activities (Dickson et al., 2006); and antidepressant activity (Magaji et al., 2012) reported.	Leaves contain cytotoxic alkaloids (Tatematsu et al., 1991).
Senna siamea	For management of malaria (Komlaga et al., 2016); antidote for snake and scorpion bites; diabetes, as laxative, abdominal pains, cough, malaria (Kamagaté et al., 2014).	Antiplasmodial activity (Komlaga et al., 2016). It is also reported to possess anti-inflammatory, analgesic and antipyretic effects, anxiolitic, antidepressant and sedative effects, and anti-bacterial activity (Kamagaté et al., 2014).	Less toxic (Oshimi et al., 2008). However, at a higher dose, diverse extracts of C. *siamea* showed acute toxicity in various experiemental animals' models (Wiam et al., 2005).
Sida acuta	The leaves, roots and whole plant are used for treatment of a range of ailments including malaria, wound, rheumatism and asthma (Dinda et al., 2015).	The plant has be tested for analgesic activity (Konaté et al., 2013); antimalarial; antimicrobial and cytotoxic (Banzouzi et al., 2004; Ahmed et al., 2011; Karou et al., 2005).	Very weak acute toxicity in mice (Konaté et al., 2013).
Solanum erianthum	For cancer (Ajasa et al., 2004), rheumatism, stomachache, abdominal pain, fracture, bruises, and chronic granular Leukemia (Kao, 1990).	Possess anti-inflammatory (Chen et al., 2014); and anticancer activity (Bayala et al., 2007).	The plant has cytotoxic activity against human cancer cell lines at concentrations up to 30 μM (Chen et al., 2014).
Solanum torvum	Fever, wounds, and tooth decay (Ndebia et al., 2007), and coughs and tuberculosis (Nguta et al., 2015) reported.	Antimycobacterial activity (Nguta et al., 2016); anti-cancer (Agrawal et al., 2010), wounds and cuts (Schippers, 2004); has antimicrobial activity (Chah et al., 2000).	Selective cytotoxic activity (Nguta et al., 2016).
Spondias mombin	The fruit decoction is drunk as a diuretic and febrifuge, and decoction from the bark and the leaves used as an emetic, anti-diarrhoea, and dysentery, hemorrhoids and for gonorrhoea and leucorrhoea (Ayoka et al., 2006).	The antimicrobial (Rodrigues et al., 2000). The leaves extracts of the plants possess sedative and anti-dopaminergic effects (Ayoka et al., 2006).	Leaf extract of the plants was non- toxic to mice up to a dose of 5 g/kg (Ayoka et al., 2005).
Strophanthus hispidus	For ulcer, conjunctivitis, leprosy and skin diseases (Ishola et al., 2013).	The plant possess anxiolytic (Ayoka et al., 2005), antiepileptic and antipsychotic (Ayoka et al., 2006), anticonceptive (Uchendu and Isek, 2008), hepatoprotective (Hamenoo, 2010), cardioprotective (Akinmoladun et al., 2010), anti-inflammatory (Nworu et al., 2011), and leishmanicidal (Accioly et al., 2012) properties.	The median lethal dose was 39.81 mg/kg carrageenan-induced rat for the aqueous root extract and therefore toxic (Agbaje and Fageyinbo, 2012).
Teclea verdoorniana	In Cote d'voire the bark is chewed for cold (Neuwinger, 1996a, 1996b).	No report	Species of the genus *Teclea* have been reported to be toxic (Neuwinger, 1996a, 1996b).
Tiliacora dielsiana	Dysentery (Waston and Preedy, 2008).	No report	No report
Vernonia cinerea	*Vernonia cinerea* has potential against cancer and inflammatory conditions (Toyang and Verpoorte, 2013).	Anti-inflammatory activity (Abeysekera et al., 1999), antiangiogenesis (Pratheeshkumar and Kuttan, 2012); and antimetastatic effect (Pratheeshkumar and Kuttan, 2011).	Methanolic extract exhibited no acute toxicity in mice and brine shrimp lethality test (Latha et al., 2010). Rajamurugan et al. (2011) found no toxicity in mice (LD50 42000 mg/kg) and brine shrimp using a methanol extract of *Vernonia cineria*.
Zanthoxylum zanthoxyloides	The plant is reported used to variously treat elephantiasis, toothache, sexual impotence, gonorrhoea, malaria, dysmenorrhoea abdominal pain (Ogwal-Okeng et al., 2003); and burili ulcer (Addo et al., 2007).	Plant posse antiblastocystis activity (Christensen et al., 2015); antibacterial and anti-inflammatory (Ogwal-Okeng et al., 2003).	Metabolic extract of root bark has been found to be safe (Ogwal-Keng et al., 2003).

Non-organ specific toxicity was found with *Capparis erythrocarpus* (Martey et al., 2013) and selective toxicity has been detected in *Solanum torvum* (Nguta et al., 2016). To guarantee the safety of the people using remedies from extracts of these plants in the study area it is important that biological and toxicological studies are conducted on the plants especially those that were identified to have not been previously screened.

3.3. Implications of our findings

There are several implications of the findings of our study. At the local level information about the toxicity and effectiveness of the plants that are being consumed can be used by health professionals and policy makers to make appropriates decisions and advice the communities living in the study area about the safety of the plants that they use. The use of species that have toxic effects at high doses (e.g., *Gymnema*

sylvestres) must be properly monitored or completely discouraged. Conservation of medicinal plants is important to ensure sustainable supplies of plants that are being used. Cultivation of the plants that are commonly used such as *Khaya senegalensis* by the communities must be encouraged so that people do not overexploit plants from the protected areas of the grove.

The findings of the study have wider scientific implications beyond local uses of the plants. Species of plants with perceived good efficacy but without published studies and with insufficient or no preclinical/clinical studies including *Ritchiea reflexa*, *Teclea verdoniana*, and *Tiliacora dielsiana,* must be tested for their safety and efficacy. These plants can be potential sources of new scientific discoveries about biologically active agents for treatment of diseases. The findings of this study have confirmed two important scientific hypotheses: 1) the importance of degraded areas as sources of medicinal plants, and 2) a high proportion of medicinal plants are non-cultivated plants. Scientific validation of the above hypotheses is an important contribution to ethnobotanical literature where hypothesis driven research is presently sparse.

3.4. Strengths and weakness of the research

The authors' aim in this study was to collate information on common use of medicinal plants in the study area. Therefore, key informants such as herbalists and traditional birth attendants who possess specialized knowledge on medicinal plants were not targeted. Future studies can investigate specialized uses of medicinal plants in the study area. While we are optimistic that the results reflect the views of the individuals and communities involved in the research, future studies should include other smaller communities living in the study area. Interviewing both households and forest guards in this study was useful in obtaining detailed information about the plants that are harvested for use by communities living in the study area. We perceived that willingness of individuals in the communities to participate and provide information about the medicinal uses of plants in the study was due to the deep participation of their leaders in the project right from its inception. Finally, the combination of field methods and extensive literature survey in this study has enabled us to identify medicinal plants that merit future studies.

4. Conclusions

This is the first ethnobotanical report on medicinal use of plants by the communities living around Apra Hills Sacred Grove in southern Ghana. The results of the study showed that the communities around the grove have rich knowledge about which plants to collect for management of their common human ailments and diseases and where they are growing. The findings of the study confirmed the hypothesis that degraded areas are important sources of medicinal plants for indigenous communities. The results also confirmed that most of the plants commonly used by indigenous communities for medicines are non-cultivated plants. Most of the plants used are documented in traditional medicines in Ghana and largely within the West African region while a few "new use reports" were identified. Majority of the plants reported being used are generally safe for treatments at appropriate dosage based on a review of studies on their biological and toxicological activities. This study provides baseline data to warrant further studies on the actual plants being used, and has prioritized plants for further biological and toxicological screening as well as promoting their conservation and sustainable use.

Conflict of interest

None.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.hermed.2018.02.001.

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