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

Adeoye Adeniyi, Alex Asase*, Patrick K. Ekpe, Bismark K. Asitoakor, Anthony Adu-Gyamfi, Prosper Y. Avekor

Department of Plant and Environmental Biology, University of Ghana, P. O. Box LG 55 Legon, Ghana

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, Akrama, 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 to 16 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.

ARTICLE INFO

Keywords:
Apra Hills Sacred Grove
Medicinal plants
Toxicology
Conservation
Ghana

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 (Thirumalal 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.

* Corresponding author.
E-mail address: aaasae@ug.edu.gh (A. Asase).

https://doi.org/10.1016/j.hermed.2018.02.001
Received 20 October 2016; Received in revised form 23 January 2018; Accepted 6 February 2018
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Please cite this article as: Adeniyi, A., Journal of Herbal Medicine (2018), https://doi.org/10.1016/j.hermed.2018.02.001
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, 2006). 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-Garcia 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; Abibw, 1996; Dokosi, 1998; Mhana 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, Akrama, Apa and Lore, 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.thepartlist.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 Lecaniodiscus cupanoides. Conversely, Monordica charantia was the least cited plant. The species of
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),
Euphorbiaceae (6 species), Sterculiaceae (6 species), and Rubiaceae (5 species) (Adeoye, 2015). Alternatively, the families Annonaceae, Cur-cubitaceae, 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 over-exploited (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 (Tieckin, 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: Azadirachta indica for malaria in Ghana (Asase et al., 2005; and elsewhere Burkhill, 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 (Omohkhu 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); Mornordica charantia for treatment of stomach aches (Dokosi, 1998); Senna siamea for treatment of malaria (Komlaga et al., 2016); Tiliacora diesiana to treat stomach aches; Vernonia cinera for inflammations; and Zanthoxylum zanthoxyloides for treatment of toothaches (Ogwual-Ogwe et al., 2002).

New use reports included use of the leaves of Afraeagle 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 (Owukuame, 1995). Capparis erythropus 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 moles. Other plants that have new use reports included Holarrhena floribunda for waist pain and malaria, Jarophya gossypifolia for fatigue, Lecaniodicus cupanoides for treatment of bone fracture, Mezoneuron benthamianum for chest pain, Pauullina 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-diarrheal activity (3 plants), anti-leishmanial (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, anti-proliferative, anti-protozoan, anti-typhoid, analgesic/pyretic, antiviral, anti-helminthic, anticancer and muscle relaxing 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 diesiana.

Evaluation of toxicity caused by plants is of fundamental
<table>
<thead>
<tr>
<th>Species (Voucher number)</th>
<th>Family (Habit)</th>
<th>Habit</th>
<th>Number of citations</th>
<th>Plant parts</th>
<th>Uses</th>
<th>Mode of preparation/ administration</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Azadirachta indica</strong></td>
<td>Meliaceae (Tree)</td>
<td>Kolebu Semi-cultivated/ degraded areas</td>
<td>8</td>
<td>Stem bark, leaves, and roots</td>
<td>Treatment of waist pain, infertility in women</td>
<td>Decoction/Oral</td>
</tr>
<tr>
<td><strong>Baphia nitida</strong></td>
<td>Rubiaceae (Shrub)</td>
<td>Wild/forest</td>
<td>15</td>
<td>Leaves and stem bark</td>
<td>For treatment of waist pain. Other use: For making mortars and pestles</td>
<td>Decoction/Oral</td>
</tr>
<tr>
<td><strong>Capparis erythrocarpa</strong></td>
<td>Rubiaceae (Shrub)</td>
<td>Wild/forest</td>
<td>8</td>
<td>Leaves and roots</td>
<td>For treatment of piles and back pain</td>
<td>Decoction/Oral</td>
</tr>
<tr>
<td><strong>Chromolaena odorata</strong></td>
<td>Asteraceae (Shrub)</td>
<td>Weed/degraded areas</td>
<td>8</td>
<td>Leaves and roots</td>
<td>For treatment of piles and back pain</td>
<td>Decoction/Oral</td>
</tr>
<tr>
<td><strong>Holarrhena Durand &amp; Schinz</strong></td>
<td>Apocynaceae (Tree)</td>
<td>Wild/forest</td>
<td>11</td>
<td>Leaves and roots</td>
<td>For treatment of waist pain, infertility in women</td>
<td>Decoction/Oral</td>
</tr>
<tr>
<td><strong>Jatropha gossypifolia</strong></td>
<td>Euphorbiaceae (Tree)</td>
<td>Adatin Semi-cultivated/ degraded areas</td>
<td>8</td>
<td>Stem bark and leaves</td>
<td>Treatment of fatigue and fever</td>
<td>Decoction/Oral</td>
</tr>
<tr>
<td><strong>Khaya senegalensis</strong></td>
<td>Meliaceae (Tree)</td>
<td>Mahogany Wild/forest</td>
<td>11</td>
<td>Fruits, stem bark, and leaves</td>
<td>For treatment of waist pain and fatigue</td>
<td>Decoction/Oral</td>
</tr>
<tr>
<td><strong>Lantana camara</strong></td>
<td>Verbenaceae (Shrub)</td>
<td>Wild/forest</td>
<td>8</td>
<td>Leaves and roots</td>
<td>For treatment of waist pain and fatigue</td>
<td>Decoction/Oral</td>
</tr>
<tr>
<td><strong>Lecaniodiscus cupanioides</strong></td>
<td>Sapindaceae (Shrub)</td>
<td>Ojujumaba Wild/forest</td>
<td>8</td>
<td>Leaves</td>
<td>For treatment of bone fracture</td>
<td>Decoction/Oral</td>
</tr>
<tr>
<td><strong>Mallotus oppositifolius</strong></td>
<td>Sapindaceae (Herb)</td>
<td>Oputinado Wild/degraded areas</td>
<td>11</td>
<td>Leaves and roots</td>
<td>For headaches</td>
<td>Decoction/Oral</td>
</tr>
<tr>
<td><strong>Momordica charantia</strong></td>
<td>Curcubitaceae (Herb)</td>
<td>Yenye Weed/forest</td>
<td>4</td>
<td>Stem bark, roots, and leaves</td>
<td>Treatment of fever and stomachache. Other use: stems and leaves for use as frames for roo</td>
<td>Infusion/Topical</td>
</tr>
<tr>
<td><strong>Paullinia pinnata</strong></td>
<td>Sapindaceae (Herb)</td>
<td>Twiantin Wild/degraded areas</td>
<td>11</td>
<td>Leaves and roots</td>
<td>For treatment of waist pain and fatigue</td>
<td>Decoction/Oral</td>
</tr>
<tr>
<td><strong>Strophanthus hispidus</strong></td>
<td>Apocynaceae (Liana)</td>
<td>Edupeyin Wild/forest</td>
<td>19</td>
<td>Leaves</td>
<td>For treatment of headache</td>
<td>Decoction/Oral</td>
</tr>
<tr>
<td><strong>Teclea verdoorniana</strong></td>
<td>Rutaceae (Tree)</td>
<td>Osu punapu Wild/forest</td>
<td>19</td>
<td>Leaves and stem</td>
<td>For cold and fever</td>
<td>Decoction/Oral</td>
</tr>
<tr>
<td><strong>Uvaria</strong></td>
<td>Annonaceae (Shrub)</td>
<td>Apotompo Wild/forest</td>
<td>19</td>
<td>Leaves</td>
<td>For treatment of back pain</td>
<td>Decoction/Oral</td>
</tr>
</tbody>
</table>

(continued on next page)
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 sylvestre will lead to side effects including hypoglycemia (Tiwari et al., 2014). Anti-mutagenic activities have been reported for Holarrhena floribunda and Afraegle paniculata.

**Table 1 (continued)**

<table>
<thead>
<tr>
<th>Species (Voucher number)</th>
<th>Local name</th>
<th>Cultivation status/habitat</th>
<th>Number of citations per household</th>
<th>Number of citations</th>
<th>Plant parts</th>
<th>Uses</th>
<th>Modes of preparation/administration</th>
<th>Number of species per household</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vernonia cinerea (L.) Less (APRA 41)</td>
<td>-</td>
<td>Semi-cultivated/ degraded areas</td>
<td>37</td>
<td>-</td>
<td>Leaves</td>
<td>To treat swollen eyes</td>
<td>Decoction/Topical</td>
<td>1</td>
</tr>
<tr>
<td>Zanthoxylum zanthoxyloides (Lam.) Zuper &amp; Timler (APRA 48)</td>
<td>-</td>
<td>Wild/degraded areas</td>
<td>11</td>
<td>3</td>
<td>Leaves, stem bark and roots</td>
<td>To treat headache</td>
<td>Decoction Oral</td>
<td>1</td>
</tr>
</tbody>
</table>

Fig. 3. Diversity of medicinal plants used in Apria 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.
Table 2  
Summary of literature survey on reported ethnomedical uses, biological activities and toxicological studies on species of plants reported as being used.

| Species                        | Previously documented ethnomedical uses                                                                 | Biological activities                                                                 | Toxicological studies                                                                 
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Afrangul paniculata</td>
<td>Malaria (Aseue et al., 2005).</td>
<td>Antimicrobial activity (Tsai et al., 2010); anti-inflammatory activity (Badmus et al., 2013)</td>
<td>The plant is reported to possess mutagenic activity in Ames tester strains (Uwakwe, 1984).</td>
</tr>
<tr>
<td>Azadirachta indica</td>
<td>Malaria and fevers (Aseue et al., 2005; Iyamah and Idu, 2015; Burkhill, 1997; Mhama et al., 2001); and diabetes (Sujawo et al., 2016).</td>
<td>Anti-oxidant activity (Gupta et al., 2016); antiviral activity (Younus et al., 2016); antihelminthic activity (Tamar and Preet, 2016) reported.</td>
<td>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 (Ashala et al., 2012).</td>
</tr>
<tr>
<td>Baphia nitida</td>
<td>For diarrhoea (Adeyemi and Akindele, 2008); and treatment of inflamed and infected umbilical cords (Onwukaene, 1995).</td>
<td>Antidiarrheal activity (Adeyemi and Akindele, 2008); antiinflammatory activity (Onwukaene, 1995); neuroprotective and muscle-relaxant activities (Adeyemi et al., 2004).</td>
<td>Non-toxic on diarepaem induced oxidative stress in rats (Akanle et al., 2011).</td>
</tr>
<tr>
<td>Capparis erythrocarnus</td>
<td>It is used as aphrodisiac (Singh et al., 2010); and treatment of inflammatory and pain conditions (Danquah et al., 2011).</td>
<td>Possess antiarthritis (Danquah et al., 2011); and antinociceptive effects (Woode et al., 2009).</td>
<td>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 (Marrey et al., 2013).</td>
</tr>
<tr>
<td>Chromolaena odorata</td>
<td>Malaria (Abayyan et al., 2010); 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 (Onwukaene, 2014).</td>
<td>Have antioxidant and immunomodulatory properties (Boudjeko et al., 2015).</td>
<td></td>
</tr>
<tr>
<td>Gymnema sylvestre</td>
<td>The plant is reported used for treatment of diabetes and diseases related to phelegm (Kirikar and Basu, 1975); jaundice, constipation, asthma, bronchitis, amnorrhoea, conjunctivitis, dyspepsia, (Anis et al., 2000);</td>
<td>Antioxidant activity (Rahman et al., 2014); radio-protective activity (Sharma et al., 2009); antidiabetic, arthritic, antibiotic, antimicrobial, anti-inflammatory, anticancer and cytotoxic activity (Tiwar, 2014)</td>
<td>High doses may lead to side effects including hypoglycemia, weakness, shakiness, excessive sweating, and muscular dystrophy (Tiwar et al., 2014); treatment of diabetic patients with Gymnema sylvestre has been shown to cause toxic hepatitis or drug-induced liver injury (Shayevich et al., 2010);</td>
</tr>
<tr>
<td>Holarrhena floribunda</td>
<td>For management of Buruli ulcer (Yemoa et al., 2015), pain (Burkili, 1985) and malaria (Fotie et al., 2006).</td>
<td>The plant possesses antioxidant (Badmus et al., 2016); and antymycobacterial activities (Yemoa et al., 2015). Badmus et al. (2013) reported antioxidant, and lipoid peroxidation inhibitory activities. Antibacterial activity (Fotie et al., 2006) have also been reported.</td>
<td>Anti-mutagenic activity has been reported (Badmus et al., 2013).</td>
</tr>
<tr>
<td>Jatropha gossypifolia</td>
<td>Diabetes (Granados et al., 2015) and malaria (Aseue et al., 2005).</td>
<td>Hypoglycemic effects (Granados et al., 2015) and antifertility activity in rats (Jain et al., 2013) reported.</td>
<td>No report (continued on next page)</td>
</tr>
<tr>
<td>Khaya senegalensis</td>
<td>Stem bark for treatment of convulsion, arthritis, hemorrhoids, malaria, boils, anenemia and heat rash while leaves are used treat headache and loss of appetite (Mshana et al., 2001).</td>
<td>Anti-diarrheal (Nwosu et al., 2012); anti-proliferative and anti-inflammatory effect (Andrunulis et al., 2006; Zhang et al., 2007); antihyperglycemic effect in rats (Kolarowode et al., 2012; Funke and Meulig, 2006).</td>
<td>According to Nwosu et al. (2012), the aqueous extract of leaves of Khaya senegalensis is not toxic.</td>
</tr>
<tr>
<td>Lantana camara</td>
<td>Used in Uganda for treatment of respiratory tract infections (Kimhuhuya et al., 2010) and inflammations of the eyes (Burkili, 2000; Abrhiw, 1990).</td>
<td>Extracts of the plant showed antimalarial activity (Nafiu et al., 2013). Aqueous root extract of the plant exhibited CNS depressant activity (Yemeni and Adeyemi, 2005).</td>
<td>Toxic to NCTC929 fibroblasts at 500µg/ml. (IC50 = 301.42µg/ml) (Barns et al., 2016).</td>
</tr>
<tr>
<td>Lecaniodiscus cupanoides</td>
<td>The root decoction of the plant is used to control epilepsy and to enhance penile erection in Nigeria (Yemeni and Adeyemi, 2005).</td>
<td>Extracts of the plants exhibited significant in-vitro antioxidant activity (Martinez et al., 2003). Antipsomadic analgetic, antipyretic and other effects of extracts from the plant (Coe and Anderson, 1996; Awe et al., 1998; Das et al., 1989) have been reported.</td>
<td>Acute oral toxicity test, up to 14 days, did not produce any visible signs of toxicity in mice. However acute (24 h) p, toxicity test produced a dose-dependent mortality with LD50 of 455.2 mg/kg (Yemeni and Adeyemi, 2003)</td>
</tr>
<tr>
<td>Mallotus oppositifolius</td>
<td>Dysesthesia, diarrhoea and other stomach disorders (Christensen et al., 2015).</td>
<td>Antiprotozoan (Christensen et al., 2015); antiproliferative and antiplasmodial (Hariharana et al., 2013); and antidepressant effect in mice (Kuku et al, 2016) has been reported.</td>
<td>No report (continued on next page)</td>
</tr>
<tr>
<td>Mangifera indica</td>
<td>For management of malaria and fevers (Aseue et al., 2005; Burkili, 1985) and wide range of ailments.</td>
<td>Extracts of the plants exhibited significant in-vitro antioxidant activity (Martinez et al., 2003). Antipsomadic analgetic, antipyretic and other effects of extracts from the plant (Coe and Anderson, 1996; Awe et al., 1998; Das et al., 1989) have been reported.</td>
<td>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).</td>
</tr>
<tr>
<td>Mecneuron benthamianum</td>
<td>The plant is used for treatment of erectile dysfunction (Zamble et al., 2008).</td>
<td>Antimicrob, activities (Dickson et al., 2006), and, antidiarrhoeal activity (Mbagwu and Adeyemi, 2008)</td>
<td>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).</td>
</tr>
</tbody>
</table>
Table 2 (continued)

<table>
<thead>
<tr>
<th>Species</th>
<th>Previously documented ethnobotanical uses</th>
<th>Biological activities</th>
<th>Toxicological studies</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>A. Adeniyi et al.</em></td>
<td>Diabetes (Nkambo et al., 2013) and stomachaches (Burkili, 1985; Mhiana et al., 2001; Dokosi, 1996).</td>
<td>The plant has been reported to possess anticyclication and antioxidant properties (Ajohi et al., 2016), in vivo hypoglycemic effect of methanolic fruit extract (Nkambo et al., 2013); and in vitro anti-microbial activity (Mwambete, 2009).</td>
<td>Teratogenic effect of the water extract on the Sprague Dawley Rats (Uche-Nwachii and McEwen, 2009) has been reported.</td>
</tr>
<tr>
<td><em>P. pinnata</em></td>
<td>Typhoid fever (Lunga et al., 2014a, 2014b); Helminthic (2014); and treatment of fatigue (Burkili, 2000).</td>
<td>Plant possesses anti-typhoid and radical scavenging properties (Lunga et al., 2014a, 2014b); antimicrobial activity (Lunga et al., 2014a, 2014b); anti-helminthic activity (Agare et al., 2014).</td>
<td>The methanol leaf extract of <em>P. pinnata</em> 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).</td>
</tr>
<tr>
<td><em>R. communis</em></td>
<td>The plant is used in treatment of malaria (Assie et al., 2005).</td>
<td>The plant possesses leishmanicidal activity and cytotoxicity (Jumba et al., 2015).</td>
<td>Ricin toxicity has been reported for this plant (Mohini et al., 2016).</td>
</tr>
<tr>
<td><em>K. reficula</em></td>
<td>The plants is reported used for treatment of migraine and nasal disorders in Ghana (Serfor-Armah et al., 2002)</td>
<td>Antimicrobial, antixiandrent and free radical scavenging activities (Dikinson et al., 2006); and antidepressant activity (Magai et al., 2012) reported.</td>
<td>No report</td>
</tr>
<tr>
<td><em>S. virosa</em></td>
<td>For management of epilepsy and mental illness (Magai et al., 2013). 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 (Burkili, 1985; Mhiana et al., 2001).</td>
<td>Antiplasmodial activity (Komlaga et al., 2016). It is also reported to possess anti-inflammatory, analgesic and pyretic effects, antioxiadn, antidespressant and sedative effects, and anti-bacterial activity (Komlaga et al., 2014).</td>
<td>Leaves contain cytoxic alkaloids (Tatematsu et al., 1991).</td>
</tr>
<tr>
<td><em>S. siamea</em></td>
<td>For management of malaria (Komlaga et al., 2016); antidiote for snake and scorpion bites; diabetes, as laxative, abdominal pains, cough, malaria (Magai et al., 2014).</td>
<td>The plant has been tested for analgesic activity (Konate et al., 2013); antimarial; anti-cytotoxic and cytotoxic (Banzouzi et al., 2004; Ahmed et al., 2011; Karou et al., 2005).</td>
<td>Less toxic (Ohshima et al., 2008); however, a higher dose, diverse extract of <em>S. siamea</em> showed acute toxicity in various experimental animal models (Wiunn et al., 2005).</td>
</tr>
<tr>
<td><em>S. acuta</em></td>
<td>The leaves, roots and whole plant are used for treatment of a range of ailments including malaria, wound, rheumatism and asthma (Dinda et al., 2013).</td>
<td>Posses anti-inflammatory (Chen et al., 2014) and anticancer activity (Bayala et al., 2007).</td>
<td>Very weak acute toxicity in mice (Konaté, 2013).</td>
</tr>
<tr>
<td><em>S. erianthum</em></td>
<td>For cancer (Ajasa et al., 2004), rheumatism, stomachache, abdominal pain, fracture, bruises, and chronic granular Leukemia (Kao, 1990).</td>
<td>Antimycobacterial activity (Nguta et al., 2016); wounds and cuts (Schippers, 2004); has antimicrobial activity (Chah et al., 2000).</td>
<td>The plant has cytotoxic activity against human cancer cell lines at concentrations up to 30 μM (Chen et al., 2014).</td>
</tr>
<tr>
<td><em>S. torvum</em></td>
<td>Fever, wounds, and tooth decay (Ndebia et al., 2013) and coughs and tuberculosis (Nguta et al., 2015) reported.</td>
<td>The antimicrobial (Rodrigues et al., 2008). The leaves extracts of the plants possess sedative and anti-dyspaminergic effects (Ayoko et al., 2006).</td>
<td>Selective cytotoxic activity (Nguta et al., 2016).</td>
</tr>
<tr>
<td><em>S. momon</em></td>
<td>The fruit decoction is drunk as a diuretic and febrifuge and decocion from the bark and the leaves used as an emetic, anti-diarrhoea, and dysentery, hemorrhoids and for gonorrhoea and leucorrhoea (Ayoko et al., 2006).</td>
<td>No report</td>
<td>Leaf extract of the plants was non-toxic to mice up to a dose of 5 g/kg (Ayoko et al., 2005).</td>
</tr>
<tr>
<td><em>S. hispidus</em></td>
<td>For ulcer, conjunctivitis, leprosy and skin diseases (Ishola et al., 2013).</td>
<td>The plant possess antioxiadn (Ayoko et al., 2005), anti-epileptic and antipsychotic (Ayoko et al., 2006), anticonceptive (Ichchou and Bk, 2008), hepatoprotective (Hassoune, 2010), cardioprotective (Akinmoladun et al., 2010), anti-inflammatory (Nguru et al., 2011), and leishmanicidal (Accioy et al., 2012) properties.</td>
<td>The median lethal dose was 39.81 mg/kg carragenan-induced rat for the aqueous root extract and therefore toxic (Abaje and Fayeoby, 2012).</td>
</tr>
<tr>
<td><em>T. voire</em></td>
<td>In Cote d’ivoire the bark is chewed for cold (Neuwinger, 1996a, 1996b).</td>
<td>No report</td>
<td>Species of the genu <em>Teclea</em> have been reported to be toxic (Neuwinger, 1996a, 1996b).</td>
</tr>
<tr>
<td><em>T. dielsiana</em></td>
<td>Dyserthy (Waston and Preedy, 2008).</td>
<td>No report</td>
<td>No report</td>
</tr>
<tr>
<td><em>V. cinerea</em></td>
<td>Vernonia cinerea has potential against cancer and inflammatory conditions (Toyang and Verpoorte, 2013).</td>
<td>Anti-inflammatory activity (Abeyesekera et al., 1999), antirangogenes (Prathheeshkumar and Kuttan, 2012), and antimetastatic effect (Prathheeshkumar and Kuttan, 2011).</td>
<td>Methanol 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 4200 mg/kg) and brine shrimp using a methanol extract of <em>Vernonia cinerea</em>.</td>
</tr>
<tr>
<td><em>Z. xanthoxylides</em></td>
<td>The plant is reportd used to variously treat elephantiasis, toothache, sexual impotence, gonorrhoea, malaria, dysmennorrhea abdominal pain (Ogwal-Ong et al., 2003) and buruli ulcer (Addo et al., 2007).</td>
<td>Plant pose antihistatocytis activity (Christensen et al., 2015); antibacterial and anti-inflammatory (Ogwal-Ong et al., 2003).</td>
<td>Metabolic extract of root bark has been found to be safe (Ogwal-Ong et al., 2003).</td>
</tr>
</tbody>
</table>

Non-organic specific toxicity was found with *Capparis erythocarpus* (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 appropriate 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*...
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Encouraged so that people do not overexploit plants from the protected areas of the grove. This study provides baseline data to warrant further studies.

Plants can be potential sources of new scientific findings, but without published studies and with insufficient information, further studies can investigate specialized uses of medicinal plants in the study area. For instance, 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 area 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.

Acknowledgments

We are grateful to the chiefs and people living around Apra Hills Sacred Grove for providing information and permission to publish the findings of this study. We are also thankful to the Forest Services Division (Winneba District) of the Forestry Commission for their support and provision of study reports and maps of the study area. We thank Messrs' Wilson Owusu Asare, Boafo Ofei and Kwame Afeez of Winneba Forestry District Office for their guidance and support. Our sincere thanks go to Department of Plant and Environmental Biology at the University of Ghana for the approval to conduct the study.

Appendix A. Supplementary data

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

References


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