Ethnobotanical study of medicinal plants used as antimalarial and repellent by Sidama people of Hawassa Zuria district, Southern Ethiopia

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ABSTRACT

Background/Aim: More than 7,000 species of flowering plants are recorded in Ethiopia, of which only 200 species are recorded for malaria treatment. A large segment of the population in Ethiopia relies on traditional medicine to get a relief from various diseases. Malaria is the major cause of death in Southern Ethiopia. The main aim of the study was to assess the indigenous knowledge and to document antimalarial and repellent plants used by Sidama people of Hawassa Zuria district, Sidama zone, Southern Ethiopia.

Methods: A total of 150 informants (32 females and 118 males) were selected randomly to collect information on medicinal plants use from 10 kebeles. Out of these, 30 key informants were purposively selected based on the recommendation of the district office and elderly people. Ethnobotanical survey was conducted from January to February 2018. Ethnobotanical data were collected and analyzed through a semi-structured interview, field observation, Use value, preference ranking, and informant consensus factor.

Results: A total of 25 medicinal plants belonging to 24 genera and 19 families were recorded in the study area. Among the total traditional medicinal plants, 21 species were used as antimalarial and eight species were used as repellent. Out of the collected plant species, nine species (38%) were trees followed by shrubs (eight species, 33%). The highest informant consensus factor was scored for repellent (0.95). The most cited species were *Azadirachta indica* A. Juss. (UV = 0.50) followed by *Premna schimperi* Engl. (UV = 0.32) and *Dodonaea viscosa* subsp. *angustifoia* (UV = 0.19). The most preferred species by the informants were *Azadirachta indica* both as antimalarial and repellent plant.

Conclusion: The result of the current study showed the existence of indigenous knowledge of medicinal plants to treat malaria, as well as to repel mosquitoes and ticks in Hawassa Zuria district. Further research should be considered to discover effective antimalarial drugs and simple repellent products from the documented antimalarial plants through phytochemical and pharmacological studies.

Introduction

Malaria is the major health problem in Africa, as well as in the world. Malaria transmission exists in 99 countries throughout the world and the greater burden of the disease is carried by African countries with the estimation of 212 million cases distributed in 45 countries [1]. Malaria is one of the fourth leading causes of death of children under the age of 5 years in developing countries [2]. Pregnant women and young children are most at risk of malaria. Malaria affects five times as many people as acquired immunodeficiency syndrome, leprosy, measles, and tuberculosis combined [3,4].

In Ethiopia, 75% of the landscape areas are below 2,000 m above sea level which is a malarious area and more than 54 million populations are at risk of malaria. It is becoming worse due to the development of Plasmodium parasite resistance against anti-malarial drugs, mosquito resistance to insecticides, increasing problems of toxicity to non-target
organisms, lack of effective control measures, and no single effective method of malaria control. In Southern Ethiopia, approximately 65% of the population is living in malaria-endemic areas [5]. It is the primary causes of outpatient and inpatient consultation and hospital deaths in the SNNP region [6]. Small-scale studies documented 5.4% malaria parasite prevalence in Southern Nations, Nationalities, and Peoples Region in all age groups [7].

Effective and affordable vaccine drugs to control malaria are not available until these days. World Health Organization (WHO) recommends the following preventive and control strategies for malaria. These are Indoor residual spraying (IRS) with insecticides, insecticide-treated nets (ITNs), larval control, preventative chemotherapy, diagnosis and treatment [8]. The most widely used methods of management of malaria in Ethiopia are environmental management, use of insecticidal nets, and indoor spraying of insecticides [6]. Despite the current efforts to control malaria in Ethiopia, the situation has not improved mainly due to parasite resistance to the antimalarial drug, vector resistance to insecticides, low coverage of malaria preventative services, and poor access to health care [9].

The use of plant-derived compounds for mosquito control has been reported since 1933 [10]. Plants may be an alternative source of mosquito repellent agents because they constitute a rich source of bioactive chemicals [10]. Insect repellent plants are used to kill insects using different methods of application of medicinal plants. Plant repellents have an important place in protecting man from the bites of insect pests. Repellent plants can be used by smoking the plants and hanging on windows and doors, planting as a fence, spraying the leaves of the plant, and so on. The use of traditional repellents is widespread in different cultures and communities of Ethiopia. Different communities use different plants in various forms to protect themselves against mosquito and other insect bites [11].

Many of the major modern drugs such as quinine, salicylic acid, and artemisinin have been discovered from folk knowledge. For instance, Chinaberry (Melia azedarach L.) was recently investigated as a locally available, low cost, and sustainable insecticide that can aid in controlling malaria in Ethiopia [12]. Approximately 1,277 plant species and 160 families are used to treat malaria in the world, whereas a total of 200 different plant species from 71 families used for traditional malaria treatment were documented in different parts of Ethiopia [13]. Higher diversity of plants used to treat malaria was documented in the SNNP region, 94 plant species were reported in Southern Nation’s National Peoples region [13]. A few ethnobotanical studies on antimalarial and repellent plants were conducted in Ethiopia [14–19].

However, the indigenous knowledge has not been systematically documented, especially there is no ethnobotanical study of antimalarial plants in Hawassa Zuria district. Documentation of traditional knowledge on medicinal plants is vital to maintain folk knowledge, conserve valuable plant resources, and rescue medicinal plants from loss. The reasons for loss of medicinal plants are deforestation, lack of written documents of medicinal plants, the death of elderly people without transferring the traditional skill to the member of the family, migration of people because of social problems, the influence of modern medicine, and exotic culture. Therefore, this study was conducted with the aim of documenting antimalarial and repellent plants and associated indigenous knowledge of Sidama people in Hawassa Zuria district. As a result to provide baseline data for further ethnopharmacological research of medicinal plants to treat malaria disease.

Research questions

1. What are the antimalarial and repellent plants in Hawassa Zuria district?
2. What type of diseases or insects are controlled by these plants?
3. Which part of the plant is used as a remedy?
4. What are the methods of preparation of the antimalarial plants?
5. What are the routes of administration of antimalarial plants?
6. What are the major threats to the loss of antimalarial and repellent plants?

Material and Methods

Description of the study area

The study area is located about 290 km South of Addis Ababa and 20 km South West of the regional capital Hawassa, in Sidama Zone of Southern Nations, Nationalities, and Peoples Region (SNNPR) of Ethiopia at 07°01’54” to 07°50’36”N latitude and 38°15’39” to 38°25’43”E longitude. The area size of the district is 22,643 hectare and dry zone
accounts 75% [20] (Fig. 1). Dore Bafeno is the administrative capital of Hawassa Zuria district.

Meteorological data recorded indicates that the rainy season spreads from March through September. The mean altitude of the district is 1,700 m above sea level. The annual rainfall ranges between 900 to 1,400 mm. Mean annual temperature ranges from 23°C to 27°C [20]. The current study area of Hawassa Zuria district falls within dry Woina Dega (Mid-altitude) category [21].

The Sidama ethnic group (19.38%) is the most predominant one in the SNNPR. The predominantly spoken language is also Sidamegna (18%) from the Cushitic linguistic family. The majority of people are followers of protestant religion (55.5%) [22]. The district has a total population of 124,472 of whom 62,774 are men and 61,698 women [22]. The total population density in the area is 465.5 people per square kilometer [23].

The most staple food of the local people in Southern Ethiopia is Enset [Ensete ventricosum (Welw.) Cheesman], which is locally called wesse, and is a unique food to Ethiopia. Hawassa Zuria district is well known by maize (Zea maiz Vell.) growing district. The other major growing crops are coffee (Coffea arabica L.), chat (Catha edulis (Vahl) Endl.), and sugarcane (Saccharum officinarum L.). In the study area, malaria is the primary public health problem and cause of the majority of people’s death. The health station and clinics in Hawassa Zuria district are few in numbers.

**Ethnobotanical methods**

Ten kebeles were selected as study sites based on the attitude of the sites and vegetation cover. Thus, the study was carried out in 10 kebeles, namely Lebu Korem, Dore Bafeno, Jara Galalcha, Jara Qerara, Galo Argiso, Jara Damowa, Jara Dado, Doyo Otilcho, Tenkaka Ombulo, and Jara Hirnesa. Snowball sampling was used and the appointment was made prior to visit the informants. Semi-structured interview, guided field walk, and group discussion were used to collect Ethnobotanical data. The interviews were carried out in Sidamooafuu with a local translator.

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**Figure 1.** Map of Hawassa Zuria district, Sidama zone, Southern region, Ethiopia.
who had a good knowledge of the local community on the use of medicinal plants.

**Ethnobotanical data collection**

Informants and the administration were formally approached to get permission to do the research. A total of 150 (32 females and 118 males) informants were selected as recommended by the elders and local authorities in the district. Among the informants, 120 were general informants whereas 30 were key informants and 15 people were interviewed from each 10 kebeles, respectively. Ethnobotanical data were collected from January to February 2018. Ethnobotanical data were collected through an interview to gather the socio-economic status of the participants, usage and knowledge of antimalarial and insect repellent plants, name of antimalarial and repellent plants, plant parts used, method of application, growth habit, and routes of administration.

**Plant specimen’s collection and identification**

Voucher specimens of the plants cited for their medicinal use were collected, numbered, pressed, and dried for identification. Plant identification was performed using the flora of Ethiopia and Eritrea book by comparison with authenticated specimens at Addis Ababa University, National Herbarium [24]. The identified plant species were further confirmed using the plant list website and finally deposited to the National Herbarium of Addis Ababa University.

**Ethnobotanical data analysis**

Descriptive statistical methods such as percentage and frequency were used to analyze and summarize the data on medicinal plants, use, and associated knowledge using Excel. Use value (UV) was calculated using the following standard formula: Use value: $UV = \sum U/n$, where $U$: number of use reports cited by each informant for a given plant species and $n$: total number of informants interviewed for a given plant [25]. The informant consensus factor was calculated using the formula: informant consensus factor (ICF) = nur-nt/nur-1, where ICF is informant consensus factor, nur is number of use citation, and nt is number of species used [26].

Medicinal plants were categorized into antimalarial and repellent groups. Repellent category consists of insects and ectoparasites such as housefly, honey bee, weevils, cockroach, corn worm, lice, and ticks, whereas antimalarial category includes malaria.

Preference ranking was conducted to rank the most frequently cited antimalarial plants by key informants following the approach of Martin [27], 10 key informants were invited to rank seven medicinal plant species that are used for the treatment of malaria. Values of 0 to 5 were used in this ranking (0 = not used, 1 = least used, 2 = less used, 3 = good, 4 = very good, and 5 = excellent) and the ranking were based on the informants perception.

**Results**

**Sociodemographic characteristics of respondents**

A total of 150 informants participated in this survey, 118 (78.6%) were males and 32 (21.4%) females. The majority of respondents were more than 50 years (42.4%) and 56 informants were with the age range between 36 and 50 (37.4%) and 30 informants were between 20 and 35 years (20%). The majority of informants were attended elementary school (48%), 76% were farmers, and 83% were followers of protestant religion (Table 1).

**Antimalarial traditional knowledge**

The number of antimalarial plants reported by males (23 species, 92%) was greater than female (13 species, 52%). The antimalarial plant species reported by the older (18 species, 72%) were greater than the younger (13 species, 52%) and adult informants (15 species, 60%). Regarding education status, illiterate people (20 species, 80%) had more traditional knowledge than the literate (8 species, 32%). This indicates that males, elder, and illiterate people are more knowledgeable than the female, younger, and literate ones in treating malaria (Table 2).

**Antimalarial and insect repellent plants**

A total of 25 medicinal plants distributed in 22 genera and 18 families were documented. Among these, 21 species were used as antimalarial and eight plant species were recorded as repellent plants, namely *Croton macrostachyus* Hochst. ex Delile, *Datura stramonium* L., *Nicotiana tabacum* L., *Premna schimperi* Engl., *Schinus molle* L., *Azadirachta indica*, *Dodonaea viscosa* subsp. *angustifoia*, and Gagasa (Table 3). Among the reported plant species, Lamiaceae represented with four species (16%), followed by Solanaceae with three species (12%), and Euphorbiaceae with two species (8%). The rest Sapindaceae, Moringaceae, Asteraceae, Cucurbitaceae, and Amaryllidaceae were represented by one species (1, 4%) (Fig. 2).
Seven plant species were recorded as repellent plants, namely: *Croton macrostachyus* Hochst. ex Delile, *Datura stramonium* L., *Nicotiana tabacum* L., *Premna schimperi* Engl., *Schinus molle* L., *Azadirachta indica*, and *Dodonaea viscosa* subsp. *angustifoia* The majority of repellent plants were used to control ectoparasites such as ticks and lice. About 41% of repellent plants were used as ticks control, whereas the rest controls lice (16%), corn worm, weevils, cockroach, housefly and bee (8% each), and mosquito (3%) (Fig. 3).

**Growth habits, forms of plants, and plant parts used**

The commonly used growth habits reported by the respondents were trees (nine species, 38%), followed by shrubs (eight species, 33%), herbs (five species, 21%), and climbers (two species, 8%) respectively (Fig. 4). Most of the antimalarial and repellent plants were collected from the wild forest, home garden, and roadsides. Most of the remedies (79%) were prepared from freshly harvested plants and 21% were prepared in dry form. The informants reported that plant parts were collected whenever needed and there is no specific time of collection. The majority of the remedies were prepared from leaf (75%), followed by stem and fruit (8% each). The rest were prepared from shoot tip, bulb, and root (3% each), respectively (Fig. 5).

**Remedy preparation and route of administration**

The majority of the remedy was prepared by crushing (21%), followed by rubbing (12%) and directly by eating (10%). The rest were prepared in liquid form, by burning and boiling (7%) each respectively. Some informants prepared the remedy by chewing, spraying, and mixed with other foods (5%). The remaining remedy was prepared from powdering (2%) the plant parts (Fig. 6). Some of
Table 3. Antimalarial and repellent medicinal plants of Hawassa Zuria district, Southern Ethiopia.

<table>
<thead>
<tr>
<th>Family</th>
<th>Scientific name</th>
<th>Local name</th>
<th>V. No.</th>
<th>Ha</th>
<th>PPV</th>
<th>MOP</th>
<th>ROA</th>
<th>UV</th>
<th>Literature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amaryllidaceae</td>
<td>Allium sativum L.</td>
<td>Netch shinkurt (Amh)</td>
<td>BN077</td>
<td>H</td>
<td>Bu</td>
<td>Fresh</td>
<td>Crushing</td>
<td>Oral</td>
<td>0.11</td>
</tr>
<tr>
<td>Anacardiaceae</td>
<td>Schinus molle L.</td>
<td>Qundo berbere (Amh)</td>
<td>ET054</td>
<td>T</td>
<td>L</td>
<td>Fresh</td>
<td>Crushing</td>
<td>Oral</td>
<td>0.01</td>
</tr>
<tr>
<td>Asteraceae</td>
<td>Vernonia amygdalina Delile</td>
<td>Girawa (Amh)</td>
<td>BN076</td>
<td>Sh</td>
<td>Sht</td>
<td>Fresh</td>
<td>Crushing</td>
<td>Oral</td>
<td>0.06</td>
</tr>
<tr>
<td>Asteraceae</td>
<td>Croton macrostachyus Hochst. ex Delile</td>
<td>Masincho (Sd)</td>
<td>ET022</td>
<td>T</td>
<td>L</td>
<td>Fresh</td>
<td>Burning, smelling</td>
<td>Oral</td>
<td>0.02</td>
</tr>
<tr>
<td>Asteraceae</td>
<td>Euphorbia abyssinica J.F. Gmel</td>
<td>Qulqual (Amh)</td>
<td>ET004</td>
<td>T</td>
<td>L</td>
<td>Fresh</td>
<td>Chewing</td>
<td>Oral</td>
<td>0.01</td>
</tr>
<tr>
<td>Asteraceae</td>
<td>Euphorbia abyssinica J.F. Gmel</td>
<td>Qulqual (Amh)</td>
<td>ET004</td>
<td>T</td>
<td>L</td>
<td>Fresh</td>
<td>Chewing</td>
<td>Oral</td>
<td>0.01</td>
</tr>
<tr>
<td>Lamiaceae</td>
<td>Rotheca myricoides (Hochst.) Steane &amp; Mabb.</td>
<td>Madisisa (Sd)</td>
<td>BN025</td>
<td>Sh</td>
<td>Sht</td>
<td>Fresh</td>
<td>Cutting</td>
<td>Oral</td>
<td>0.01</td>
</tr>
<tr>
<td>Lamiaceae</td>
<td>Ajuga integrifolia Buch.-Ham.</td>
<td>Anamuro (Sd)</td>
<td>BN031</td>
<td>H</td>
<td>L</td>
<td>Fresh</td>
<td>Crushing</td>
<td>Oral</td>
<td>0.01</td>
</tr>
<tr>
<td>Lamiaceae</td>
<td>Premna schimperi Engl.</td>
<td>Hochst. ex Delle</td>
<td>BN025</td>
<td>Sh</td>
<td>Sht</td>
<td>Fresh</td>
<td>Crushing</td>
<td>Oral</td>
<td>0.01</td>
</tr>
<tr>
<td>Lamiaceae</td>
<td>Ocimum gratissimum L.</td>
<td>Angabisha (Sd)</td>
<td>ET015</td>
<td>Sh</td>
<td>L</td>
<td>Fresh</td>
<td>Crushing</td>
<td>Oral</td>
<td>0.01</td>
</tr>
<tr>
<td>Lamiaceae</td>
<td>Eucalyptus globulus Labill.</td>
<td>Netch bahir zaf (Amh)</td>
<td>ET023</td>
<td>T</td>
<td>L</td>
<td>Fresh</td>
<td>Crushing</td>
<td>Oral</td>
<td>0.01</td>
</tr>
<tr>
<td>Papaveraceae</td>
<td>Argemone mexicana L.</td>
<td>Kokole (Sd)</td>
<td>ET008</td>
<td>T</td>
<td>L</td>
<td>Fresh</td>
<td>Eating</td>
<td>Oral</td>
<td>0.03</td>
</tr>
<tr>
<td>Podocarpaceae</td>
<td>Afrocarpus falcatus (Thunb.)</td>
<td>Tikau amzud (Amh)</td>
<td>EN008</td>
<td>T</td>
<td>L</td>
<td>Fresh</td>
<td>Mixed with honey</td>
<td>Oral</td>
<td>0.02</td>
</tr>
<tr>
<td>Sapindaceae</td>
<td>Dodonaea viscosa (L.) J.G. West</td>
<td>Ittancha (Sd)</td>
<td>ET011</td>
<td>Sh</td>
<td>L</td>
<td>Fresh</td>
<td>Dry</td>
<td>Oral</td>
<td>0.19</td>
</tr>
</tbody>
</table>
the ingredients mixed during the antimalarial remedy preparation are milk, honey, water, and other medicinal plant species. This ingredient makes the preparation of remedy to be very strong and effective for malaria treatment.

The majority of the antimalarial medicinal plants were administered orally (64%) and followed by dermal (3%). The repellent plants were mainly applied externally in smoke form. Some people just use the repellent plants by hanging around their bedroom, door, and windows.

**Informant consensus factor**

A total of 25 species were identified to treat malaria, repel insects and ectoparasite. The categories with the highest ICF values were repellent (0.95), followed by antimalarial (0.91) (Table 4). A high ICF value (0.95) indicates the informant’s uses relatively few taxa to manage the specific disease. According to the informant consensus data analysis, *Azadirachta indica* with citation by 75 informants (50%) ranked first followed by *Dodonaea viscosa* subsp. *angustifolia* (29 informants, 19%) and *Aloe adigratana* Reynolds. (24 informants, 16%) for antimalarial disease category. For repellent category group, *Azadirachta indica* scored also the first rank with 75 informants (50%) citation, followed by *Premna schimperi* (49 informants, 33%) and *Dodonaea viscosa* subsp. *angustifolia* (29 informants, 19%).

**Preference ranking of antimalarial medicinal plants**

Ten key informants were asked to rank seven selected medicinal plant species used against malaria disease. The result showed that *Azadirachta indica* was the most preferred and followed by *Aloe adigratana*, *Moringa stenopetala* (Baker f.) Cufod., *Peponium vogelii* (Hook.f) Engl., and *Allium sativum* L. in the preference ranking conducted by key informants (Table 5). This is due to the preferred plant species were strong enough to treat malaria disease and also easily availability of the plant from the home garden and roadside.

**Discussion**

Plants play an important role in every aspect of our lives and without them, life is not possible. One of their major roles is as a medicinal plant to treat different ailments and also as an alternative source of insect repellent agents. Repellent plants have an important place in protecting human from the bites of insect pests and livestock from ectoparasites.
such as tick. More than half of the population in Ethiopia relies on medicinal plants. This is due to the high cost and unavailability of modern drugs, as well as faith on the potential of traditional medicines. Malaria is one of the major health problems in the study area and there is no vaccine for malaria until today.

In the present study, a total of 25 medicinal plants were documented. The majority of these medicinal plants were reported for use in the treatment of malaria whereas the rest were used as repellent plants to drive away some insects and ectoparasites. Thus, this indicates the existence of medicinal plants used as antimalarial and repellent plants for the control of malaria disease in Hawassa Zuria district.

Regarding the sociodemography details of the respondents, the majority of the respondents were male, attend elementary school, farmers, and followers of the Protestant religion. Previous ethnobotanical studies [47–50] reports similar findings. Regarding the traditional knowledge of informants, male, older, and illiterate people were more knowledgeable than female, younger, and literate people, respectively. This is due to high secrecy of traditional knowledge by older peoples, the transferring of knowledge to the first son of family member than daughter, modernization and exotic culture influence, unwillingness of the young generation to be a traditional practitioner like their ancestors. In the current study, elder people were
the highest respondents than the young. This indicates the older people have experience in the practice of traditional medicine and responsible for transferring the knowledge to the younger generation. However, this indigenous knowledge is not shared among all other communities equally. Therefore, the motivation of both the elder and young generation to share and accept the indigenous knowledge is the key to fill the gap beside the documentation of the indigenous knowledge for further research.

In the current study, *Nigella sativa* L., *Schinus molle* L., *Euphorbia abyssinica* J.F. Gmel, *Rhamnus prinoides* L’ Herit., *Solanum americanum* Mill., and *Ampelocissus bombycina* (Baker) Planck were recorded as antimalarial and repellent plants. It is important to test the antimalarial activity of these medicinal plants to find out their effectiveness for future use. *Carica papaya* L. were mostly reported as antimalarial plant species in Awash Fentale district [49], Sasiga district [47], and Jimma zone [19]. *Allium sativum* [51–53] and *Argemone mexicana* [54] were mentioned in previous studies as antimalarial plants. The current study identified *Croton macrostachyus*, *Datura stramonium*, *Nicotiana tabacum* L., *Premna schimperi*, and *Dodonaea viscosa* subsp. *angustifolia* species for the control of ticks. Repellent activities of these plants should be extracted and tested for the management of ticks. In previous ethnobotanical studies, *Croton macrostachyus* [19,48] and *Nicotiana tabacum* L. [52] were documented as an antimalarial and repellent plant.

Most of the antimalarial and repellent plants in the study area were collected from the wild forest, home garden, and roadsides. Thus, the majority of the antimalarial plants were harvested from the home garden and roadsides. This result is similar

![Figure 5. Plant parts used in the study area.](image)

![Figure 6. Methods of preparation of antimalarial and repellent plants.](image)

### Table 4. ICF values by categories for treating malaria and other ectoparasites.

<table>
<thead>
<tr>
<th>Category</th>
<th>List of plant species used and number of citations in the bracket</th>
<th>Total number of Species</th>
<th>Use citations</th>
<th>ICF</th>
</tr>
</thead>
</table>
with other studies conducted in Ethiopia, as well as other countries of the world. Around 49.0% of the antimalarial plants were harvested from the forest, whereas 39.0% were from roadsides in Boricha district [14].

In Hawassa Zuria district, the major families that contributed more medicinal species were Lamiaceae (four species), followed by Solanaceae (three species) and Euphorbiaceae (two species). This could be an indication for considerable diversity of plant species. Ethnobotanical research reports have also shown that these families had high domination in Ethiopia [8,14], as well as in other countries [55–58].

Trees (38%) were the most widely used growth forms from which Sidama people of Hawassa Zuria district prepare herbal remedies. This is in agreement with the studies reported 59% of the identified populations in Nigeria were trees [59]. 50% of the medicinal plants were trees in Cameroon [60]. However, other findings [8] indicated herbs were the most frequently used plant categories.

The plant parts used to treat malaria disease varied from species to species. Leaf was reported as the dominant plant part for antimalarial remedy preparation in the study area. Similar findings indicated leaf as a major dominant plant part in Ethiopia [14,49,57,61] for herbal medicine preparation. The most frequently used plant part was also leaf in Kenya [57] and Ghana [62]. The preference of leaves was due to its easy availability and simplicity in remedy preparation. In addition, the less effect to the whole plants makes leaf as the most preferred one than other plant parts. These uses of plant parts are also important for the conservation of medicinal plants as it cannot cause the death of the whole plant. Stems and fruits were the other used plant parts next to leaves. However, root was mentioned as the most frequently used plant part in Southern Ethiopia [63].

Antimalarial and repellent medicinal plants in the study area were prepared in different ways. The majority of the remedies in the study area were prepared by crushing followed by rubbing the plant parts. Ethnobotanical research survey conducted elsewhere in Kenya showed the majority of the respondents prepared the remedy by decoction [64]. Other methods of remedy preparation used were burning, smelling, rubbing, and boiling. Burning to generate smoke was reported as the major methods of remedy preparation to drive away insects [61]. Boiling was also reported as the most used methods of remedy preparation in Ghana [62]. Smoke by burning was reported as a major application of repellent plants in Tigray [17]. Decoction cited as the major mode of preparation in Togo [65]. Burning and smoldering were reported as the commonly used methods of remedy preparation [48] Decoction mentioned as the major methods of preparation in Guji zone [66].

The malaria disease was mainly treated by taking the prepared remedies orally, whereas repellent plants were applied externally. This result was similar to the findings of previous studies that revealed oral as the major route of administration in Guji zone [66] and Bennin [54]. Higher number of respondents uses repellent plants to control ectoparasites such as ticks and lice. Research findings in Kenya [67] showed repellent plant species had the highest repellency for ticks.

The current study revealed that *Azadirachta indica* as the most preferable medicinal plants for the treatment of malaria, followed by *Premna schimperi* and *Dodonaea viscosa subsp. angustifolia*. Similar findings reported that *Azadirachta indica* as the dominant antimalarial plants in Somali region [53] and Nigeria [52]. Other findings also reported protection against mosquito bites by these species [28,68]. Among the various species of the genus *Premna, Premna angolensis* (Lamiaceae) has been

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**Table 5. Preference ranking of medicinal plants used against malaria disease.**

<table>
<thead>
<tr>
<th>Antimalarial plants</th>
<th>Informants (I1–I10)</th>
<th>Total score</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Azadirachta indica</em> A. Juss</td>
<td>5 5 4 4 5 3 5 5 4 5</td>
<td>45</td>
<td>1st</td>
</tr>
<tr>
<td><em>Aloe adigiratana</em> Reynolds</td>
<td>4 4 3 3 5 3 4 4 4 4</td>
<td>39</td>
<td>2nd</td>
</tr>
<tr>
<td><em>Moringa stenopetala</em> (Baker f.) Cufod.</td>
<td>4 4 3 3 3 4 3 4 3 2</td>
<td>33</td>
<td>4th</td>
</tr>
<tr>
<td><em>Peponium vogelli</em> (Hook.f) Engl.</td>
<td>3 4 4.5 4 3 4 3 3 2</td>
<td>33</td>
<td>4th</td>
</tr>
<tr>
<td><em>Allium sativum</em> L.</td>
<td>2 2 3 3 3 3 2 3 2 2</td>
<td>24</td>
<td>5th</td>
</tr>
<tr>
<td><em>Vernonia amygdalina</em> Delile</td>
<td>2 2 1.5 1 1 2 3 2 1 1</td>
<td>16</td>
<td>6th</td>
</tr>
<tr>
<td><em>Eucalyptus globules</em> Labill.</td>
<td>2 1 1.5 2 1 2 2 1 1 1</td>
<td>14</td>
<td>7th</td>
</tr>
</tbody>
</table>

**Note:** I1–I10 represent informants 1–10.
reported to have repellency potential [69]. Thus, *Premna schimperi* should be investigated for its antimalarial and repellency activity. Antimalarial plants have promising therapeutic potential in different African countries. Previous findings reported that promising candidates have been identified from the antimalarial plant [70–73]. Therefore, further research should be considered for the current documented antimalarial plants to identify the therapeutic potential of promising antimalarial plants. Among the documented antimalarial and repellent medicinal plants in Hawassa Zuria district, 22 species were mentioned in previous ethnobotanical studies conducted in Southern Ethiopia [29–32,34,37–43,45], North West Ethiopia in Shinasha [33], Cheyla Woreda [46] and [44]. Whereas three species were mentioned for the first time as antimalarial and repellent plant in Hawassa Zuria district. The two plants were *Ampelocissus bombycina* and *Aloe adigratana*, for treating malaria disease. The third species were not identified scientifically yet but it is known by the local name called “Gagasá” and used for cockroach and lice control by Sidama people in Hawassa Zuria district. Therefore, further efficacy test should be considered for those new candidate species that were documented for the first time in the current study area.

**Conclusion**

The present study findings indicate that the Sidama people of Hawassa Zuria district have rich traditional knowledge of medicinal plants to treat malaria and repel insects pests. However, the knowledge is mainly elderly people-centered. The young generation have/had little knowledge regarding traditional knowledge. Thus, this might lead to the loss of indigenous knowledge and medicinal plants from the area. Usage of medicinal plants other than their medicinal value leads to the overexploitation of medicinal plants. In Hawassa Zuria district, the major threats for the loss of antimalarial and repellent plants and associated knowledge were deforestation, agriculture expansion, urbanization, and firewood collection. The other reason for the loss of indigenous knowledge is the secrecy of elder people and their willingness to transfer their knowledge only to the first son of the family member and this might lead to the death of elder people without transferring the knowledge. Therefore, awareness of the community concerning traditional knowledge and creating medicinal plants conservation strategy is vital in order to rescue medicinal plant threats. Beside the antimalarial plants, repellent plants are also promising for tick controls in this study. Therefore, repellency effectiveness of plants against tick should be further tested for ticks management. Further research is needed to identify the therapeutic potential of antimalarial and repellent plants.

**Acknowledgments**

The authors are thankful to the local informants for sharing their indigenous knowledge on antimalarial and repellent medicinal plants with us. We are also grateful for all people who sincerely support this ethnobotanical study until the end. Without their contribution, this study would have not been possible.

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