Journal of Medicinal Plants Studies
www.PlantsJournal.com

ISSN (E): 2320-3862
ISSN (P): 2394-0530
NAAS Rating: 3.53
JMPS 2019; 7(4): 28-33

Received: 16-05-2019
Accepted: 18-06-2019

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Review on medicinal plants used for the management of malaria in Amhara regional state, Ethiopia

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Abstract
Malaria has been known as deadly communicable disease for decades in Ethiopia. The Amhara Regional State accounts for 31% of malaria epidemics in the country. Traditional medicines have been used to treat malaria for thousands of years. About 90% of the Ethiopian populations are dependent on traditional medicines for the management of the diseases. Traditional medicinal plants used to treat malaria in Amhara Reginal State were collected from available literature. Data collected from the literature includes scientific and local names, habit of the plant, plant parts used, mode of preparation and rout of administration. A total of 34 articles that provide information about the use of medicinal plant species to treat malaria in the region were reviewed and about 48 medicinal plant species are reported. The important parts of plants used for the management of the disease are leaves (60.42%), roots (29.17%), shoots (10.42%) and seeds (8.33%). However, latex, bulb, stem bark and stem were also used. The plant preparations consisted mostly of solutions, mixture of powders, infusions, powdering, and chopping decoction and burning. To administer remedies in the treatment of malaria, oral drinking (95.83%) was the common route followed by dermal (4.17%).

Keywords: Malaria, medicinal plants, traditional medicine, plasmodium, review

Introduction
Malaria is one of the world's most serious infectious diseases; causing five hundred million cases of clinical illness in each year. Approximately 90% of these cases occur in sub-Saharan Africa [1]. Malaria is a common and life-threatening disease in many tropical and subtropical areas. It is caused by the protozoan parasites named as Plasmodium: *P. falciparum*, *P. malaria*, *P. ovale* and *P. vivax*. Over 80% of malaria cases and malaria deaths occur in tropical sub-Saharan Africa where *P. falciparum* predominates [2]. In 2016, there were an estimated 212 million cases of malaria globally and led to 445, 000 deaths, most of which were in African children under the age of five [3].

Malaria has been Ethiopia's predominant communicable disease for decades. Approximately 52 million people (68%) live in malaria-endemic areas in Ethiopia, chiefly at altitudes below 2,000 m. Malaria is mainly seasonal in the highland fringe areas and of relatively longer transmission duration in lowland areas, river basins and valleys [4, 5]. Ethiopia is located in the North Eastern part of Africa; lies between 3- and 15-degrees north latitude and 33- and 48-degrees east longitude. The country has total area of 1.1 million square kilometers. Ethiopia's topographic features range from peaks as high as 4,550m above sea level at Ras Dashen to 110m below sea level in the Afar Depression. There are three broad ecological zones that follow the above topography. The "Kolla" or hot lowlands are found below an altitude of 1,000 meters (m), the "Weyna Dega" between 1000 and 1500m, and "Dega" or cool temperate highlands between 1500 and 3000m above sea level. Mean annual temperatures range from 10 to 16 ^{0}C in the "Dega", 16 to 29 ^{0}C in the "Weyna Dega" and 23 to 33 ^{0}C in the "Kolla". In general, the highlands receive more rain than the lowlands, with annual rainfalls of 500mm to over 2000mm for the former and 300mm to 700mm to the later [6].

The Amhara Region accounts for 31% of Ethiopia's malaria cases. The Amhara Region is one of the nine geographic divisions in Ethiopia and is located in the north-west of the country. The region covers approximately 150,000 km2 and it is Ethiopia's second most populated state comprising a number of districts. The altitudes in Amhara region ranges from 506 m at the Blue Nile Gorge, to 4533 m at Ras Dashen, which makes the prediction of the timing and

geographic range of malaria outbreaks challenging. In 2012, the Amhara Region counted 1,127,241 malaria cases [4].

Traditional herbal medicines have been used to treat malaria for thousands of years and are the source of the two main structural groups (artemisinin and quinine derivatives) of modern antimalarial drugs. Because of the problems of increasing drug resistance and difficulties in poor areas to afford and access effective antimalarial drugs, traditional medicines are an important and sustainable source of treatment [7]. Medicinal plants are regarded as rich resources of traditional medicines. For thousands of years medicinal plants have been used to treat health disorders and to prevent diseases epidemics [8]. A number of studies on ethnomedicinal plants and herbal medicines have been conducted in the past and plants have been reported for being used for medicinal purpose by tribal in several countries [9]. Medicinal plants are presently in demand and their acceptance is increasing progressively [10].

Traditional medicines, including herbal medicines, have been, and continue to be, used in every country around the world in some capacity. In many developing countries, 70–95% of the population relies on these traditional medicines for primary care. About 90% of the Ethiopian populations are dependent on traditional medicines for the management of diseases [11].

Traditional malaria preventing techniques are effective for temporarily reducing the severity of the disease. Therefore, this review attempts to present medicinal plants used in the treatment of malaria in Amhara Regional State.

Materials and Methods

Traditional medicinal plants used to treat Malaria in Amhara Reginal State, Ethiopia, were collected from available literature published in scientific journals, MSc thesis reports, proceedings, and reports. Literature was searched in different electronic databases (Web of Science, PMC, PubMed, AJOL, Cite Seer^{x}, Science Direct, and Google Scholar). No limit was placed on the search time frame in order to retrieve all relevant papers. Data collected from the literature includes scientific and local names, habit of the plant, plant parts used, mode of preparation and rout of administration of the species. We reviewed a total of 34 publications, MSc thesis and reports that provided information about the use of medicinal plant species to treat Malaria in Amhara Regional State.

Herbal plants used for the treatment of malaria in Amhara Regional state

Medicinal plants are regarded as rich resources of traditional medicines. The microbial growth in diverse situations is controlled by plant derived products. Most of medicinal plants are obtained from local sources in the wild by knowledgeable traditional practitioners. Traditional healers play a great role in the primary health care systems in Amhara Reginal State. However, the practice is not really completely recognized by the modern medicine, traditional healers are using various plants for the treatment of malaria. Large number of plant species has been identified as anti-malarial medicinal plants. A wide variety of plants belonging to several families have been identified through ethnobotanical and ethno pharmacological studies as anti-malarial medicinal plants in Amhara Regional State (Table 1).

Table 1: Traditionally used plant species for treatment of malaria in Amhara Regional State

No	Scientific name	Family	Local name (Amharic)	Pu.	Ha.	Route	Preparation	Ref.
1	*Allium sativium* L.	Alliaceae	Nech shinkurt	Bu. Fr. Bu.	H	O	Eating the bulb with injera or mix with honey and take orally	[12,13]
							Boiling crushed fruit and then drink it with much amount of milk for a day	[14]
							Mixing powdered bulb of *Allium sativum* and seed of *Lepidium sativum* with small amount of water then drink or eat with injera.	[15]
							Chewing fresh bulb after removing external scales	[16]
							Fresh bulb of *Allium sativum* and rhizome of *Zinger officinale* are pounded together, mixed with honey and eaten.	[17]
2	*Buddleja polystachya* F.	Buddlejacea	Anfare	L		O	Squeeze the juice and drink it before food	[16]
3	*Brassica nigra* L.	Brassicaceae	Senafich	Se	H	O	Powdered seed of *Brassica nigra*, chopped *Allium sativum* and *Cicer arietinum* seed are soaked with water and eaten after one day with injera in the morning.	[17]
							Fermenting the roasted and ground seed in water for 1 h and serving as food with 'bokelt' made from chickpea or pea or faba bean	[18]
4	*Artemisia abyssinica*	Asteraceae	Harit	L	H	O	Fresh leaf is crushed and pounded with water, filter and drunk until recovery.	[17]
5	*Asparagus africanus* L.	Asparagaceae	Yesetkest	L	Cl	O	Leaf is smashed, mixed with water and decanted, then mixed with milk and one coffee cup is taken every morning.	[17]
6	*Carissa spinarum* L.	Apocynaceae	Agam	L	Sh.	O	Fresh root is pounded, mixed with cold water, decanted and drunk after one day.	[17]
7	*Eucalyptus globulus* Labill.	Myrtaceae	Nech bahirzaf	L	T	O	Dried leaf is put on fire and smoked	[17]
8	*Juniperus procera* Endl.	Cupressaceae	Ye abesha tsid	Ba.	T	O	Dried bark is boiled with water and the decoction is drunk	[17]
9	*Ocimum basilicum* L.	Lamiaceae	Zikakibe	L	H	O	Leaf of *Ocimum basilicum* and bulb of *Allium sativum* are pounded together and eaten with honey (morning).	[17]
10	*Zingiber officinale* Roscoe	Zingiberaceae	Jinjible	Rh	H	O	Rhizome of *Zingiber officinale* and bulb of *Allium sativum* are pounded together and eaten with honey	[17]

11	*Lepidium sativum* L.	Brassicaceae	Feto	Se	H	O	The seed of *Lepidium sativum* with bulb of *Allium sativum* are pounded together and mixed with water and drunk or eaten with Injera.	[15]
							Ground mixture of seed of *Lepidium sativum*, bulb of *Allium sativum* and rhizome of *Zingiber officinale* are eaten with honey	[17]
12	*Carica papaya* L.	Caricaceae	Papaya	L	T	O	Freshly crushed, boiled, and drunk with honey	[12, 19]
							The leaf of *Carica papaya* is squeezed, then mix with water & sugar to drink	[20]
							Juice of leaves is taken orally	[21]
							Leaf of *Carica papaya* and *Allium sativum* bulb are pounded together and made in the form of soup, boiled and mixed with honey and two cups are drunk	[17]
13	*Melia azedarach* F.	Meliaceae	Neem	L	T	O	Chewing and swallowing the juice of fresh leaf.	[17, 22]
14	*Phytolacca dodecandra* L' Herit.	Phytolaccaceae	Endod	R	Cl	O	Fresh root is smashed, mixed with water, decant and drunk in the morning.	[17, 23]
				Fr			Crush the fruit and mix with water then drunk it	[20]
15	*Vernonia amygdalina* Del.	Asteraceae	Girawa	L	T	O	Crushed leaves of *Vernonia amygdalina* with *Ruta chalepensis* are drink a cup for 3-5 days with cold water in the morning.	[17]
				R/L	T	O	Either the roots or leaves are crushed, mixed with water, filtered and drunk	[23]
16	*Cicer arietinum* L	Fabaceae	Shimbra	Wp	H	O	Powdered, boiled and drunk or germinate then eat the concoction	[12,33]
17	*Artemisia afra* Jacq. ex Wilk	Asteraceae	Chiqugn	L	H	O	Fresh leaf crushed and pounded with water and then filtered and drunk in one tea cup	[19]
18	*Croton macrostachyus* Del.	Euphorbiaceae	Bisana	L	T	O	Boil fresh leaf in water, filter, and drink with milk or tea.	[19]
				Sho.			The shoot is boiled and squeezed between palms as Besso and dried. The dried one is crushed, cooked with wot and eaten.	[23]
				L			Crushing the leaf and drink with either *Guizotia abyssinica* (L.F.) Cass. or milk	[14]
				Sho.			3-7 meristems from side branches taken and boiled by adding salt and butter then drink one cup from the solution.	[18]
				Ba			Dried stem bark powder mixed with honey and given orally	[24]
19	*Dodonaea angustifolia* L.f.	Sapindaceae Juss	kitkita	L/Fr	Sh	O	The leaf and fruits mixed with ¼ of bulb of garlic, fruits and leaf of rue are crushed, powdered, soaked in honey and one glass is taken continuously.	[25,26,22]
							Dried leaf and fruit mixed with *Allium sativum* and honey is given orally	[24]
20	*Euphorbia abyssinica* Gmel,	Euphorbiaceae	kulkual	R	T	O	The root is chopped, dried, crushed and eaten with egg	[23]
							Crushing the root and drink with milk	[14]
21	*Combretum molle*	Combretaceae	avalo	L	T	O	Fresh leaf is boiled in water and the decoction is drunk in a cup of tea	[27]
22	*Gossypium hirsutum*	Malvaceae	Tit	se	H	O	Ground seed is soaked in water with small amount of salt and drunk by a cup of tea	[27]
23	*Hagenia abyssinica*	Rosaceae	Kosso	Ba	T	O	The bark chopped and powdered with the root of *Silene macrosolen*, *Phytolacca dodecandra*, *C. ficifolus* and the leaf of *C. myricoides* and is drunk in a half size cup of coffee	[27]
24	*Rumex abyssinicus*	Polygonaceae	Meqmeqo	L	H	O	The leaf of *Rumex abyssinicus* with leaf of *Zehneria scabra* is pounded, powdered, mixed with milk and boiled and then drunk	[28]
				R			Dried root boiled with butter and taken orally	[13]
25	*Justicia schimperiana*	Acanthaceae	Smiza	L/sho	Sh.	O	Dried leaf and shoot boiled in water with salt and butter then given orally	[26]
				L			The leaf is pounded, squeezed and mixed with milk and drunk for 3 days	[28]
26	*Capsicum annuum*L.	Solanaceae	Karia	Fr/se	H	O	The fruit/seed of *Capsicum annuum* is pounded, powdered and mixed with little water and drunk or eaten by Injera	[18]
				Fr			----------	[29]
27	*Calpurnia aurea*	Fabaceae	Digita	L	Sh	O	The leaf is mixed with bulbs of garlic, leaf and fruits of rue and then crushed, soaked in the water for Overnight, decanted and one cup is taken orally during night.	[22,26]
28	*Gnidiain volucrata*	Thymelaeaceae	Yezngero telba	R&L	H	O	The root and leaf is crushed, soaked in Local 'Tella' overnight for one day and one glass is drunk continuously	[26]
29	*Otostegia integrifolia*	Lamiaceae	Tnjut	L&Sho	Sh	O	The leaf and shoot is crushed with garlic, rue and soaked in honey for one day then one glass is taken continuously at night	[26]
				L			Leaf will be chopped and mixed with water then drunk	[20]
				L			Fresh leaf soaked with *Allium sativum* and given orally	[24]

30	*Ruta chalepensis*	Rutaceae	Tenadam	Br	H	O	The branches are boiled with rhizome of zinger, bulb of garlic and one cup is taken continuously with tea.	[26]
				Sho.			Dried or fresh shoot boiled with ginger and given orally	[24]
31	*Echinops kebericho* M.	Asteraceae	Kebericho	R	H	O	Powdered the root and inhaling the powder	[30]
							Roots are crushed with seeds of *Guizotia abyssinica*, add water and take the solution orally	[31]
32	*Acanthus polystachyus* Delile	Acanthaceae	Dendero	R	H	O	Grinding and taking orally	[22, 32]
33	*Zehneria scabra* (L. f.) Sond.	Cucurbitaceae	Areg-resa	R/L	Cl	O	----	[22]
34	*kebergia capensis* Sparrm.	Meliaceae	Lol	Ba	T	O	Infusion of fresh pulverized bark	[14]
35	*Urtica simensis*	Urticaceae	Sama	R	H	O	The root will be crushed, dried and mixed with water;then drink one glass of it and drink much amount of milk	[14]
36	*Justicia schimperiana*	Acanthaceae	Sensel	L	Sh	O	Squeeze then drink with coffee	[33]
						D	The leaf is chopped and mixed with water, then wash the body	[20]
37	*Aloe weloensis* Sebsebe	Aloaceae	Eret tafa	La	H	O	Isolate the latex and take orally	[33]
38	*Aloe sinana*	Aloaceae	Eret	La	H	O	Latexes are collected, mixed with honey or sugar and half glass is taken in the morning until recovery	[20]
39	*Croton macrostachyus* Del.		Mekanisa	Fr	T	O	The froot is crushed and mash then drink with Tella	[33]
40	*Lobelia gibberoa* Hemsl.	Lobeliaceae	Jibara	R	T	O	The root is crushed and powdered then drink with water	[33]
41	*Polygala sphenoptera* F.	Polygalaceae	Kibie zelzil	R	H	O	The root will be peel, chew, and absorb the juice	[33]
42	*Lycopersicon esculentum* Mill	Solanaceae	Timatim	L	H	O	Squeeze then drink	[33]
43	*Acokanthera schimperi* Schweinf.	Apocynaceae	Miriez	L	Sh	O	The leaf of *Acokanthera schimperi* crushed, powdered, mixed with honey and then eaten orally	[20]
44	*Euclea racemosa* Murr	Ebenaceae	Dedeho	Sm	Sh	D	Stems are burned on fire and Fumigate it	[31]
45	*Silene macrosolen* Steud. ex A. Rich.	Caryophyllaceae	Wogert	R	H	O	Roots are crushed with seeds of *Guizotia abyssinica*; mixed with water and taken orally	[31]
46	*Clerodendrum myricoides* (Hochst.) Vatke,	Lamiaceae	Misrich	L	Sh	O	Dried leaf and fruit mixed with honey and given orally	[24]
47	*Gnidia involucrate Steud. ex A. Rich.*	Thymelaeaceae	Yezenjerotelba	R/L	H	O	Dried root and leaf soaked with local beer and given orally	[24]
48	*Dorstenia barnimiana* Schweinf	Moraceae	Werk bemieda	R	H	O	Root powder is mixed with water and filter; then drink for 3 days	[34]

Key: - H= herb, Cl=climber, Sh=shrub, and T: tree;
Parts: Ba=bark, L= leaves, La= Latex, Se=seed, Fr=fruit, sho=shoot, sm=stem, Wp=wholeplant, Rh=Rhizome, Bu=Bulb,Br=branch and R=root;
Route of application: O=Oral and D=dermal
Ref. =References

Discussion

Traditional medicine plays a significant role in the healthcare of the majority of the people in Amhara Reginal state. This review brings out information on different medicinal plants used in various parts of the region for the treatment of malaria. Forty-eight medicinal plants have been recorded here for their activity as anti-malarial agent. In the traditional treatment of malaria, various plants part either in combination or alone are employed as shown in Table 1. The review revealed that the parts used for treatment were leaves 60.42%, roots 29.17%, shoots 10.42% and seeds 8.33%. However, latex, bulb, stem bark and stem were also used. The most widely used plant part for the preparations of remedy were leaves followed by roots. In the traditional treatment of malaria, Herbs and trees constitute majority of the plants listed in the above table (47.92% and27.08%) respectively followed by shrubs (18.75%).

Regarding the preparation of medicinal plants for treatment of malaria, the traditional medical practitioners use simple methods and equipment's during their remedy preparation. The plant remedy preparations consisted mostly of solutions, mixture of powders, infusions, powdering, chopping decoction and burning. The prepared traditional medicines were applied in a number of methods; of the routes commonly used to administer remedies in the treatment of malaria, oral drinking (95.83%) was the common route followed by dermal (4.17%) way of administration.

Medicinal properties derived from plants may come from many different parts of a plant including leaves, roots, barks, seeds, fruits, stems, stem barks, bulbs, and latex. The different parts of these plants may contain different active ingredients (secondary metabolites) that used to treat malaria.

Conclusion

Traditional Healers still play a great role in the primary health care systems in Amhara Regional State. The review showed a rich diversity of medicinal plants commonly used for treatment of malaria diseases in Amhara regional state,

Ethiopia. In this review paper, 48 medicinal plant species are reported that are used in the traditional malaria treatment by the people of Amhara regional state. Herbs and trees constitute majority of the plants while the commonly used plant part was leaves followed by root. To treat malaria traditionally, most practitioners prefer oral route of administration.

This literature review provides useful information about the management of malaria in traditional medicine. However, there is a need for further study to the chemical composition, phytochemicals, physicochemical properties, toxicity, safety, efficacy and its clinical potential in the management of malaria in the future.

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