Traditional phytotherapy of some remedies used in treatment of malaria in Meru district of Kenya

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Abstract

In Kenya, most people especially in rural areas use traditional medicine and medicinal plants to treat many diseases including malaria. Malaria is of national concern in Kenya in view of development of resistant strains of *Plasmodium falciparum* to drugs especially chloroquine, which had been effective and affordable. This has led the Government to provide free antimalarial treatment because the cost of newer antimalarial drugs is unaffordable to local communities. However, traditional remedies against malaria are practised among the rural communities because of ease of availability and convenience and also due to social, psychological and cultural reasons. This paper examines the use of antimalarial plants among the Meru community of Imenti forest area and Gatunga, in Eastern Province, Kenya. Forty seven plant species belonging to 28 families were encountered during the study. Rutaceae, Compositae and Celestraceae families represented the species most commonly cited in treatment of malaria. Six plant species namely: *Periploca linearifolia*, *Maytenus heterophylla*, *M. putterlickioides*, *Albizia amara*, *Teclea simplicifolia* and *Olea capensis* are documented for the first time for treatment of malaria.

Keywords: Antimalarial plants; Meru district

Article Outline

1. Introduction

Plants have been used as sources of medicines since ancient times. The use of plant-derived drugs for the treatment of malaria has a long and successful tradition. Of particular interest are the plants used in popular medicine, for some of which it has been possible to confirm their traditional uses, and new biologically active molecules have been isolated such as quinine isolated from *Cinchona* bark and Artemisinin from *Artemisia annua* L., which illustrates the potential value of investigating traditionally used antimalarial plants for development of pharmaceutical antimalarial drugs (Srisilam and Veersham, 2003). The success of these drugs against resistant strains of *Plasmodium falciparum* has rekindled the search for novel antimalarial molecules from plants. In Kenya, several plant species including *Azadirachta indica* A. Juss (Meliaceae), *Ajuga remota* Benth. (Labiatae) and *Caesalpinia volkensii* Harms (Caesalpinaceae) are used in the treatment of malaria (Kuria et al., 2001). The use of traditional and herbal remedies seems to be the alternative choice of treatment in countries where malaria is endemic ([Sofowora, 1982], [Rasoanaivo et al., 1992] and [Gessler et al., 1995]). The World Health Organisation (WHO) considers phytotherapy in its health programs and suggests basic procedures for the validation of drugs from plant origin in developing countries (Vulto and Smet, 1998). Considering the importance of the traditional medicine, plant drugs must be scientifically evaluated for their alleged uses, safety and as suitable approach for development of new drugs (Calixto, 1996). The resurgent interest in drugs of plant origin is due to resistance of some infective agents to convectional drugs, and that approximately 80% of the rural population in sub Sahara Africa relies on traditional medicines for their primary health care needs (WHO, 2002). Approximately 25% of the drugs prescribed worldwide come from plants and of the drugs considered as basic and essential by WHO, 11% are exclusively of plant origin or synthetic drugs obtained from natural precursors (Shu, 1998). The study of African medicinal plants has not been realized as fully as other traditional communities elsewhere such as India (Iwu, 1993). Consequently there is limited development of therapeutic products from African countries.

With the increase of anthropogenic activities in many African countries, deforestation is on the increase with consequent loss of important medicinal plants. In Kenya 2.9 million people live within 5 km of forest area exerting high pressure on the main forests such that out of the original closed canopy indigenous forest cover of 6.8 million hectares, only 1.2 million hectares is left (Wass, 1995). In view of the rapid loss of natural habitats, traditional community life, cultural diversity and knowledge of medicinal plants, documentation of

African medicinal plants is an urgent matter (Van Wyk et al., 2002). The aim of the study was to therefore document a comprehensive list of antimalarial plants used in traditional and cultural set up of the Meru community as a first step in proposing appropriate scientific measures to identify through bioassay guided isolation of active constituents for use as markers in standardization of phytomedicines and possible antimalarial drug development. Two different agroecological zones representing communities living in fertile agricultural highlands and those in marginal lowland areas were studied reflecting different lifestyles of the Meru community as a whole.

2. Study site and methods

The study was made at Imenti Forest Game Reserve in Meru district, Kenya, which is located at 0 °07′ N latitude and 37 °43′ E longitude, about 6 km from Meru town and at Gatunga, Tharaka, locality 0 °07′ S latitude and 37 °57′ E longitude about 40 km south east of Meru town (Fig. 1). Meru district is in Eastern Province of Kenya with headquarters at Meru town (0 °07′ N, 37 °39′ E; 1600 m above sea level), next to Imenti forest. The district is home of the Ameru, a Bantu ethnic tribe and located on the fertile north eastern slopes of Mt. Kenya but traverses high altitude to low altitude. It has a population of 1,409,373 (1999 census) people who are predominantly Christian in an area of 9922 km^2. The district straddles the equator and Mt. Kenya (3000–5200 m above sea level) has influenced the natural conditions in the district leading to a wide variety of microclimates and agroecological zones. The southern slopes of Mt. Kenya receive ample rainfall, between 1250–2500 mm while the leeward and the lowlands to the north receive 380–1000 mm rainfall in two seasons. Vegetation varies from typical tropical savanna to mountain forest and grassland interspersed with shrubs and small trees. The Imenti forest is facing great pressure due to over-utilization of indigenous trees and medicinal plants may disappear before their uses are documented. However, there is increased awareness on the need to conserve natural resources and the Government of Kenya has initiated remedial measures.

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Fig. 1. Map of Kenya showing Meru district with study areas Imenti forest and Gatunga.

Tharaka, part of the greater Meru district comprises of low hilly and marginal lowlands. The soils are sandy and stony. The Tharaka community lives, a much harsher life than most Meru.
The area has a bimodal rainfall pattern which is fairly erratic averaging 500–800 mm with frequent crop failure. Malaria is endemic in most parts of Tharaka. Most areas are remote and health facilities far apart, consequently the local population is more disposed to traditional ways of treatment because of ease of availability and cheaper cost (Koinange, 1982). In other areas traditional medicine is preferred to modern medicine owing to social, psychological and cultural reasons (Katz and Kimani, 1982). The two study sites are fairly representative of the agroecological zones of the district.

2.1. Collection of ethnomedical information

Fieldwork to collect plant samples was carried out between October and December 2004. Permission for a sustainable plant harvesting was sought from Kenya Wildlife Services in the forest reserve, and the local community outside the forest areas. To obtain information on medicinal plants traditionally used for the management of malaria, traditional health practitioners (THP) and local people were interviewed with standardized questionnaires. Group interviews were also carried out among members of THP associations. Prior to surveys in each area, a research assistant was identified who had grown up in the area and knew the people and the local language well. Several contacts were made with THP to win their trust. A taxonomist who was conversant with the flora of the area was part of the collection team. Twenty five informants (5 women and 20 men; mean age: 55 years) were interviewed at Imenti forest while 13 informants (3 women and 10 men; mean age: 50 years) were interviewed at Gatunga, Tharaka.

2.2. Collection of plant samples

The Ameru word for malaria is the same as the English word for malaria and therefore the concept of the disease malaria was clearly understood by the local people. Traditionally the disease is treated in function of symptomatology and those plants claimed to treat malaria, fevers and joint pains as identified by the local people and THP were collected. The plants were identified by a taxonomist and voucher specimens deposited at the East Africa Herbarium, National Museums of Kenya. The information gathered included plant species, parts used, plant habit, method of preparation, posology and vernacular names.

3. Results

The ecological zones in the two study areas were different, but a number of species were common to both sites. Table 1 shows a documentation of plant species collected from the two areas based on traditional

reputation for their use as antimalarials. In total 47 species in 37 genera and 28 families were identified as being used to treat malaria. The plant family, Rutaceae had the highest number of species mentioned in treatment of malaria followed by Compositae and Celestraceae in that order. Ten families had at least two species mentioned in the treatment of malaria. Eleven species in 11 genera and 8 families were common to both regions and these were: *C. edulis*, *V. brachcalyx*, *C. articulatus*, *S. henningsii*, *R. staddo*, *Z. usambrense*, *F. angolensis*, *T. asiatica*, *S. incanum*, *W. somnifera* and *C. myricoides*. The root bark was the most frequently mentioned part of the plant used in the preparation of the herbal remedies and results from the habit of the species showed that most of the antimalarial herbal remedies were obtained from trees and shrubs.

Table 1.

Plant species collected from Meru district based on traditional reputation for their use as antimalarials

Family/species /(Voucher no.)	**Vernacular name**	**Habit**	**Part used**	**Preparation**	**Biological activities reported**	**Relevant reported uses**
Apocynaceae						
Carissa edulis Forssk. (CM 045M)	Kamuria (I/G)	Shrub	RB	The roots are boiled in meat bone broth.	Antiplasmodial activity ([Clarkson et al., 2004] and [Koch et al., 2005])	Decoction of the root used for malaria (Kokwaro, 1993), also as a pain killer (Beentje, 1994)
Asclepiadaceae						
Periploca linearifolia Dill. & A. Rich. (CM 051)	Muimba iguru (I)	Liana	RB	Hot water decoction	No information	Roots in soup used for chest pains and fevers (Gachathi, 1989)
Bignoniaceae						
Kigelia africana (Lam.) Benth. (CM 049)	Murantina (I)	Tree	L	Hot water decoction	Antiplasmodial activity ([Clarkson et al., 2004], [Oketch-Rabah et al., 1999] and [Weenen et al., 1990])	Infusion of stem bark used for malaria in Tanzania (Gessler et al., 1995), leaf infusion used for malaria in East Africa (Arnold and Gulumian, 1984)
Caesalpinaceae						
Caesalpinia volkensii Harms (CM 131)	Mujuthi (I)	Liana	L	Hot water decoction	Antiplasmodial activity (Kuria et al., 2001)	Decoction of leaf used in Tanzania for malaria (Chhabra et al., 1984)
Celastraceae						

Family/species /(Voucher no.)	Vernacular name	Habit	Part used	Preparation	Biological activities reported	Relevant reported uses
Maytenus arbutifolia (A.Rich.) Wilczek (CM 074)	Muraga (I)	Shrub	RB	Hot water decoction	Antiplasmodial activity (**Gakunju et al., 1995**)	Dried stem bark used for fever and malaria (**Gakunju et al., 1995**)
Celastraceae						
Maytenus undata (Thunb.) Blakelock (CM 053)	Muthithioi (G)	Shrub	RB/L	Decoction in hot water	Antiplasmodial activity (**Clarkson et al., 2004**)	Stem bark decoction used as a tonic (**[Beentje, 1994]** and **[Kokwaro, 1993]**), root bark decoction used for syphilis (**Kokwaro, 1993**)
Celastraceae						
Maytenus putterlickioides (Loes.) Excell & Mendonca (CM 047)	Muthuthi (G)	Shrub	RB	Decoction in soup	DNA polymerase inhibition (**Feng et al., 2004**)	Root bark used in Tanzania as emmenagogue (**Hedberg et al., 1983**), roots in Kenya used as aphrodisiac and leaves for hookworm (**Kokwaro, 1993**)
Celastraceae						
Maytenus heterophylla (Eckl. & Zeyh) Robson (CM 048)	Muraga (I)	Shrub	RB	Roots boiled in water, decoction	Topoisomerase II inhibition (**Wall et al., 1996**)	Root decoction used as anthelmintic and for syphilis (**Kokwaro, 1993**)
Compositae						
Schkuhria pinnata (Lam) O.Ktze (CM 050)	Gakuinini (I)	Herb	W/P	Infusion in hot or cold water	Antimalarial activity (**Munoz et al., 2000**), Antibacterial, *Bacillus subtlis* (**Taniguchi et al., 1978**)	Leaf decoction used for malaria in Zimbabwe (**Watt and Breyer-Brandwijk, 1962**). Also

Family/species /(Voucher no.)	Vernacular name	Habit	Part used	Preparation	Biological activities reported	Relevant reported uses
						used for malaria in Peru (Ramirez et al., 1988)
Compositae						
Sphaeranthus suaveolens (Forsk.) DC (CM 052)	Njogu-ya-iria (I)	Herb	W/P	Infusion in hot or cold water	No information	Decoction of the whole plant used as a cough remedy and that of the leaves rubbed on the body of person with malaria (Kokwaro, 1993)
Compositae						
Vernonia brachycalyx O. Hoffm. (CM 088)	Muthiamura (I/G)	Shrub	L	Infusion in hot or cold water	Antiplasmodial activity (Oketch-Rabah et al., 1998)	Leaf infusion used for malaria ([Kokwaro, 1993] and [Beentje, 1994])
Compositae						
Vernonia auriculifera Hiern (CM 044)	Muthakwa (I)	Shrub	L	Infusion in hot or cold water	Antiplasmodial activity (Muregi et al., 2003)	Root infusion used for malaria in Uganda (Hamill et al., 2000)
Compositae						
Vernonia lasiopus O. Hoffm. (CM 062)	Mwatha (I)	Shrub	RB/L	Infusion in cold or hot water	Antiplasmodial activity (Muregi et al., 2003)	Leaf infusion used for malaria in Uganda (Hamill et al., 2000)
Cyperaceae						
Cyperus articulatus L. (CM 046)	Ndago (I/G)	Herb	Tuber	Infusion in cold or hot water	Antimalarial activity (Etkin, 1997)	Leaves used in Guinea for cerebral malaria (Akendengue, 1992), root used in Nigeria for malaria (Etkin, 1997)

Family/species /(Voucher no.)	Vernacular name	Habit	Part used	Preparation	Biological activities reported	Relevant reported uses
Euphorbiaceae						
Neoboutonia macrocalyx Pax (CM 057)	Mutuntuki (I)	Tree	SB	Hot water decoction	Antiplasmodial activity (**Kirira et al., 2006**)	Stem bark decoction used for malaria (**Kirira et al., 2006**)
Euphorbiaceae						
Clutia abyssinica Jaub. & Spach (CM 055)	Muthimamburi (I)	Shrub	L/RB	Decoction in soup	Antiviral-coxsackie (**Vlietinck et al., 1995**)	Decoction from the leaf in soup used in East Africa for malaria (**Kokwaro, 1993**)
Labiatae						
Ajuga remota Benth. (CM 071)	Kirurite (I)	Herb	W/P	Infusion in cold or hot water	Antiplasmodial activity (**Kuria et al., 2001**)	Leaves used for fever (**Odek-Ogunde et al., 1993**), leaves used as diuretic and hypertension (**Kloos et al., 1978**) and malaria (**Kuria et al., 2002**)
Lamiaceae						
Fuerstia africana T.C.E. Fries (CM 056)	Muti jwa maigo (I)	Herb	W/P	Infusion in hot or cold water	Antiplasmodial activity (**Koch et al., 2005**)	Leaf decoction used for malaria (**Koch et al., 2005**), whole plant cold infusion used in South Africa as galactagogue (**Watt and Breyer-Brandwijk, 1962**)
Lauraceae						
Ocotea usambarensis Engl. (CM 059)	Muura (I)	Tree	RB	Infusion in hot water	Weak antiplasmodial activity (**Weenen et al., 1990**)	Decoction from the root used in East Africa for malaria (**Kokwaro, 1993**)

Family/species /(Voucher no.)	Vernacular name	Habit	Part used	Preparation	Biological activities reported	Relevant reported uses
Leguminosae						
Cassia didymobotrya Fres.(CM 064)	Murao (I)	Shrub	RB/L	Hot water decoction	Antiplasmodial activity (Kuria et al., 2001)	Leaf, root bark decoction used in Tanzania for malaria (Gessler et al., 1995)
Liliaceae						
Aloe secundiflora Engl. (CM 069)	Sukurui (G)	Shrub	L	Infusion in hot or cold water	Antiplasmodial activity (Oketch-Rabah et al., 1999)	Cold infusion of the leaves used for malaria (Kokwaro, 1993)
Loaniaceae						
Strychnos henningsii Gilg (CM 063)	Muchambi (I/G)	Tree	SB	Decoction, hot water extract	Antiplasmodial activity ([Kirira et al., 2006], [Philippe et al., 2005] and [Oketch-Rabah et al., 1999])	Stem bark infusion used for schistosomiasis in South Africa (Sparg et al., 2000), in Kenya stem bark decoction used for malaria (Kuria et al., 2001)
Menispermaceae						
Cissampelos pareira L. (CM 070)	Karigi munana (G)	Liana	RB	Hot water decoction	Antiplasmodial activity ([Antoun et al., 2001] and [Gessler et al., 1994])	In India leaf powder used for malaria (Sudarsanam and Prasad, 1995), leaf decoction used for malaria in Tanzania (Gessler et al., 1995)
Mimosaceae						
Albizia amara (Roxb.) Boiv. (CM 073)	Mwiradathi (G)	Tree	SB	Hot water decoction	Active cytotoxic activity (Mar et al., 1991)	Seed oil used to treat leprosy and leucoderma in India (Chandra et al., 1956)

Family/species /(Voucher no.)	Vernacular name	Habit	Part used	Preparation	Biological activities reported	Relevant reported uses
Mimosaceae						
Albizia gummifera J.F Gmel.) C.A. Sm. (CM 060)	Mukurue (I)	Tree	SB	Hot water decoction	Antiplasmodial activity ([Wanyoike et al., 2004] and [Gessler et al., 1994])	In Kenya stem bark used for fever (Rukunga and Waterman, 1996), stem bark decoction used in Tanzania for malaria (Gessler et al., 1994)
Myricacea						
Myrica salicifolia A.Rich. (CM 066)	Murima (I)	Tree	RB	Hot water infusion	Antiplasmodial activity (Kirira et al., 2006), analgesic activity (Njung'e et al., 2002)	Root infusion used for malaria in Uganda (Hamill et al., 2000)
Oleaceae						
Olea capensis L. (CM 061)	Mucharage (I)	Tree	SB	Hot water decoction	No information	Dried root used for swollen joints (Arnold and Gulumian, 1984)
Oleaceae						
Olea europaea L. (CM 058)	Mutero (I)	Tree	SB	Decoction, hot water extract	Antiplasmodial activity ([Koch et al., 2005] and [Clarkson et al., 2004])	Stem bark decoction used in South Africa as antipyretic (Tsukamoto et al., 1984)
Onagraceae						
Ludwigia erecta (L.) Hara (CM 054)	Mungei (I)	Herb	W/p	Infusion in hot water	No information	Decoction of whole plant used for malaria (Kokwaro, 1993)
Pittosporaceae						
Pittosporum viridiflorum Sims (CM 068)	Munati (I)	Tree	SB	Decoction in soup	Antiplasmodial activity ([Clarkson et al., 2004] and [Gakunju et	Decoction of the stem bark in soup used for malaria (Kokwaro, 1993)

Family/species /(Voucher no.)	Vernacular name	Habit	Part used	Preparation	Biological activities reported	Relevant reported uses
					al., 1995])	
Ranunculaceae						
Clematis brachiata Thunb (CM 065)	Mwimba muthumbi (I)	Liana	RB	Hot water decoction	Antiplasmodial activity ([Koch et al., 2005], [Clarkson et al., 2004] and [Okalebo et al., 2002])	Leaf infusion used for malaria (Chhabra et al., 1991), leaf and stem bark infusion used for schistosomiasis in South Africa (Sparg et al., 2000).
Rhamnaceae						
Rhamnus prinoides L. (CM 142)	Muborona (I)	Shrub	RB	Decoction, hot water extract	Antiplasmodial activity ([Koch et al., 2005], [Muregi et al., 2003] and [Kuria et al., 2001])	Root decoction used in Kenya for malaria (Kuria et al., 2001) and in Tanzania for pneumonia (Chhabra et al., 1991)
Rhamnaceae						
Rhamnas staddo A. Rich (CM 080)	Mukuru (I/G)	Shrub	RB	Decoction, hot water extract	Antiplasmodial activity ([Koch et al., 2005] and [Muregi et al., 2003])	Root decoction used for malaria, venereal diseases and anaplasmosis (Beentje, 1994)
Rosaceae						
Prunus africana (Hook.f.)Kalkm. (CM 077)	Mwiria (I)	Tree	SB	Decoction, hot water extract	Inhibition of cell proliferation (Lowe and Fagelman, 1999)	Leaves used as inhalant for fever and stem bark for stomach and malaria (Bussmann, 2006), stem bark decoction used in Africa for prostatic hypertrophy (Catalano et al., 1984)
Rubiaceae						

Family/species /(Voucher no.)	Vernacular name	Habit	Part used	Preparation	Biological activities reported	Relevant reported uses
Boscia angustifolia A.Rich (CM 076)	Murure(G)	Shrub	SB	Decoction, hot water extract	Larvicidal activity—*Aedes aegypti* (Cepleanu et al., 1994)	Stem bark decoction used for malaria (Kokwaro, 1993)
Rubiaceae						
Vangueria madagascariensis Gmel (*Vangueria acutiloba* Robyns) (CM 079)	Mubiru (I)	Shrub	SB	Decoction, hot water extract	No information	Infusion of the stem bark used in Tanzania for malaria (Chhabra et al., 1984)
Rutaceae						
Zanthoxylum usambarense (Engl.) Kokwaro (CM 072)	Muguata nderi (I/G)	Tree	SB	Bark boiled in water	Antiplasmodial activity ([Kirira et al., 2006] and [Kuria et al., 2001])	Stem bark decoction used for malaria (Beentje, 1994), root decoction used for malaria and fever (Kokwaro et al., 1983)
Rutaceae						
Fagaropsis angolensis (Engl.) Dale (CM 143)	Murumu, mukuriampungu (I/G)	Tree	SB	Bark boiled in water	Antiplasmodial activity (Kirira et al., 2006)	Stem bark decoction used for malaria (Kirira et al., 2006)
Rutaceae						
Clausena anista (Willd.)Benth. (CM 082)	Mukibia (I)	Shrub	RB	Decoction, hot water extract	Antiplasmodial activity (Clarkson et al., 2004)	Root decoction used for malaria (Beentje, 1994), root decoction in soup used for malaria (Kokwaro, 1993)
Rutaceae						
Teclea simplicifolia (Engl.) Verdoom (CM 085)	Muteretu (I)	Shrub	SB	Decoction, hot water extract	No Information	Root decoction used in Kenya for pneumonia (Chhabra et

Family/species /(Voucher no.)	Vernacular name	Habit	Part used	Preparation	Biological activities reported	Relevant reported uses
						al., 1991)
Rutaceae						
Toddalia asiatica (L.) Lam. (CM 083)	Muchani (I/G)	Liana	RB	Root bark boiled	Antiplasmodial activity ([Gakunju et al., 1995] and [Kuria et al., 2001])	Leaf infusion used in Madagascar for malaria ([Novy, 1997] and [Chhabra et al., 1991]), root bark used in China as antipyretic and analgesic (Wang and Chang, 1981)
Rutaceae						
Zanthroxylum chalybeum Engl. (CM 084)	Mugucwa (G)	Shrub	RB	Root bark boiled	Antiplasmodial activity (Gessler et al., 1994)	Decoction of the stem bark used for malaria (Beentje, 1994)
Simaroubaceae						
Harrisonia abyssinica Oliv. (CM 078)	Mutagata (G)	Shrub	RB	Decoction, hot water extract	Antiplasmodial activity ([Kirira et al., 2006] and [El Tahir et al., 1999]).	Root decoction used for malaria in Tanzania (Chhabra et al., 1993)
Solanaceae						
Solanum incanum L. (CM 067)	Mutongu (I/G)	Shrub	RB	Hot water extract	Antibacterial activity—*Streptococcus mutans* (Chen et al., 1989)	Root bark decoction used for malaria, whooping cough and liver diseases in Rwanda (Vlietinck et al., 1995)
Solanaceae						
Withania somnifera (L.) Dunal (CM 090)	Mugumbao (I/G)	Shrub	RB	Decoction, hot water extract	Antibacterial activity, *Staphylococcus aureus* (Jaffer et al., 1988)	Root decoction used for malaria in Ethiopia (Asres et al., 2001)

Family/species /(Voucher no.)	Vernacular name	Habit	Part used	Preparation	Biological activities reported	Relevant reported uses
Verbenaceae						
Clerodendrum eriophyllum Guerke (CM 089)	Muumba (G)	Shrub	RB/L	Decoction, hot water extract	No information	Leaves infusion used for malaria ([Beentje, 1994] and [Kokwaro, 1993])
Verbenaceae						
Clerodendrum myricoides (Hochst.) Vatke (CM 086)	Munjugu (I/G)	Shrub	RB	Roots boiled in water	Antiplasmodial activity ([Muregi et al., 2004] and [Gessler et al., 1994])	Root decoction used for malaria and venereal diseases ([Beentje, 1994])

RB = root bark, SB = stem bark, W/p = whole plant, L = leaves, I = Imenti forest game reserve, G = Gatunga.

The method of preparation was mostly a decoction or a hot water infusion usually prepared just before use and filtered through a cloth. The plant material was used fresh or dried and most plants to be used as a remedy were stored for later use in the dry state, which allowed their utilization throughout the year. Posology was difficult to quantify but was indicated as drinking boiled but cold decoction half a cup twice daily for adults and half this amount for children which approximated to: a half cup ~ 125 ml; a pinch: 5 g of powdered plant material in 250 ml (1/2 cup × 2) of water to be taken twice daily; a few leaves: 5 g wet leaves or 10 g dry leaves in 250 ml of water to be taken twice daily; and a handful: 20 g of powdered plant material, or 40 g coarse plant material in 250 ml of water to be taken twice daily. Treatment was supposed to be continued until recovery.

4. Discussion

The aim of the ethnomedical survey and documentation was to catalogue the plants used traditionally against malaria. The results of this study show that a large number of medicinal plants are traditionally used in treatment of malaria among the communities in the two study areas. Eleven plant species were common in both study sites. This may confirm the effectiveness of traditional herbal remedies prepared from these species in the two communities. Studies from other regions of Africa indicate Rubiaceae to have many species used in the management of malaria in different countries (Iwu, 1994). In this study Rutaceae was reported to have more species than Rubiaceae, and nine other families were reported to have a similar and or greater frequency on the number of species cited as sources of antimalarial remedies as Rubiaceae, which would indicate the importance of these families as possible sources of antimalarial plants. The information on the frequently utilized antimalarial plant species is also an important lead to the species that can be targeted for antiplasmodial tests and phytochemical analysis. Since there is no safer, effective and cheaper antimalarial remedies than chloroquine in the treatment of malaria, development of new antimalarial drugs from plant sources may be the way forward in dealing with global drug resistant problems of malaria (Gessler, 1995). Natural products and their derivatives represent over 50% of all the drugs in clinical use in the world (Van Wyk et al., 2002).

The root bark was the most commonly used part of the plant and this was found to be destructive where in some cases the whole plant had to be uprooted. This calls for conservation and harvesting strategies to facilitate sustainable utilization of these plant resources (Cunningham, 2001). Among African medicines, indigenous plants play an important role in the treatment of a variety of diseases (Phillipson, 1995) and are often used by healers to treat diseases identified as malaria ([Sofowora, 1980] and [Omulokoli et al., 1997]). They are commonly used in East Africa ([Kokwaro, 1993] and [Chhabra et al., 1993]), in South Africa (Watt and Breyer-Brandwijk, 1962) and in West Africa (Oliver-Bever, 1986). The practice of traditional medicine is widespread in China, Japan, Sri Lanka, Pakistan and Thailand. In China and India pharmaceutical companies produce and market galenicals (Norman et al., 1985).

There are species, which were commonly cited in this study that are also known to be used as sources of antimalarial remedies in other parts of Africa. They are also reported to contain antiplasmodial activity against *P. falciparum*. Those from South Africa included many plants screened against *P. falciparum* on chloroquine (CQ) sensitive strain D10 such as: *C. edulis* stems (IC_{50}, 33 μg/ml), *K. africana* leaves (IC_{50}, 51 μg/ml), *M. undata* leaves (IC_{50}, 21 μg/ml), *C. didymobotrya* leaves (IC_{50}, 40 μg/ml), *O. europaea* leaves (IC_{50}, 12 μg/ml), *P. viridiflorum* whole plant (IC_{50}, 30 μg/ml), *C. brachiata* leaves (IC_{50}, 20 μg/ml) and *C. anisata* twigs (IC_{50}, 18 μg/ml) (Clarkson et al., 2004).

In Kenya, Kajiado district, Koch et al. (2005) reported some of the species as having antiplasmodial activity against CQ sensitive *P. falciparum* clone D6 although his defined activity was rather high (IC_{50} < 10 µg/ml). These were *C. edulis* root bark (IC_{50}, 6.41 µg/ml), *O. europaea* stem bark (IC_{50}, 9.48 µg/ml), *R. prinoides* root bark (IC_{50}, 3.53 µg/ml), *C. brachiata* root bark (IC_{50}, 1.50 µg/ml), *C. myricoides* root bark (IC_{50} > 10 µg/ml), *R. staddo* root bark (IC_{50} > 10 µg/ml), *F. africana* leaves (IC_{50}, 3.76 µg/ml) and *B. angustifolia* stem bark (IC_{50} > 10 µg/ml). Other notable antiplasmodial activities for similar species from Kisii, Kenya screened against CQ sensitive strain K39 were *R. staddo* root bark (IC_{50}, 25.6 µg/ml), *R. prinoides* root bark (IC_{50}, 15.1 µg/ml), *V. auriculifera* leaves (IC_{50}, 52.2 µg/ml), *V. lasiopus* leaves (IC_{50}, 3.2 µg/ml), *C. myricoides* root bark (IC_{50}, 8.5 µg/ml) and *A. remota* leaves (IC_{50}, 21.6 µg/ml) ([Muregi et al., 2003] and [Muregi et al., 2004]). Others screened against *P. falciparum* CQ sensitive strain K67 included *T. asiatica* root bark (IC_{50}, 5.0 µg/ml), *M. arbutifolia* whole plant (IC_{50}, 4.0 µg/ml) and *P. viridiflorum* stem bark (30.0 µg/ml) (Gakunju et al., 1995). Gessler et al. (1994) while screening CQ resistant *P. falciparum* strain KI against plant extracts from Tanzania found the water extract of *Z. chalybeum* root bark to have one of the strongest antiplasmodial activity among the plant species tested (IC_{50}, 1.2 µg/ml).
Kirira et al. (2006) while screening CQ sensitive *P. falciparum* strain NF54 and resistant strain ENT30 against plant extracts from Meru and Kilifi districts found *H. abyssinica* root bark (IC_{50}, 72.66 µg/ml), *Z. usambarense* root bark (IC_{50}, 3.20 µg/ml), *F. angolensis* stem bark (IC_{50}, 72.66 µg/ml), *M. salicifolia* root bark (IC_{50}, 51.07 µg/ml) and *N. macrocalyx* stem bark (IC_{50}, 78.40 µg/ml) active, while *W. somnifera* root bark (IC_{50}, 125.59 µg/ml), *C. edulis* root bark (IC_{50} > 125 µg/ml) and *S. heningsii* stem bark (IC_{50} > 125 µg/ml) were inactive. It is of interest that the latter two species, which have been cited severally as potent traditional antimalarials, were reported as having insignificant activity whereas other studies reported good antiplasmodial activity. The strychnos species (Loganiaceae) are among the most renowned plants of traditional pharmacopoeias. Philippe et al. (2005) reported activity of *S. henningsii* Gilg leaves, ethyl acetate extract (IC_{50}, 15.9 µg/ml) against CQ susceptible *P. falciparum* strain FCA20. Crude alkaloids from *S. myrtoides* Gilg and Buss significantly enhanced in vitro and in vivo CQ action (Rasoanaivo et al., 1998) and isostrychnopentamine, an alkaloid isolated from *S. usambarensis* Gilg showed in vitro as well as in vivo activities (Frederich et al., 2004). *Carissa edulis* described above by Clarkson et al. (2004) was extracted in dichloromethane while that reported by Kirira et al. (2006) was extracted in methanol. These plants could be effectively more active on *P. falciparum* in man, as it is the case for plants containing prodrugs, non-active by themselves but which can be metabolized to active drugs as has been demonstrated for *A. indica* extracts (Parida et al., 2002). The potency of the extract may also depend on solvent of extraction, georeference, time and season of harvesting or other environmental factors (Prance, 1994).
Several classes of secondary plant metabolites are responsible for antiplasmodial activity; the most important and diverse biopotency has been observed in alkaloids, quassinoids, sesquiterpene lactones, courmarins, triterpenoids, and limonoids. Nitidine, an alkaloid isolated from *T. asiatica* (Gakunju et al., 1995), sesquiterpene lactone from *A. annua* (Klayman, 1985), courmarins from *V. brachycalyx* ([Oketch-Rabah et al., 1997] and [Oketch-Rabah et al., 1998]) are some of specific examples.
A. indica is the third most commonly used herbal medicine to treat malaria in Kenya after *A. remota* and *C. volkensii* (Kuria et al., 2001). As Sofowora (1982) noted, many people in several African countries take a decoction of *A. indica* (neem tree) for malaria fever. Their reasons for doing so include reaction to chloroquine, a dislike for synthetic drugs, and the expense and unavailability of synthetic antimalarials. The lack of standardization and quality control is one of the main disadvantages of traditional medicine ([Evans-Anfom, 1986] and [Sofowora, 1982]). Isolation and characterization of active constituents need to be undertaken for use as markers in standardization of the extracts, thus minimizing the risk of overdoses.
Most of the plants were collected within Imenti forest, the latter is facing great pressure due to over-utilization of indigenous trees and medicinal plants may disappear before their uses are documented. Kenya's strategy for conservation of forests involves intensification of timber and other non-wood products outside forest areas (Njuguna et al., 2000). Consideration of plants of medicinal value for such conservation activities is lacking in part due to lack of knowledge of their value. Documentation of medicinal plants traditionally used in treatment of malaria will lead to their recognition and conservation. It is also important that the entire ethnoflora of the study areas be documented as a measure of conservation strategies for target species that could support the health and economy of the communities concerned. Some plant resource users in other developing countries have realized that community forestry is not a question of trees but should include on-farm non-timber forest products for subsistence as well as commercial purposes (Byron, 1995).

5. Conclusion

Many plant species reported in this study have been investigated for their phytoconstituents and pharmacological activities, and the latter are in agreement with the ethnomedical uses reported in this paper. The plants studied were selected from an ethnopharmacological inquiry during an ethnobotanical survey for medicinal plants traditionally used for treatment of malaria in Meru district. Six plant species are documented for the first time for treatment of malaria.
The study allowed the recovery of a rich patrimony of empirical knowledge regarding the traditional uses of plants, which is handed on orally and thus inevitably destined to get lost over the years; it also permitted the singling out of new medicinal plants. Chemotaxonomy, bioactivity and isolation of principles may lead to other uses of the plant apart from its traditional use. And besides allowing the recovery of empirical knowledge linked to medical and other uses, ethnobotany also permits the preservation and handing down of anecdotes, proverbs, rhymes and rituals regarding plants. For example in Meru a sick person with mumps would go round several times the tree *Croton macrostachyus* and sing:

Mutuntu twaria mbucu
Nani gutwarie ntuntu
(*C. macrostachyus* help me carry my mumps and I assist you carry your seeds).
The sick person would leave confident that he has left behind the illness afflicting him and that he would feel well gradually.
C. macrostachyus is also a medicinal plant whose decoction from root bark is drunk for malaria and venereal diseases.

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