International Scholars Journals

International Journal of Medicinal Plants Research ISSN 2169-303X Vol. 4 (8), pp. 157-167, November, 2015. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Full Length Research Paper

Ethnobotanical and vegetation survey of kiango'mbe and Kianjiru Hill Forests In Embu County, Kenya

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Accepted November, 10, 2015

Ethnobotanical study and vegetation survey was carried out in Kiang'ombe and Kianjiru hill forests of Embu County to evaluate the indigenous knowledge relevant to malaria cause, diagnosis, treatment and prevention as well as to establish the hills' medicinal plants species diversity. Semi-structured questionnaires were used to gather ethnobotanical information while trees with diameter at breast height ≥5 cm, shrubs and herbs were sampled by use of 20×20, 5×5 and 1×1 m plots respectively. Malaria symptoms mentioned in this study were in concurrent with the widely acceptable ones and they included: headache, vomiting, loss of appetite, joint pains and fever. Mosquito was recognized as the main malaria vector. Fifty six species belonging to 31 families were documented from the ethnobotanical study. *Achyrothalamus marginatus*, *Dombeya rotundifolia*, *Monanthotaxis schweinfurthii* and *Premna resinosa* were documented for the first time in this study indicating high endemism. Barks, roots, trees and shrubs were the most commonly harvested parts and growth forms respectively. Charcoal burning, timber harvesting, grazing and forest fires were observed. Kianjiru had significantly (P≤0.001) higher diversity index (H'=2.92) than Kiango'mbe (H'=2.63). The two hill forests are major sources of medicinal plants and therefore the need to conserve them.

Key words: Malaria, Ethnobotanical, Knowledge, Vegetative, Embu.

INTRODUCTION

Malaria is still the world number one killer disease especially among pregnant women and children below the age of five years (WHO, 2010). Ninety percent of these deaths occur in sub-Saharan Africa (WHO, 2009). More than 200 million episodes of clinical illness that merited anti-malarial therapies occurred worldwide in 2012 (WHO, 2013). In Kenya, the highest incidences of the disease are in the Rift valley, Nyanza, Western, Central and Eastern provinces (Gitonga et al., 2010; Abdisalan et al., 2009). To control the disease, a lot of efforts have been directed towards both the parasite and the vector. However, limitation in use of drugs in malaria treatment is mainly hindered by the Plasmodium species developing resistance to many of the antimalarial drugs in use (Winzeler and Manary, 2014).

Vector directed strategies on the other hand are mainly aimed at reducing contact with the host and includes the use of indoor residual spray (IRS) and long lasting insecticide treated nets (LLINs). Unfortunately, the vector

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has developed resistance to chemicals commonly used (Liu, 2015; Owusu et al., 2015). Such phenomenon therefore, calls for more research geared towards the discovery of new mosquito repellants and antimalarial drugs. One possible strategy would be to search for compounds with antimalarial and mosquito repellent efficacy from plants. Gyllenhaal et al., (2012) recommends the selection of such plants for further screening based on ethnobotanical information.

Approximately 80% of the world's population relies on herbal medicine for their primary health care needs (WHO, 2003). In Kenya, herbalists play a significant role in the treatment of malaria as well as malaria related fevers (Orwa et al., 2002; Odhiambo et al., 2011). In some regions herbal medicines are considered as the first line for malaria and referral to formal health care system is only made where these medicines fail (Kiringe, 2006; Kidane et al., 2014). The reliance on herbal medicine is attributed to factors such as affordability, availability and accessibility (Olowokudejo et al., 2008). The use of medicinal plants is also integrated in most cultures in Africa and therefore more acceptable than conventional medicine (Musa et al., 2011). In addition, modern health care systems are still beyond the reach of most rural populations mainly due to massive shortage of health workers as well as long distances and poor road networks (Omwega, 2014).

Timely diagnosis, treatment and control are crucial for effective management of malaria. However, treatment of malaria by the herbalists assumes that the symptoms of the disease are clearly identifiable by the herbalist which is rarely the case (Nsagha et al., 2011). Consequently, there is need to do an analysis of the malaria problem from a community point of view when planning to implement sustainable disease intervention strategies. Such analysis should seek to determine the level of community knowledge on malaria cause, symptoms and prevention.

Understanding the community attitudes and belief in regard to malaria disease has been argued as the best approach towards effective control of the disease (Joshi and Banjara, 2008; Singh et al., 2014). However, previous research has documented medicinal plants used in malaria treatment with little attention being shown to indigenous knowledge relevant to the cause, diagnosis and prevention of the disease (Omwega, 2014; Kareru et al., 2007). This is despite possibility of misconceptions that could hinder its effective eradication (Nsagha et al., 2011). In Embu County, malaria is the major health problem since it is the number one killer especially to children below five years (KNBS, 2009). The disease is also the most commonly treated by herbalists in the region (Kareru et al., 2007). However, the indigenous knowledge of this county in regards to malaria cause, diagnosis and prevention has not been documented.

To diagnose the disease herbalists have evolved unique indigenous knowledge (Nguta et al., 2011) which has been accumulated through instinct or observation of natural phenomenon such as feeding habits of other animals (Kareru et al., 2007). In the process of treating and preventing the disease, the herbalists have demonstrated possession of rich and diverse knowledge. However, this knowledge is so highly guarded to an extent of only being transferred orally within family lines (Kunwar and Bussmann, 2008). This has been attributed to the fact that the practice of herbal medicine is a major income generating activity for most poor regions of the world (Yineger et al., 2008). As a result this knowledge is rarely documented and its continual practice relies purely on the herbalists' ability to remember. These therefore risk extinction in the event the young generation loose interest in inheriting the knowledge (Voeks, 2007) or some of the rare species used are depleted (Cordell, 2008).

In Kenya a significant amount of medicinal plants are harvested from the wild (McMullin et al., 2012) and this is supported by the fact that wildly collected medicinal plants are believed to be more potent in comparison to cultivated ones (Musa et al., 2011). Embu County is endowed with rich plants biodiversity which improves the livelihoods and the wellbeing of the community (Ngugi et al., 2011). The plant biodiversity of this county harbors indigenous plants species which have been disappearing over time leaving only isolated pockets of forests (Olson et al., 2003). However, little has been done in regard to establishing the diversity of these medicinal plants in their natural habitats.

Most herbalists understand the ecology of the plants they use and hence able to articulate the requirement for their sustainable harvesting. However, this knowledge is not well documented and thus likely to disappear. Consequently, when local knowledge is lost communities living around areas of high plant biodiversity have no motivation to conserve the species. Loss of indigenous knowledge on plant use has been shown to impact negatively on the success of any community engagement strategies that aim at conserving the plants (Kalayu et al., 2013). Lack of adequate information on plants used and their distribution are some major factors that hinder resource managers from establishing effective sustainable strategies towards conserving plant diversity (Kalayu et al., 2013). In addition, lack of awareness of threateaned and/or endangered species by local population may leads to indiscriminate harvesting resulting in vulnerability of the plants (Kayombo et al., 2013). This study was conducted to establish baseline information on indigenous knowledge of Embu County community in regard to malaria cause, diagnosis, treatment and prevention as well as plant diversity in Kiang'ombe and Kianjiru hill forests.

MATERIAL AND METHODS

Study Site

Embu County is located in the Eastern province of Kenya and it has four constituencies namely Manyatta, Runyenjes, Mbeere North and Mbeere South (Figure 1). The County borders Tharaka Nithi to the North, Kitui to the East, Machakos to the South and Kirinyaga to the West. It covers 2,818 Km^{-2} and was formally subdivided into two districts i.e. Embu and Mbeere districts. The population in the County is estimated at 543, 221 people (KPHC 2009). Embu County is composed of two major tribes (Embu and Mbeere). The Embu are traditionally farmers whose main cash crops are tea and coffee. The Mbeere are mainly herders rearing livestock although they also practice small scale farming including bee keeping. The communities in this region rely on forest products such as medicinal plants, timber, and charcoal as their main source of income. Studies conducted by Ngugi et al., (2011) ranked medicinal plants as the second best source of income in the region. High reliance on medicinal plants was attributed to poverty that makes conventional medicine unaffordable to most households (Ngugi et al., 2011). In this region malaria is the most prevalent parasitic infection accounting to 42% of all outpatient visits (CRA, 2011). In addition, it is the most treatable disease by the herbal doctors (Kareru et al., 2007).

Ethnobotanical Data Collection

Data was collected between January-July 2014. Purposive sampling was used in selecting herbalists who participated in this study. A representative of registered herbalist in the area was contacted through the office of the Director, Ministry of Gender, Sports, Culture, and Social Services. A meeting was organized with the representative where the intention of the researcher was explained. Through the representative, all registered herbalists in the region were invited for a meeting with the researcher and the objective/methodology of the study explained including the need for them to volunteer information to the researcher. In total 84 herbalists attended the meeting. Oral informed consent was sought from the volunteers prior to their participation in the research.

A semi-structured questionnaire was used to collect ethnobotanical information in this study and the researcher guided the herbalist through the questions. In each of the questionnaire the respondents were required to list any known signs and symptoms of malaria as well as cause(s) of the disease to humans; medicinal plants species used to treat malaria and prevent mosquito bites, mode of preparation of effective dosage(s) and route of administration; the part(s) harvested as well as how they acquired the knowledge relevant to malaria cause, diagnosis treatment and prevention. A few herbalists (the most knowledgeable about medicinal plants per constituency) were purposively selected through a nomination process by the rest of the herbalist. They were requested to join the research team that included the researcher and a trained plant taxonomist where all listed plants were identified in the field. Those that could not be identified in the field were collected and identified later at the National Museum of Kenya using existing keys and national reference collection.

Vegetative Survey

A vegetation survey was conducted in Kiang'ombe and Kianjiru hill forests within Embu County in the month of August 2014 (Figure 1). A reconnaissance survey prior to this study enabled the researcher to identify and assign vegetation types of the forests ecosystems based on visual evaluation together with topographical pattern and size before establishing the study transects. Stratified random sampling was applied to ensure that different vegetation formations were considered while proportionately distributing transects in both forests. This was to ensure the realization of comparative analysis of the data. One kilometre belt transects were laid on both forests on radiating orientations from the forests tops in all directions. Systematic sampling was then applied to sample the plots as follow; on each transect, four plots measuring 20×20 meters were established equidistantly after every 200 meters interval. In each plot two 5×5 and 1×1 meters plots were established at random and used to estimate the number of shrubs and herbs respectively. Diameter at breast height (DBH) of trees with DBH of ≥5cm was measured in all the trees within the 20×20 meter plots. Other attributes including disturbances, canopy cover and tree heights were also recorded. Plant specimens that could not be identified in the field were confirmed at the East Africa Herbarium of National Museum of Kenya. Plant nomenclature and utilization was based on Agnew and Agnew's (1994); Beentje (1994); Maundu and Tengnas, (2005).

Data Analysis

Data was entered into Microsoft excel and summarized using excel tool kit. Further analysis to determine fidelity levels (FL) of each plant was calculated as per the formula:

$FL = (LP/LU) \times 100$ (Friedman et al., 1986) where LP is the total number of respondent who cited a given plant species and LU is the total number of respondents.

Plant species diversity, richness and evenness were calculated using the formula:

Shannon-Wiener diversity index: $H' = \sum [pi (\log pi)]$

Where; pi is the proportion of individuals found in the ith species.

(Shannon and Weaver, 1948)

Pielou's eveness $J' = H'/ \text{Log} (S)$ Where; H' is Shannon-Wiener diversity index and S is the total number of species in a sample (Pielou, 1975).

Figure 1. A Map of Embu County, Eastern Kenya.

Table 1. Percentage mentions of diseases treatable by herbalist (n=48).

Disease	% of mention	Disease	% of mention	Disease	% of mention
Malaria	100	Stomach aches	16.6	Cardiac problems	6.3
Typhoid	66.6	Cancer	16.6	Kidney problems	6.3
Flu	58.3	Headache	14.5	Wounds	6.3
Diabetes	39.5	Skin disease	12.5	Epilepsy	4.2
Asthma	37.5	Diarrhea	8.3	Allergy	2.1
Blood pressure	35.4	Eye infection	8.3	Heartburn	2.1
Gout	33.3	Measles	8.3	Meningitis	2.1
Pneumonia	33.3	Toothache	8.3	Tonsil	2.1
Intestinal parasites	31.2	Backaches	6.3	Anorexia	2.1
Joint pain	27	Brucellosis	6.3	Mental disturbance	2.1

Margalef species richness, d= (S-1)/Log (N)

Where; S is the number of species; N is the total number of individuals in a sample (Clifford and Stephenson, 1975).

Relative density (Rd) = $\frac{\text{Number of individuals of a species}}{\text{Total number of all species}} \times 100$

Relative frequency (Rf) = $\frac{\text{Frequency of a species}}{\text{Total frequency value of all species}} \times 100$

Relative dominance (Rd) = $\frac{\text{TBA of a species}}{\text{TBA of all species}} \times 100$

Importance value index (IVI) = Rd+Rf+Rd.

At each sampled site, indicators of disturbance such as grazing, charcoal burning, human or animal tracks, fire, and wood harvesting were quantified by assigning numbers up to a maximum of 3, based on levels of strengths as follows. 0 = absence; 1 = low; 2 = Moderate and 3 = High.

Table 2. Percentage mentions of signs relevant in malaria diagnosis (n=48).

Symptom	% of mentions	Symptom	% of mentions	Symptom	% of mentions
Headaches	68.8	Stomach aches	35.4	Chest pain	22.9
Vomiting	60.4	Body weakness	33.3	Yellow eyes	22.9
Loss of appetite	58.3	Fatigue	31.2	Bitter taste in the Mouth	12.5
Joint pains	54.1	Nausea	31.2		
Fever	50	Excess sweating	29.2	Cough	8.3
Feeling cold	50	Backaches	29.2	Passing yellow Urine	4
Restlessness	39.5	Feeling weak	29.2		
Shivering	37.5	Dizziness	27	Drinking a lot of water	4

Data was analysed using PRIMER version 5 analytical software.

RESULTS

Ethnobotanical Data

A total of 48 herbalists aged between 25-92 years were interviewed. Among the interviewed 15 were female and 33 were male (between 1-58 years of experience). The most treatable diseases in the region were malaria with 100% of the interviewed herbalist claiming to treat it followed by typhoid (66.6%) and flu (58.3%) (Table 1). About 75% of interviewed herbalists inherited the knowledge within the family line.

Results indicate that 83.3% of the herbalists were aware that malaria was spread by mosquito bites while 16% believed that malaria was caused by living near stagnant water or by consuming mangoes fed on by infected mosquitoes. Others believed that malaria was caused by living around bushy plantations or nearby dirty water.

Headache, vomiting, loss of appetite, joint pain and fever were the most commonly mentioned symptoms of malaria with at least 50% of the herbalist mentioning them. Cough, passing yellow urine and drinking a lot of water were the least mentioned malaria symptoms (Table 2).

Medicinal Plants Used in Malaria Treatment

A total of 56 species distributed in 31 families were reported to be used in malaria treatment and control (Table 3). *Caesalpinia volkensii, Senna didymobotrya, Tinthonia diversifolia, Schkuhria pinnata* and *Terminalia brownie* were the most commonly used plants in malaria treatment. Family Fabaceae dominated the list of plants used in malaria treatment and control. Seventy five percent of the herbalist collected the plants from the forest. The plants were either used singly or in combination with other species. Some preparations were mixed with soap or honey to make them more palatable while the administered dosage varied from one herbalist to another. Majority of the herbalist claimed not to treat pregnant women for fear of causing an abortion. The plants were prepared as concoction or decoction after which they were administered by use of a spoon, cup or glass. In some instances concoction/decoction was used to bathe young children in order to reduce malaria related fever. Some herbalists reported that they harvested the plants at night or early in the morning. Herbalists believed that medicinal plants are more safe, available, affordable and efficient in comparison to conventional medicine. Honey was used as a preservative and the preparation stored for up to a month. Plants used as mosquito repellents included: *Tegetes minuta; Allium sativum, Ocimum gratissimum, Osyris lanceolata* and *Premna resinosa* (Table 3). They are either hanged in the houses, applied on the skin or burned to repel mosquitoes.

Bark (30.6%), roots (28.1%), leaves (25.3%), stem (6.6) and whole plant (5.3) were the most popularly harvested parts. The least harvested parts were tubers, flowers and seeds (4.1%). Some plants such as *Caesalpinia volkensii, Strychnos henningsii, Warburgia ugandensis* and *Erythrina abyssinica* had more than one part being harvested. The most frequently used growth forms for malaria treatment were trees 50%, shrubs 28.5%, herbs 17.8% and climbers 3.57%. Herbalists claimed that some species such as *Caesalpinia volkensii*, *Acacia tortilis*, *Terminalia brownie*, and *Strychnos henningsii* were among the plants already becoming scarce (Table 4).

Vegetative Diversity

The vegetative survey revealed that out of the 56 species used for malaria treatment and prevention 41 of them were encountered in the 52 study plots (Table 3 marked by an asterix). They belonged to 17 families distributed as follows Fabaceae (six); Compositae (four) Rutaceae (three); Annonaceae; Celastraceae; Labiatae, Verbenaceae and

Table 3. List of plants used to treat malaria and as mosquito repellents, parts used, fidelity levels (FL), family and growth form (n=48).

Scientific name	Part used	FL	Family	Growth form
Plants used to treat malaria				
Caesalpinia volkensii Harms	Seeds/leaves	58	Caesalpinaceae	C
Senna didymobotrya (Fresen.) Irwin & Barneby*	Leaves/flower	50	Caesalpinaceae	S
Tithonia diversifolia (Hemsl.) A. Gray*	Leaves/flower	50	Compositae	S
Schkuhria pinnata (Lam.) Kuntze*	whole plant	43	Asteraceae	H
Terminalia brownii Fresen*	Leaves/bark	41	Combretaceae	T
Erythrina abyssinica Lam. Ex DC*.	Stem bark/roots	40	Fabaceae	T
Azadirachta indica A. Juss	Leaves	35	Meliaceae	T
Strychnos henningsii Gilg*	Stem/roots	27	Loganiaceae	T
Zanthoxylum chalybeum Engl*.	Leaves/stem bark/root bark	23	Rutaceae	S
Ajuga remota Benth.	stem/leaves/roots	17	Labiatae	H
Leonotis mollissima Gurke	Leaves	17	Labiatae	H
Aloe secundiflora Engl.*	whole plant	13	Aloaceae	H
Olea europaea L.*	Leaves/stem	10	Oleaceae	T
Vernonia lasiopus O.Hoffm.*	Leaves	8	Compositae	S
Warburgia ugandensis Sprague*	leaves/bark	8	Canellaceae	T
Fagaropsis hildebrandtii Engl.) Milne-Redh*.	Roots/bark	6	Rutaceae	T
Lonchocarpus eriocalyx Harms*	Bark	6	Papilionaceae	T
Solanum incanum L.	Roots	6	Solanaceae	S
Uvaria scheffleri Diels*	Roots	6	Annonaceae	S
Zanha Africana (Radlk.) Exell*	Bark/roots	6	Sapindaceae	T
Acacia ataxacantha DC*	Roots	4	Fabaceae	S
Acacia drepanolobium Harms ex Sjöstedt	Roots	4	Fabaceae	T
Clerodendrum myricoides (Hochst.) Vatke*	Roots	4	Verbenaceae	S
Dombeya rotundifolia (Hochst) Planch*.	Stem	4	Sterculiaceae	T
Harrisonia abyssinica Oliv.*	Bark/roots	4	Simaroubaeae	T
Senna singueana (Del.) Lock*	Roots/bark	4	Caesalpiniaceae	T
Toddalia asiatica (L.) Lam.*	Roots	4	Rutaceae	S
Acacia mellifera (Vahl) Benth.*	Bark	2	Fabaceae	T
Acacia nilotica (L.) Willd. ex Delile*	Bark	2	Fabaceae	T
Acacia tortilis (Forssk.) Hayne	Bark	2	Fabaceae	T
Achyrothalamus marginatus O.Hoffm.*	Whole plant	2	Compositae	H
Adansonia digitata L.	Stem	2	Bombacaceae	T
Albizia gummifera (J.F.Gmel.) C.A.Sm*	Bark	2	Fabaceae	T
*Cissampelos pareira L.**	Tubers	2	Menispermaceae	C
Croton dichogamus Pax*	Roots	2	Euphorbiaceae	S
Dalbergia melanoxylon Guill. & Perr. *	Bark	2	Fabaceae	T
Launaea cornuta (Hochst. ex Oliv. & Hiern) C.Jeffre	Roots	2	Asteraceae	H
Mangifera indica L.*	Roots\bark	2	Anacardiaceae	T
Maytenus putterlickioides (Oliv.) Exell & Mendonça*	Bark/roots	2	Celastraceae	T
Maytenus senegalensis (Lam.) Exell*	Roots	2	Celastraceae	T
Monanthotaxis schweinfurthii (Engl. & Diels) Verdc.*	Roots	2	Annonaceae	S
Newtonia hildebrandtii (Vatke) Torre*	Bark	2	Fabaceae	T
*Pappea capensis Eckl. & Zeyh.**	Bark	2	Sapindaceae	T
Pentas parvifolia Hiern*	Bark/roots	2	Rubiaceae	S
Plectranthus barbatus Andr.*	Leaves	2	Labiatae	S
Premna resinosa (Hochst.) Schauer*	Roots	2	Verbenaceae	S
Securidaca longipedunculata Fresen.	Bark	2	Polygalaceae	T
Steganotaenia araliacea Hochst*.	Bark	2	Umbelliferae	T
Teclea simplicifolia (Engl.) Verd.	Leaves	2	Rutaceae	T
Carissa edulis (Forssk.) Vahl *	Leaves	2	Apocynaceae	S
Sterculia Africana (Lour) Fiori	Bark	2	Sterculiaceae	T
Plants used as mosquito repellents				
Tagetes minuta L*	Whole plant	85	Compositae	H
Allium sativum L.	Tubers	75	Amaryllidaceae	H
Ocimum gratissimum Forssk*	Leaves	29	Labiatae	H

Table 3. Cont.

Osyris lanceolata Hochst. & Steud*	Leaves	29	Santalaceae	S
Premna resinosa (Hochst.) Schauer*	Leaves	17	Verbenaceae	S
Ocimum basilicum L.	Leaves	16	Labiatae	H
Senna didymobotrya (Fresen.) Irwin & Barneby*	Leaves	15	Caesalpinaceae	S
Azadirachta indica A. Juss	Leaves	4	Meliaceae	T

FL= FL= (LP/LU) × 100 where LP is the total number of respondent who cited a given plant species and LU is the total number of respondents.
T = Trees, S = Shrubs, H = Herbs, C = Climbers.
*****Denotes species encountered during the vegetative survey.

Sapindaceae (two species each). The rest of the families were represented by one species each.

Majority of medicinal plant species encountered within the sampled plots were trees (51.2%); shrubs (34.2%) herbs; (12.2%) and climbers (2.4%) (Table 3). The trees with the highest density were *Pappea capensis* and *Terminalia brownie* and they were only encounterd in Kianjiru hill forest. The shrubs with highest density were *Uvaria scheffleri* and *Pentas parvifolia* which were encountered in both Kianjiru and Kiango'mbe hill forests. The herbs with the highest density were *Achyrothalamus marginatus* and *Cissampelos pareira* which were only encountered in Kianjiru hill forest. Species with high important value index were *Pappea capensis*, *Terminalia brownie*, *Albizia gummifera* and *Senna singueana*.

Species Richness, Diversity and Evenness

There was significant difference in the diversity of the two hill forests (df 11; t = 4.11; P = 0.001). Kianjiru had higher diversity (H'= 2.92) as compared to Kiang'ombe (H'=2.63) on Shannon-Wiener diversity index (table 5). In Kiang'ombe the highest diversity was observed in grassed woodlands habitat while in Kianjiru the highest diversity was observed in woodland habitats. However, the least diversity was observed in moist forest and fern transition zone of Kiang'ombe forest. Similarly, species richness was significantly different in the two forests (df 9; t = 3.71; P = 0.004). Kianjiru was richer (d = 5.03) than Kiang'ombe (d = 4.30). However, there was no significant difference in species eveness between the two forests (df 7; t = 1.01; P = 0.34). Diversity was significantly different between habitats types (F (1,12) = 12.6; P=0.04). Similarly, there was significant difference in species richness between different habitats types (F(1,12) = 13.25; P = 0.003). However, eveness did not significantly differ between habitat types (F(1,12) = 0.61; p = 0.44).

Threat to Medicinal Plants

Grazing of domestic animals within the forests was noted as one of the most common cause of disturbance in nearly all sites. Observed human activities included: Signs of wood harvesting, charcoal kilns, domestic grazers, hunter snares and numerous paths that crisscrossed most sampled plots. In Kiang'ombe hill forest there was evidence of many pipes used to tap water from the hill to the surrounding homes. In most mid-altitude zones of the hill forests, incidences of erosion caused by flood water were noted. Past forest fires as well as human settlements/encroachments were noticed at the forest edge. Debarking of several plant species probably for medicinal use was also noted.

DISCUSSION

Malaria tops the list of diseases treated by the herbal doctors in Embu County. Generally, malaria is the most treatable disease by the herbalists especially in other regions in Kenya where malaria incidences are frequent (Kiringe et al., 2006). This could probably be explained by the fact that malaria is still a major threat to human health especially in Sub-Saharan Africa (WHO, 2010). This study revealed that 75% of the herbalists inherited the knowledge from a family member. This concurs with Yineger et al., (2008) who reported that the knowledge is highly guarded and transferred orally only within family line. This therefore calls for an urgent documentation of the knowledge with an aim of preserving it. Over 80% of the respondents were aware that malaria is transmitted by mosquitoes. However breeding habitats such as stagnant water or bushy plantations were also mentioned. This probably corresponds to the observation of mosquito vectors being abundant near breeding habitats.

Symptoms such headache, vomiting, loss of appetite, joint pains, fever accompanied by excessive sweating, fatigue, stomachache, nausea and diarrhea, among others were attributed to malaria infection. These are in concurrent with widely accepted malaria signs and symptoms (WHO, 2010). However, there were a few misconceptions on the cause and symptoms of the disease among herbalists in this region. For instance, some herbalists believed that malaria is caused by feeding

Table 4. Percentage mentions of scarce species, local name, family and growth form.

Scientific name	%	Family	Growth form
Caesalpinia volkensii Harms	52	Caesalpiniaceae	C
Acacia tortilis (Forssk.) Hayne	31	Fabaceae	T
Terminalia brownii Fresen.	21	Combretaceae	T
Strychnos henningsii Gilg	18	Longaniacea	T
Albizia gummifera (J.F.Gmel.) C.A.Sm.	16	Fabaceae	T
Fagaropsis hildebrandtii Engl.) Milne-Redh.	13	Rutaceae	T
Senna didymobotrya (Fresen.) Irwin & Barneby	13	Caesalpiniaceae	S
Olea europaea L.	10	Oleaceae	T
Newtonia hildebrandtii (Vatke) Torre	10	Fabaceae	T

on mangoes that have been fed on by infected mosquitoes and that passing yellow urine was one of the symptoms attributed to malaria. Misconceptions in regard to the cause and symptoms of malaria are widespread and have been reported in previous studies (Nsagha et al., 2011). For instance, some communities believe that malaria is caused by drinking dirty water; feeding on contaminated food, excess sunlight, shortage of blood, evil spirit or by bites of mosquitoes that have been into contact with unclean environment (Diggle et al., 2014; Makemba et al., 1996). It therefore implies that there is still need to educate the herbalist on cause of malaria if any community engagement measures towards malaria eradication are to succeed.

Majority of plants used in malaria prevention and control belonged to family Fabiaceae and the findings compares favorably with other studies since plants in this family are commonly known to constitute some antimalarial compounds such as terpenoids and tannins (Ahmed et al., 1999; Duker-Eshun et al., 2004). Some plants mentioned in this study have been documented elsewhere for similar use (Nguta et al., 2011). However, others such as *Achyrothalamus marginatus; Dombeya rotundifolia, Monanthotaxis schweinfurthii, Premna resinosa* and *Osyris lanceolata,* were documented for the first time in regards to malaria treatment and prevention indicating that they were either endemic to the region or perhaps relevant reference could not be accessed in literature. The study also revealed that some introduced species such as *Magnifera indica*, *Azadirachta indica*, *Tinthonia diversifolia* and *Allium sativum* were used for malaria treatment and control in this region. This implies that traditional medicine in Embu County is dynamic a phenomenon linked to influence of information exchange between people. Factors contributing to use of medicinal plants in this region include reports that they were safer, affordable and are easily available. These support findings elsewhere and thus underscores the important role played by herbal medicine in addressing human medical related problems (Nguta et al., 2011).

Plants used for mosquito repellents were either hanged in the house strategically to repel incoming mosquitoes, burned to release smoke that also repelled mosquitoes or bruised and the resultant fluid applied on the skin to repel mosquitoes. This concurred with previous studies that reported repellent activity of potted plants and of smoke emanating from burned leaves of *Ocimum* species (Seyoum et al., 2003; Dugassa et al., 2009).

Most herbalists collected the plants from the wild since they claimed that they were more potent than cultivated ones. Believe on wildly collected plants being more potent than cultivated one is widespread. For instance, in China the wild ginseng is believed to be 5-10 times more potent than those cultivated artificially (Robbins, 1998). Some also claimed to collect the plants at night basically because they believed that active compounds are more concentrated at this time. This could probably be attributed to the fact that the amount of plants metabolites in a species is influenced by factors such as the time and season of collection, geographical location and the age of the plant among others (Jayanthy et al., 2013).

There were inconsistencies in both the dosage and in the prescription given by different herbalist indicating the need for validation and standardization. Water was the

Table 5. Plants species richness (S), Eveness (J’) and diversity (H’).

	KNG	KNJ	KNG T1	KNG T2	KNG T3	KNG T4	KNG T5	KNG T6	KNG T7	KNG T8	KNJ T1	KNJ T2	KNJ T3	KNJ T4	KNJ T5
Species No (S)	17	23	5	2	8	4	2	2	1	4	10	7	14	7	10
Eveness (J’)	0.92	0.87	0.92	0.91	0.97	0.95	1	0.91	0	0.87	0.95	0.93	0.96	0.90	0.94
Richness (d)	4.30	5.03	1.92	0.91	3.04	1.67	1.44	0.91	0	1.44	3.41	2.33	4.34	2.50	3.41
Species diversity (H’)	2.63	2.74	1.49	0.63	2.02	1.33	0.69	0.63	0	1.21	2.20	1.81	2.55	1.76	2.16

S=species richness; J’=Pielou’s eveness d= Margalef species richness; H’=Shannon-Wiener diversity index.
KNG=Kiang’ombe, KNJ=Kianjiru, T=Transect number.

main media of preparations and in some cases honey and soup were used alongside with the drug probably to enhance palatability or to facilitate extraction of non-polar compounds of the plant (Gathirwa et al., 2011). Consequently, efficacy of plant extracts differs between solvent used. For instance, while methanol extracts of *Maytenus putterlikioides* were considered active against Plasmodium parasite those of water extracts were considered inactive (Muthaura et al., 2007). This call for further studies aimed at validating the efficacy of water extracts of the plants used in this region for malaria. The drugs were either administered orally by use of cups, glasses or spoons or used to bathe young children to relieve fever. The World Health Organisation (WHO, 2010) recommends oral route for administration of antimalarial drugs.

This study revealed that barks and roots were the most popularly harvested parts for malaria treatment and control. This is probably attributed to the fact that bark and roots have high partitioning for the photosynthates or exudates which act as toxin for protection against intruders that would consequently confer protective to human diseases (Balick and Cox, 1996). There is danger in the use of roots and bark since there is a high risk of extinction to the individual plant. Trees and shrubs were the most commonly used in this study. This could probably be linked to the fact that they are available almost in all seasons since they are relatively drought resistance and not affected by seasonal variations (Bussman and Sharon, 2006). Some plants such as *Caesalpinia volkensii*, *Acacia tortilis* and *Terminalia brownie* were claimed as rapidly becoming scarce due to overexploitation, conversion of natural habitats to farmlands as well as timber harvesting. This concurs with previous studies that reported a decline of medicinal plant species due to overexploitation (Kiringe, 2006). There is therefore an urgent need to document this knowledge with an aim of preserving and conserving the genetic resources.

Kianjiru recorded a high diversity index on shannon-Wiener diversity index (H’=2.92) as compared to Kiang’ombe (H’=2.63). This could probably be due to the open nature of Kianjiru hill forest that promoted the growth of herbaceous vegetation. In addition, its ragged nature could also be making it less accessible. Kianjiru had significantly high species richness than Kiang’ombe. This concurred with previous finding that observed an increase in species diversity as species richness increased (Okpiliya, 2012).

Trees were the most abundantly encountered plants species and thus strengthening the characterization of the general ecosystems as woodlands. This concurs with previous finding by (P.M. Maluki, Miami University Oxford, Ohio, individual communication) who characterized Kiango’mbe hill forest as a woodland. The Tree, shrub and herb species with highest density were *Pappea capensis, Uvaria scheffleri* and *Achyrothalamus marginatus* respectively. This species thrives best in rocky forest sides, dry forest and in wooded grasslands habitats that were characteristic of Kianjiru hill forest.

Plants in the two hill forests are at risk from myriads of threat including anthropogenic activities as a result of increasing human population. Globally population growth has accelerated the biodiversity extinction rate by at least 100 times more than the natural rate (Millennium Ecosystem Assessment, 2005). This has led to extinction of some of endangered species. For instance *Brucea macrocarpa*, a shrub only found in Kenya’s central swampy areas and river lines of Kamiti, Thika Falls, Rojwero Swamp and Kiambu is quickly disappearing as a result of human population growth. It was also evident that in these hill forests there is high level of medicinal plants exploitation a phenomenon linked to high poverty levels of the surrounding communities (Ngugi et al., 2011). In addition, although the hill forests are under trust land managed by the County government they are poorly managed and hence prone to overexploitation.

CONCLUSION AND RECOMMENDATIONS

The study revealed that although the indigenous knowledge on the cause and symptoms of malaria is well articulated, there is real danger of losing it since it is still transferred orally. Some of the documented plants in this study are not only used elsewhere for the treatment and prevention of malaria, but their efficacy has also been scientifically validated. This therefore calls for validation of those whose efficacy is not known. Barks and roots were the most commonly harvested plant parts and thus endangering their survival. In addition, some plants species were reported as becoming scarce and thus the need to consider ex-situ conservation to guard against their disappearing. The vegetative survey revealed that most of the medicinal plants used in this study were encountered in the field however there was evidence of anthropogenic disturbances thus calling for more efforts towards protecting the two hill forests.

ACKNOWLEDGEMENT

I thank the Center for Sustainable Dryland Ecosystem and Societies (CSDES) and Mount Kenya University who sponsored this research. I also want to thank the herbalists who participated in this study.

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