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Medicinal plants used in malaria treatment by Prometra herbalists in Uganda

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ABSTRACT

Ethnopharmacological relevance: The aim of the survey was to document medicinal plants used in malaria treatment by Prometra (Promocion de la medicina tradicional amazonica) Traditional Medical Practitioners (TMPs) of Uganda and for search of new antiplasmodial herbal medicines (HMs) for further phytochemical analysis.

Materials and methods: In this study, semi structured guided open and close ended questionnaires were used. Focus group discussions were conducted and key informants were chosen within the TMPs who helped in further discussions of how the herbal remedies where collected, prepared and administered.

Results: A sample size of 51 respondents was randomly selected among the TMPs with the help of their leader. 86 species distributed over 81 genera and 39 families were reportedly being used as herbal remedies in malaria treatment. The TMPs use symptoms like high temperature, shivering, among others in malaria diagnosis an indication that they understand malaria. They emphasized the use of leaves and bark in treatment because they can regenerate and therefore ensure sustainable use of plants rather than the use of roots which would be destructive. These TMPS treat and also advise their patients on preventive measures against malaria attacks like sleeping under mosquito nets, clearing bushes near homesteads, among others which is an indication that they help in the prevention and mitigation of malaria incidences and prevalence in the areas where they live. The Informant Consensus Factor (FIC) value of 0.8 demonstrated that the TMPs of Prometra-Uganda tend to agree with each other in terms of the plant species they use in malaria treatment an indication of quality control in as far as administration of the herbal remedies. *Vernonia amygdalina* Delile, *Bidens pilosa* L., *Justicia betonica* L. were highly cited as being used in malaria treatment with frequencies of mention of 38, 28 and 25, respectively.

Conclusion: TMPs of Prometra-Uganda understand and treat malaria using the available plant diversity from their huge forest and the herbal gardens within Buyija forest. The healers are very keen at plant conservation which is a good practice. Species like *Justica betonica* may be investigated further for antiplasmodial assays to justify its efficacy.

1. Introduction

Plants as natural products, provide unlimited opportunities for new drug discoveries because of the unmatched availability of chemical diversity (Cosa et al., 2006). Plants used for traditional medicine contain a wide range of substances that can be used to treat chronic as well as infectious diseases (Duraipandiyan et al., 2006). Because of adverse effects and resistance of parasites to synthesized drugs, humans turned to ethnopharmacognosy. They found literally thousands of naturally occurring chemicals from plants as safe and broadly effective alternatives with less adverse effects (Sasidharan et al., 2011). Biological activities such as antimalarial, anticancer, antimicrobial, antioxidant, antidiarrheal, analgesic, wound healing and many others, were reported from certain natural or herbal products (Sasidharan et al., 2011).

Malaria is among the most adverse health problems at present that needs attention all the time because it can be severe and

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cause death due to an increasing prevalence of resistance to standard antimalarial drugs (Maregesi et al., 2010). By 2005, over 80% of malaria deaths in the world were estimated to occur in Africa South of the Sahara (WHO, 2005). Globally an estimated 3000 children and infants were dying from malaria every day and 10,000 pregnant women were dying from malaria in Africa South of the Sahara by 2006 (WHO, 2006). A 2003 report stated that malaria killed 2.7 million people each year and that more than 75% of whom were African children under the age of five (WHO, 2003). The World Health Organisation African region bears the highest burden of malaria with 80% of the estimated 203 million cases and 90% of the estimated 627,000 malaria deaths worldwide occurring in this region in 2012 and more than three quarters (77%) of all malaria deaths occur in children under 5 years of age (WHO, 2014).

Child mortality rates were known to be higher in poorer households and malaria was responsible for a substantial proportion of the deaths by 2003 (WHO, 2003). Compared to HIV, malaria was responsible for a larger number of deaths in young children, accounting for approximately 20% of all deaths among children in Africa South of the Sahara (WHO, 2005). According to the New Vision published May 2013, it was reported that 100,000 Ugandans die of malaria related deaths every year with children being the majority; this is not surprising given the fact that Uganda has been reported to have the World's highest malaria transmission rate of 478 cases per 1000 population per year (Chimp Corp, 2013).

Malaria disproportionately affected poor people, with almost 60 percent of malaria cases occurring among the poorest 20% of the world's population" (WHO, 2006). Poor people are at increased risk both of becoming infected with malaria and of becoming infected more frequently. Poor people are not able to afford mosquito nets, and also most of them live in congested areas. Forty percent of the world's population is exposed to malaria and there is a constant need for new anti-malarials in the face of the ever-emerging resistance of parasites to available drugs, whether used in monotherapy or in combination (Ginsburg and Deharo, 2011). Humans have been using the medicinal properties of many plants to fight malaria (Phillipson and Wright, 1991; Zirihi et al., 2010). The need for active antiplasmodial drugs with new mode of action becomes more and more urgent to replace the drugs to which the parasites are resistant (Zirihi et al., 2005).

In a study that was done in Mukono district, central Uganda, malaria was reported to affect mainly pregnant women and children under the age of five years (Mbonye et al., 2006) because of very low immunity. A study that was done in Mbarara district, southwestern Uganda, reported that peripheral malaria infections during pregnancy, contribute significantly to perinatal morbidity (De Beaudrap et al., 2013). It was also reported in a study that was done in Masaka district, that there is a direct relationship between HIV-postive persons and the density of malaria parasites. That lower CD4-cell counts were associated with higher malaria parasite densities and that this association become more pronounced with advancing immunosuppression (Whitworth et al., 2000).

Traditional medicine is a key element among the rural communities in developing countries for provision of primary health care, which contributes directly to the socio-economic status and well being of the rural communities according to the ethnobotanical surveys (Kakudidi et al., 2000; Shrestha and Dhillion, 2003; Tabuti et al., 2003). These surveys seem to indicate that in rural Uganda, the majority of the people depend largely on herbal remedies for treating various diseases. The reliance on herbal remedies in Uganda could also be attributed to the poverty levels of people in most rural areas of the country. According to figures reported by Uganda Bureau of Statistics, an average Ugandan lived on only a dollar per day between 2003 and 2009 (UBOS, 2003, 2009). Based on a personal survey of clinics and pharmacies in Kampala, the cost of a single dose of coartem, which is the most common antimalarial drug, is between USD 7 and 12 (1 USD= 2500 Ugx). This price of conventional medicine seems to be high in relation to the poverty levels especially the rural communities. Therefore, herbal remedies provide a cheaper alternative for malaria treatment.

2. Materials and methods

2.1. Study area

This study was conducted in Mawokota, Mpigi district, central Uganda at an institution of Traditional Healers called Prometra-Uganda. The institution is located in Buwama-Buyija, 67 km from Kampala along Masaka road. Its geographical coordinates are 0° 33′ 39″ North, 32° 5′ 47″ East. It is situated on land of more than 100 acres comprising hills, valleys and forest. Prometra-Uganda was founded by Dr. Sekagya Yahaya to train and build capacity of traditional healers in promoting primary health care. The traditional healers come from 20 villages within Mpigi and Butambala districts.

2.2. Nature of the TMPs and their association

The healers in Prometra-Uganda are both male and female from the age of 18 years upwards. Some of the healers inherited traditional knowledge from their parents and others acquired the knowledge from their spiritual ancestors (the dead underworld spirits or ones invisible allies) through dreams. Some of the healers go through formal training. Prometra-Uganda association has got training classes in the forest where they also do formal examinations to qualify as healers. The majority of the healers are Baganda who speak Luganda. Luganda is also the language of instruction in the classes. Those already qualified as healers and practicing healing continue meeting on weekly basis at the Institution to share knowledge of the new plant species, how they prepare them, mode of administration, conservation and also the various diagnostic methods as well as the first aids to give the patients. The forest where the institution is situated is a natural forest but the learners/healers have gardens adjacent to the forest where they plant various species for conservation and easy access.

2.3. Data collection

This study was conducted between October, 2012 and March, 2013. Data was collected through a survey with the help of questionnaires. The questionnaires had semi structured and guided open and close ended questions. A sample size of 51 respondents was randomly selected with the help of their leader out of which 18 were males and 33 were females. A written prior informed consent was obtained from each of the participants with the research objectives and methods explained before every interview. With the help of the leaders, focus group discussions were conducted and key informants were chosen from within the TMPs. The selected TMPs had experience and knowledge in the practice. These helped in further discussions of how the herbal remedies were collected, prepared and administered. Questions in the questionnaire required respondent's biodata, how they understood and diagnosed malaria, the symptoms thereof and how they prepared and administered the herbal remedies. The questionnaires were translated into Luganda, the local language spoken by the TMPs in the study area.

Plant species mentioned in the study were identified in the field with the help of key informants and voucher specimens were collected for confirmation of the species by a taxonomist. Voucher

specimens were deposited at Makerere University herbarium. The Scientific names of the plant species were identified based on the International Plant Names index (IPNI) http://www.ipni.org.

2.4. Informant consensus factor for malaria

The informant consensus factor (FIC) in relation to the medicinal plants use in malaria treatment was calculated from the relation FIC = $(Nur - Nt)/(Nur - 1)$, Where Nur = Number of use reports, Nt = Number of species mentioned (Heinrich et al., 1998). FIC helps to find out if there is a well defined relation regarding information sharing among the TMPs in the use of medicinal plants in treatment of a particular ailment (Heinrich et al., 1998).

3. Results

3.1. Socio-economic characteristics of respondents

TMPs of Prometra-Uganda, who were interviewed, come from Mpigi (75%) and Butambala (25%) districts. 41% of the TMPs indicated they had lived in their respective areas since birth, 31% had lived in their respective districts for the last 20 years, 12% for last 10 years and 10% for less than 10 years. The healers' age was between 20 to 70 years old with 37% between 42 to 52 years old followed by the category of 31 to 41 years then 53 to 63 years. 69% of respondents were married, 29% were single and 2% widowed. 59% of the TMPs had attained primary education, 35% secondary education, 4% college level and only 2% did not go to school at all. The source of traditional Knowledge (TK) varied: 39% of the respondents mentioned that they acquired traditional healing knowledge from their grandparents, 16% from their parents, 4% from spiritual ancestors through dreams, 4% from reading the literature about herbal treatment and 37% acquired healing knowledge from Prometra classes. Apart from using herbal remedies to treat ailments, the respondents also believe in God for healing. Most of them mentioned praying to God before administering of the herbal medicines. From the survey, the majority of the TMPs were Catholics (68%), followed by Moslems (14%), Anglicans/Protestants (12%) and 6% were Seventh day Adventists. A few of them mentioned the help of spiritual ancestors through dreams in healing practice. They believe the spirits help them to identify the patients' ailments and the subsequent herbal remedies. 12% of the TMPs in the study sample size had been practicing healing for the last 16 years and above, 6% for the last 15 years, 41% for the last 10 years and 41% between one and five years implying that the TMPs in the study had enough experience in healing. The researchers also got an opportunity to see some patients under treatment.

3.2. Tradition knowledge about malaria

Malaria in this region is locally referred to as *omusujja gwensiri*. The majority of the healers understood that malaria is caused by a mosquito bite carrying malaria parasites (96%) and could easily differentiate it from other fevers. Some of them mentioned that fevers like cold and flu are symptoms of malaria. Some respondents also mentioned that drinking unboiled water (2%) and drinking unboiled water carrying mosquito eggs (2%) from ponds and swamps could also cause malaria. The respondents were knowledgeable of symptoms of malaria and used them in diagnosis. Table 1 presents symptoms of which, high temperature, red eyes and vomiting were commonly mentioned. However, use of hospital results from hospital is also a confirmation that a patient had malaria. The herbalists also mentioned that sometimes they give first aid to the patients and send them to hospitals for blood test before they administer the full dose. This arises where the patient prefers traditional medicine to conventional medicine.

Table 1
Malaria symptoms mentioned by respondents ($n = 51$).

Symptoms	(%)	Symptoms	(%)
High temperature	75	Sweating	6
Red eyes	39	Yellowish eyes	6
Vomitting	37	Body pain	4
Shivering	25	Diarrhea	4
Loss of appetite	24	Sour mouth	4
Headache	22	Convulsion in children	2
Energyless/ Body weakness	16	Cough	2
Hosipital results	14	Feeling thirsty	2
Joint pains	12	Flu	2
Dehydration checked by pale eyes	10	Tears in eyes	2
Abdominal pain	9	Weight loss	2
Dry mouth	8	Wounds in the mouth	2
Ichy body	6		

3.3. Malaria treatment practices

Eighty six species distributed over 81 genera and 39 families were reportedly being used as herbal remedies in malaria treatment. Asteraceae (32%) was the most commonly used family in malaria treatment followed by Lamiaceae (24%), Euphorbiaceae (12%), Poaceae (10%), four families had 7%, nine families with 5% and the rest of the families with 2% of the plant species used for treating malaria. *Vernonia amygdalina* Delile, *Bidens pilosa* L., *Justicia betonica* L. were commonly used in malaria treatment either singly or in combination with other herbal remedies with frequencies 38, 28 and 25 respectively (Table 2).

The reported most commonly used life form was the herb followed by trees, among others (Fig. 1). The healers mentioned the leaves as the most commonly used plant part in malaria treatment followed by the bark, whole plant, a root, while the rest were used occasionally (Fig. 2).

The TMPS also mentioned that they do not only treat their patients but also advise them on ways of preventing malaria attacks. Among the preventive measures mentioned was sleeping under mosquito nets, clearing bushes near homesteads, avoiding stagnant waters, closing windows and doors after sunset among others. Other healers however, believed that drinking unboiled water, living in a dirty environment like not burning trash and keeping dirty utensils would also lead to malaria attacks (Table 3).

3.4. Preparation and administration of herbal remedies

The herbs are prepared mainly as decoctions (91%) and sometimes as infusions (6%). Powders are preferred mainly because they can be stored for long periods. Infusions are taken within one day and decoctions are kept in containers well covered for at least one week at room temperature. A few of the herbals are taken as teas (2%) and a few as steam baths (1%) under specified doses (Table 2). Some of the herbals used in treatment of malaria were also used to treat other ailments (Table 4).

Some of the plants that were mentioned for use in malaria treatment were also edible. These include *Bidens pilosa*, *Solanum nigrum*, *Amaranthus hybridus*, and *Rosmarinus officinalis*.

According to the Prometra TMPs, there are no contraindications mentioned by their patients due to use of their herbal medicines. However, they mentioned plants like *Spathodea campanulata* and *Aloe dawei* not to be used in pregnancy.

Table 2
Plant species commonly used in Malaria treatment.

Family /Species/Use reports, $n=51$	Local name (Luganda)	Life form	Part used	Mode of preparation and administration
Acanthaceae				
Justicia betonica L.(MAM 84); *Fr*=25	Nalongo/Lukawa	H	WP/L	Powder the leaves and boil for 15 min. Take a half a glass thrice a day for 7 days.
Thunbergia alata Sims (MAM 14); *Fr*=2	Kasaamusaamu/ Ntudde buleku	C	WP	Boil a handful of leaves in one litre of water and take half a glass 3 times a day for 7 days.
Aloeceae				
Aloe dawei A. Berger (MAM 5); *Fr*=15	Kigagi	H	L	Boil a handful of leaves in one litre of water and take half a glass orally once a day for 7 days.
Amaranthaceae				
Amaranthus hybridus L. (MAM 113); *Fr*=1	Bbuga	H	L	Boil a handful of leaves in one litre of water and take half a glass orally once a day for a week.
Anacardiaceae				
Mangifera indica L. (MAM112); *Fr*=3	Muyembe gwakona	T	B	Dry bark, make powder and boil until water volume in halfway and drink. 4 teaspoons thrice a day for 7 days for adults and 3 teaspoons thrice a day for 7 days for children.
Rhus vulgaris Meikle (MAM 12); *Fr*=3	Kakwasokwaso/ Tebudda	S	L	Boil a handful of leaves in one litre of water. Take half a glass 3 times a day for 7 days.
Apiaceae				
Centella asiatica (L.) Urb. (MAM 37); *Fr*=8	Mbutamu/ Kutukumu/Kabo Kabakyala	H	WP	Boil a handful of leaves in one litre of water and take 4 tablespoons 3 times a day for 4 days
Apocynaceae				
Catharanthus roseus G. Don (MAM 107); *Fr*=1	Sekagya	H	L	Boil a handful of leaves in one litre of water and drink half a glass 3 times a day for 7 days.
Araceae				
Culcasia faleifolia Engl. (MAM 26); *Fr*=1	Ntangawuzi yomukibira	H	R	Decoction or powder and boil until water is half way. Drink half glass a day for 7 days.
Asclepiadaceae				
Gomphocarpus physocarpus E.Mey. (MAM 23); *Fr*=1	Kafumbo	H	L	Boil a handful of leaves in one litre of water and take orally. Half a glass a day for a week.
Asteraceae				
Ageratum conyzoides L. (MAM 27); *Fr*=3	Namirembe	H	WP/L	Boil a handful of leaves/whole plant in one litre of water and drink one glass thrice a day for one week.
Artemisia nr. afra Jacq. (MAM 19); *Fr*=1	Pasile	H	L	Pound fresh leaves and mix with pounded roots of *Vernonia amygdalina* make an infusion then take orally.
Aspilia africana (Pers.) C.D.Adams (MAM 35); *Fr*=15	Makayi	H	WP/L/R	Dry and pound to get a powder. Make a decoction by boiling until the water is half way. Take 8 teaspoons thrice a day for 7 days.
Bidens pilosa L. (MAM 83); *Fr*=28	Sere	H	WP	Boil a handful of whole plant in one litre of water and take 4 tablespoons 3 times a day for 4 days or squeeze a handful of freshly picked leaves and drink half glass a day for 4 days.
Conyza floribunda H.B.K. (MAM 38); Fr=1	Kafumbe	H	L	Boil a handful of leaves in one litre of water and take orally. Half a glass a day for a week.
Crassocephalum vitallerium (MAM 104); *Fr*=2	Kitonto	H	L	Boil a handful of leaves in one litre of water and add honey (optional). Take 2 teaspoons 3 times a day for 7 days.
Emilia javanica (*Burm. F.*) *C. B. Rob.*(MAM 20); *Fr*=1	Nakate	H	WP	Make a decoction by boiling until the water is half way and take orally. Take half a glass for seven days.
Microglossa pyrifolia (Lam.)O. Ktze (MAM 1); *Fr*=22	Kafugankande	H	L/WP/R	Boil a handful of leaves or roots for 20 minutes. Take half a glass 3 times a day for 7 days.
Tagetes minuta L. (MAM 45); Fr=2	Kawunyira	H	L/WP	Boil a handful in one litre of water and take half a glass 3 times a day for 7 days.
Tithonia diversifolia A.Gray (MAM 86); *Fr*=11	Kimyula	H	L	Boil a handful of leaves in one litre of water. Take half a glass 3 times a day for 7 days.
Vernonia amygdalina Delile (MAM 82); *Fr*=38	Mululuza	S	R/WP	Boil a handful of roots/whole plant for about 45 minutes. Half glass twice a day for 5 days.
Vernonia cinerea (L.) Less. (MAM 21); *Fr*=2	Kayayana	T	B	Make a decoction by boiling until the water is half way and take orally. Take half a glass 3 times a day for 7 days.
Vernonia lasiopus O. Hoffm. (MAM 33); *Fr*=18	Kaluluza kasajja/ katono	S	L/R	Squeeze a handful of freshly picked leaves and drink 2 teaspoons 3 times a day for 7 days or boil powder of roots for 20 minutes and add honey.
Bignoniaceae				
Markhamia lutea K. Schum. (MAM 95); *Fr*=3	Musambya/ Muzanganda	T	R	Make a decoction by boiling until the water is half way and take orally. Take one glass once a day for one week.
Spathodea campanulata Buch. -Harm. ex DC. (MAM 87); *Fr*=7	Kifabakazi	T	B	Make a decoction by boiling until the water is half way and take orally. Take half a glass thrice a day for 5 days.
Caesalpinaceae				
Cassia didymobotrya Fres. (MAM 24); *Fr*=4	Mukyula	S	L	Powder made from leaves and decoction made by boiling for 30 minutes. Then taken orally. Half a glass thrice a day for 3 days.
Senna spectabilis (DC.) H.S.Irwin & Barneby (MAM 32); *Fr*=2	Gasiya	T	L	Boil a handful of leaves in one litre of water and drink half a glass twice a day for 5 days.
Canelliaceae				
Warbugia ugandensis Sprague (MAM 110); *Fr*=1	Omukuzanume/ Abasi	T	B/L	Make a decoction by boiling until the water is half way and take orally. Take half a glass a day for a week.
Caricaceae				
Carica papaya L. (MAM 92); *Fr*=3	Paapali essajja	T	L	Make Powder from leaves and make a decoction for 15 minutes. Then take orally half a glass twice a day for 3 days.
Combretaceae				
Combretum molle G.Don (MAM 43); *Fr*=2	Ndagi	T	B	Boil the bark for 5 hours to reduce on the toxicity. Half glass taken orally once a day for 3 days.

Table 2 (*continued*)

Family /Species/Use reports, $n=51$	Local name (Luganda)	Life form	Part used	Mode of preparation and administration
Cucurbitaceae				
Cucurbita maxima Lam. (MAM 114); *Fr*=1	Kasuunsa	H	L	Boil a handful of leaves in one litre of water. Drink half a glass a day for seven days.
Dracaenaceae				
Dracaena steudneri Engl. (MAM 120); *Fr*=1	Kajjolyenjovu	S	B	Make a decoction by boiling until the water is half way. Take half a glass 3 times a day for 7 days.
Euphorbiaceae				
Alchornea cordifolia(Schumach.) Mull. Arg. (MAM 44); *Fr*=1	Luzibaziba	S	L	Boil a handful of leaves in one litre of water and drink half glass a day for seven days.
Bridelia micrantha Baill. (MAM 3); *Fr*=8	Katazamiti	T	B	Make a decoction by boiling until the water is half way. Take half a glass 3 times a day for 7 days.
Fluegea virosa (Roxb. Ex Willb.) Voigt (MAM 36); *Fr*=4	Lukandwa /Mukandula	S	L	Boil a handful of leaves in one litre of water. Take half a glass 3 times a day for 7 days.
Macaranga schweinfurthii Pax (MAM 39); *Fr*=1	Kyeganza	T	B	Make a decoction by boiling until the water is half way. Take half a glass 3 times for 5 days.
Phyllanthus pseudo-niruri Mull. Arg. (MAM 7); *Fr*=3	Nakitembe/ Kabalira mugongo	S	L	Boil a handful of leaves in one litre of water and take half a glass 3 times a day for 7 days.
Fabaceae				
Crotalaria agathiflora Schweinf. (MAM 41); *Fr*=1	Kijjebejebbe	S	AP	Squeeze a handful in cold water and bath.
Entada africana Guill.&Perr. (MAM 10); *Fr*=2	Mwolola	T	B	Boil a handful of bark in about 3 l of water for 3 hours. Take 2 teapoons 3 times a day for 7 days for children. For adults 4 teaspoons thrive a day for 7 days.
Erythrina abyssinica Lam. (MAM 85); *Fr*=14	Girikiti	T	B	Boil a handful of bark until the water is half way. Take half a glass thrice a day for 5 days.
Erythrina excelsa Bak. (MAM 40); *Fr*=1	Bajjangala	T	B	Make a decoction by boiling until the water is half way. Take half a glass 3 times a day for 7 days.
Hypericaceae				
Harungana madagascariensis Lam. (MAM 99); *Fr*=2	Mukaabiransiko or mulirira	T	B	Make a decoction by boiling until the water is half way. Take 2 table spoons three times a day for 3 days.
Lamiaceae				
Aeolanthus repens Oliv. (MAM 15); *Fr*=1	Ntulagi	H	L	Pound a handful of bark and boil until water is halfway. Take quarter a glass 3 times a day for 3 days.
Ajuga remota Benth. (MAM 48); Fr=1	Kitinwa	H	L	Boil a handful of leaves in one litre of water and drink half glass a day for seven days.
Clerodendrum myricoides R. Br. (MAM 4); *Fr*=1	Kikonge	S	L	Boil a handful of leaves in one litre of water. Drink half a glass a day for a week.
Clerodendrum rotundifolium Oliv. (MAM 2); *Fr*=20	Kisekeseke	S	R/L	Squeeze a handful of freshly picked leaves and drink once a day for 5 days or boil the roots for 15 minutes and drink half a glass once a day for 5 days.
Hoslundia opposita Vahl. (MAM 94); *Fr*=5	Kamunye	H	L	Boil a handful of leaves in one litre of water and take orally, half a glass 3 times a day for 7 days.
Leonotis nepetifolia Schimp. ex Benth (MAM 34); *Fr*=17	Kifumufumu	H	WP	Powder plant and add one teaspoon of powder to a cup of hot water or tea. Take 3 times a day for 3 days.
Ocimum grattisimum Willd. (MAM 90); *Fr*=4	Mujaaja	H	L	Boil a handful of leaves in one litre of water. Take half a glass thrice a day for 5 days.
Plectranthus caninus Roth (MAM 96); *Fr*=2	Kibwankulata	H	L	Boil a handful of leaves in one litre of water. Take 2 teaspoons 3 times a day for 7 days for children. For adults 4 teaspoons thrice a day for 7 days.
Rosmarinus officinalis L. (MAM 123); *Fr*=1	Rosemary	H	L	Boil a handful of leaves in one litre of water. Drink half glass twice a day for seven days.
Tetradenia riparia (Hochst.) Codd (MAM 93); *Fr*=3	Kyewamala	H	L	Sqeeze a handful of freshly collected leaves and drink about one teaspoon twice a day for 7 days.
Loranthaceae				
Tapinanthus constrictiflorus (Engl.) Danser (MAM 29); *Fr*=2	Enzirugaze	H	L	Boil a handful of leaves in one litre of water and drink one glass a day for 7days.
Malvaceae				
Hibiscus surattensis L. (MAM 16); *Fr*=1	Nantayitwako musota	S	L	Boil a handful of leaves in one litre of water. Take half a glass 3 times a day for 7 days.
Meliaceae				
Azadirachta indica A. Juss. (MAM 102); *Fr*=2	Neem	T	L	Boil a handful of leaves in one litre of water and drink half glass a day for 7 days.
Carapa grandiflora Sprague (MAM 119); *Fr*=1	Omukeete	T	L/B	Make a decoction by boiling until water half way. Drink half a glass twice a day for 7 days.
Menispermaceae				
Cissampelos mucronata A. Rich. (MAM 31); *Fr*=1	Kavawala	H	L/WP	Make a decoction by boiling until the water is half way. Take half a glass twice a day for 5 days.
Mimosaceae				
Albizia coriaria Welw. (MAM 47); *Fr*=4	Lugavu	T	B	Boil a handful of bark in about 4 l of water for 6 hours. Take one teaspoon 3 times a day for 7 days for children. For adults 3 teaspoons thrice a day for 7 days.
Albizia grandibracteata Taube (MAM 121); *Fr*=1	Nongo	T	B	Decoction or dry and make powder to dissolve in hot boiled water and drink half glass a day for 7days.
Newtonia buchananii (Baker) Gilb.&Perr. (MAM 8); *Fr*=7	Mpewere	T	B	Powder bark. One table spoon in half a litre of water and boil. Drink half glass once a day for 7 days.
Moraceae				
Antiaris toxicaria Lesch. (MAM 122); *Fr*=1	Kirundu	T	B	Make a decoction by boiling until the water is half way. Take half a glass a day for 7 days.
Ficus saussureana DC. (MAM 46); *Fr*=1	Muwo	T	B	Make a decoction by boiling until the water is half way. Take half a glass 3 times a day for 7 days.
	Muvule	T	B	

Table 2 (*continued*)

Family /Species/Use reports, $n=51$	Local name (Luganda)	Life form	Part used	Mode of preparation and administration
Milicia excelsa (*Welw.*)*C.C.*Berg. (MAM 30); *Fr*=2				Make a decoction by boiling until the water is half way. Take half a glass 3 times a day for 7 days
Myristicaceae				
Pycnanthus angolensis (Welw.) Warb. (MAM 115); *Fr*=1	Lunaba	T	L	Boil a handful of leaves in one litre of water and take half a glass a day for a week.
Myrsnaceae				
Maesa lanceolata Forssk. (MAM 28); *Fr*=2	Kiwondowondo	S	L	Boil a handful of leaves in one litre of water and take half a glass 3 times a day for 7 days.
Myrtaceae				
Eucalptus grandis Maiden. (MAM 118); *Fr*=1	Kalitunsi	T	L	Boil a handful of leaves in one litre of water and drink half glass a day for 7 days.
Psidium guajava L. (MAM 103); *Fr*=1	Mupeera	T	L	Boil a handful of leaves in one litre of water and take half a glass 3 times a day for 7 days.
Syzygium cumini (L.) Skeels (MAM 105); *Fr*=2	Jambula	T	L	Boil a handful of leaves in one litre of water and take half a glass 3 times a day for 7 days.
Pittosporaceae				
Pittosporum mannii Hook. f. Subsp. ripicola (J. Leon) Cuf. (MAM 25); *Fr*=2	Mubajjankon	S	L	Make a decoction/infusion and drink half glass a day for 7 days.
Poaceae				
Cymbopogon citratus Stapf. (MAM 109); *Fr*=2	Kisubi	G	L	Boil a handful of leaves in one litre of water and take half a glass 3 times a day for 7 days.
Digitaria scalarum Chiov. (MAM 106); *Fr*=2	Lumbugu	G	L	Boil a handful of leaves in one litre of water and take half a glass 3 times a day for 7 days.
Imperata cylindrica(*L.*) Beauv.var.africana (Anderss.) C.E. Hubbard (MAM 42); *Fr*=1	Lusenke	G	R	Decoction or dry and make powder to dissolve in hot boiled water and drink half a glass a day for 7 days.
Zea mays L. (MAM 108); *Fr*=1	Luyange Lwakasoli	CG	F	Boil a handful of flowers in one litre of water. Take half a glass 3 times a day for 7 days.
Rhamnaceae				
Maesopsis eminii Engl. (MAM 100); *Fr*=2	Musizi	T	B	Make a decoction by boiling until the water is half way. Take half a glass 3 times a day for 7 days.
Rosaceae				
Prunus africana (*Hook.f.*) *Kalkman* (MAM 97); *Fr*=5	Ntaseesa or Ngwabuzito	T	B	Boil a handful of bark in about 3 l of water for 3 hours. Take 2 teaspoons 3 times a day for 7 days for children. For adults 4 teaspoons thrice a day for 7 days.
Rubus steudneri Schweinf. (MAM 117); *Fr*=1	Nkenene	H	L	Boil a handful of leaves in one litre of water and drink half glass a day for 7days.
Rubiaceae				
Vangueria apiculata K. Schum. (MAM 98); *Fr*=3	Matugunda	S	B	Boil a handful of bark in about 3 l of water for 3 hours. Take 2 teaspoons 3 times a day for 7 days for children. For adults 4 teaspoons thrice a day for 7 days.
Rutaceae				
Toddalia asiatica Baill. (MAM 88); *Fr*=9	Kawule	C	R	Scrape the root bark and boil a handful in 3 l of water for about one hour. Take half a glass 3 times a day for 5 days.
Zanthoxyllum leprieurii Guill.&Perr. (MAM 11); *Fr*=4	Mutatembwa/ Munyenye	T	B	Boil a handful of bark in about 4 l of water for 4 hours. Take half a glass 3 times a day for 7 days.
Sapindaceae				
Blighia unijugata Baker (MAM 116); *Fr*=1	Nkuzanyana	T	B	Make a decoction by boiling until the water is half way and drink half glass twice a day for seven days.
Solanaceae *Datura stramonium* Thunb. (MAM 22); *Fr*=1	Amadudu	H	L	Boil a handful of leaves in one litre of water. Take half a glass thrice a day for one week.
Physalis peruviana L. (MAM 89); *Fr*=6	Ntuntunu	H	L	Boil a handful of leaves in one liter of water and add honey (optional). Take 2 teaspoons 3 times a day for 7 days or boil powder and take half a glass thrice a day for 7 day.
Solanum nigrum L. (MAM 101); *Fr*=2	Nsugga	H	L	Boil a handful of leaves in one liter of water. Take half a glass 3 times a day for 7 days.
Tiliaceae				
Trumfetta rhomboidea Jacq. (MAM 9); *Fr*=1	Musombankoko	S	R	Make a decoction of the roots by boiling in 2 l of water for one hour. Take half a glass a day for a week.
Ulmaceae				
Celtis africana L. (MAM 111); *Fr*=1	Akasisa	T	L	Boil a handful of leaves in one liter of water. Take half a glass a day for a week.

Key: Column 1: Voucher specimen number in brackets, *Fr*=Number of use reports
Column 2: Vernacular names in Luganda end periods.
Column 3: C=climber, T=tree, H=herb, S=shrub, G=grass, CG=cereal grass
Column 4: WP=whole plant, R=root, B=bark, L=leaf, AP=aerial parts, F=Flower

3.5. Challenges faced by Prometra TMPS

Storage was a major problem especially infusions and decoctions. Infusions are administered the same day when they are prepared and if a patient has to take the dose for a week then it necessities harvesting and preparing the medicine daily. Decoctions can be stored for one week after which, they will go bad and have to be poured away.

Tree cutting for timber and charcoal was the other challenge mentioned which destroys the habitats of plants used. Sometimes these TMPs have to walk long distances or even pay transport fee to go and look for a particular herbal medicine in a given forest or at another person's garden. The other problem was overgrazing.

The TMPs mentioned that though some people in their areas still have some reservations in the use of herbal medicines, they have those who frequently use them especially the females and the elderly. The reasons for reservations by some people was lack of proper documentation for dosages and also the poor packaging of these herbal remedies which is still a challenge to the TMPs of Prometra - Uganda.

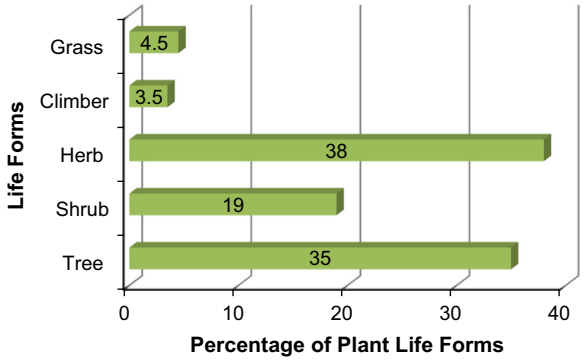

Fig. 1. Life forms of species used.

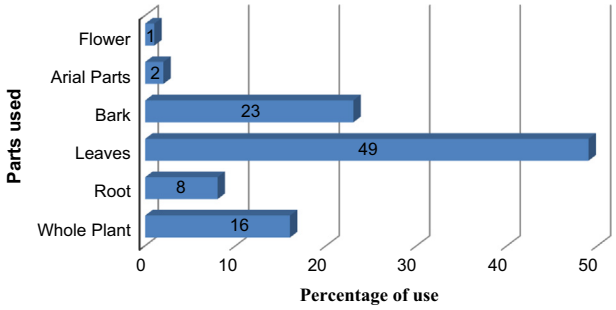

Fig. 2. Plant parts used in malaria treatment.

Table 3
Advice for Control and Prevention of Malaria in the area ($n=51$).

Advice	Frequency
Sleeping under mosquito nets	43
Clearing bushes near homesteads	28
Avoiding stagnant waters around homesteads	23
Boiling drinking water	14
Smoking traditional herbal mosquito repellants in the evenings	10
Keeping away dirty foodstuffs by drying and burning leftovers.	8
Closing windows and doors after sunset	6
Taking traditional immunity boosters	4
Spraying with insecticides	2
Avoid planting maize near homesteads	1
Sleeping in long night gowns	1

4. Discussion

The healers have had a long association with the areas where they stay. However, some of the healers migrated from their home districts to where they are now living. The migration has been mainly driven by marriage and job seeking.

The higher number of female healers (65%) compared to the males (35%) could be attributed to females being always responsible for primary health care of their families and also as a societal norm. Therefore, treating people becomes a responsibility for the females.

Age category of 20 to 30 years and that of 64 years and above had the least number of participants. This has to do with experience and also the fact that traditional knowledge is transferred from one generation to another, one has to be mature enough to articulate the traditional medicines. Secondly, many of the young generation seek jobs outside their villages while some are not interested in traditional medicine as they consider it not modern. The very old were also few because the medicines have to be looked for in the forest or planted which needs extra energy that the elderly may not easily have.

The nature of the association of TMPs of Prometra and the training classes they have in the forest confirms that these healers attained formal education because most of them can read and write their local language (Luganda) and some English. It is also evident through the giving of patients' first aid and sending them to hospitals/health centers for blood tests before they administer the full dose.

TMPs who acquired TK from Prometra had come in as patients for treatment. When they cured, they picked interest in healing practice. The majority of the TMPS mentioned that they do not only provide primary health care to the residents but also do it as a source of income generation in addition to small scale farming which is practiced by most of them.

Vernonia amygdalina has been reported as being used in malaria treatment by the locals in other parts of Uganda (Katuura et al., 2007; Namukobe et al., 2011; Stangeland et al., 2011; Tabuti, 2008). The water and ethanol extracts of *Vernonia amygdalina* were found active against *Plasmodium falciparum* with IC_{50} Values of 13.6 μg/ml and 11.2 μg/ml in Nigeria (Sha'a et al., 2011). The ethanol extracts of the roots of *Bidens pilosa* showed in vivo activity against *Plasmodium falciparm* (Oliveira et al., 2004). The ethanol extracts of *Bidens pilosa* were also found active both in vitro against *Plasmodium falciparm* and in vivo against *Plasmodium berghei* isolates in Brazil (Andrade-Neto et al., 2004). Still in Brazil, the crude ethanol extract of the whole plant, leaves and roots of *Bidens pilosa* was tested at concentrations of 25 to 50 μg/ml and caused in vitro inhibition of *Plasmodium falciparum* growth (Brandão et al., 1997). Polyacetylenidioc acid isolated from *Bidens pilosa* was also found potent against malaria parasites both in vitro and in vivo in Japan (Tobinaga et al., 2009). *Justicia betonica* was also reported in surveys in Western Uganda as a remedy for malaria (Namukobe et al., 2011, Stangeland et al., 2011). It was also reported as a remedy for labor induction in Western Uganda (Kamatenesi-Mugisha and Oryem-Origa, 2007) and as an antidote, remedy for diarrhea, dysentery, edema, dropsy, gout, swellings in Bhopal, India (Nema et al., 2012). The methanol extract of *Justicia betonica* showed mild activity IC_{50} of 69.6 ± 1.9 against *Plasmodium falciparum* isolate (Muregi et al., 2003). However, *Justicia betonica* as an antimalaria herbal remedy needs further antiplasmodial screening to confirm the TMPs claim.

Family Asteraceae contains prevalent sesqueterpene lactones which are responsible for human health, both as part of a balanced diet and as pharmaceutical agents (Chadwick et al., 2013). Some sesqueterpene lactones isolated from the acetone extracts of *Vernonia guineensis* from Cameroon like vernopicrin and vernomelitensin showed antiplasmodial activity against the chloroquine sensitive strain with IC_{50} values of 0.614 and 0.472 μg/ml (Toyang et al., 2013) an indication that sesqueterpene lactones from family Asteraceae do treat malaria.

The TMPs emphasized the use of leaves and bark in treatment because they can regenerate and therefore ensure sustainable use of plants rather than the use of roots which would be destructive to the plants where they are collected. The use of leaves mainly also explains why the herb life form is the most commonly used because the leaves can easily be obtained as compared to when they are to be picked from trees where the leaves are not easily accessible.

The use of some of these plants for other ailments could be that the TMPS are trying to treat the symptoms of malaria. *Vernonia amygdalina* and *Momordica foetida* were also mentioned to be used as baths to cool down the body temperature and also to ease headache for the former.

Table 4
Plants used for malaria treatment and other ailments.

Family/ Species	Local name	Life form	Part used	Other ailment	Mode of Preparation & administration
Acanthaceae					
Justicia betonica L.; *Fr*=15	Nalongo/ Lukawa	H	WP/L	Yellow fever/ diabetes	Make a powder and boil for 15 min. Take a half a glass thrice a day for 7 days.
Aloaceae					
Aloe dawei A. Berger; *Fr*=10	Kigagi	H	L	Candida	Make a decoction and take orally once a day for seven days.
Asteraceae					
Aspilia africana (Pers.) C.D.Adams; *Fr*=10	Makayi	H	WP/ L/R	Abdominal pains	Dry and pound to get a powder. Make a decoction. Take 8 teaspoons thrice a day for 7 days.
Bidens pilosa L.; *Fr*=16	Sere	H	L/WP	wounds/diarrhea	Squeeze a handful of leaves and apply on the wound after cleaning it thriece a day for 7 days. Boil a handful of whole plant in one litre of water and take 4 tablespoons 3 times a day for 4 days for diarrhea.
Conyza floribunda H.B.K *Fr*=1	Kafumbe	H	L	Relieves headache	Decoction taken orally. Half a glass a day for a week.
Microglossa pyrifolia (Lam.)O. Ktze; *Fr*=11	Kafugankande	H	L/ WP/ R	Abdominal disorders/ cough/chest pain	Boil a handful of leaves or roots for 20 minutes. Take half a glass 3 times a day for 7 days.
Tithonia diversifolia A. Gray; *Fr*=7	Kimyula	H	L	diabetes	Boil a handful of bark. Take half a glass thrice a day for 5 days.
Vernonia amygdalina Delile; *Fr*=25	Mululuza	S	R/L	Baths /Burns/ headache	Squeeze a handful of leaves in a basin of water and bathe and decoction of roots taken orally half glass twice a day for 5 days for headache. Squeeze leaves and apply to burnt areas.
Vernonia lasiopus O. Hoffm.; *Fr*=10	Kaluluza kasajja/katono	S	WP/ R	Abdominal pains	Squeeze a handful of freshly picked leaves and drink 2 teaspoons 3 times a day for 7 days or boil powder for 20 minutes and add honey.
Cucurbitaceae					
Momordica foetida Schumach.; *Fr*=5	Bombo	C	AP	Baths/cough/ vomitting	Squeeze a handful in a basin of water and bathe. Boil a handful of leaves. Take half a glass 3 times a day for 7 days.
Fabaceae					
Crotalaria agathiflora Schweinf.; *Fr*=1	Kijebejebe	S	AP	Relieves high blood pressure.	Decoction taken orally. Take half a glass 3 times a day for 7 days.
Erythrina excelsa Bak.; *Fr*=1	Bajjangala	T	B	Candida and wounds	Decoction taken orally. Take half a glass 3 times a day for 7 days.
Lamiaceae					
Clerodendrum myricoides R. Br.; *Fr*=1	Kikonge	S	L	Syphilis and Intestinal disorders.	Decoction taken orally. Half a glass a day for a week.
Clerodendrum rotundifolium Oliv.; *Fr*=11	Kisekeseke	S	R/L	diabetes	Squeeze a handful of freshly picked leaves and drink for 5 days.
Hoslundia opposita Vahl.; *Fr*=4	Kamunye	H	L	Ulcers	Boil a handful of leaves and take orally, half a glass 3 times a day for 7 days.
Leonotis nepetifolia Schimp. ex Benth; *Fr*=10	Kifumufumu	H	WP	Headache	Powder plant and add one teaspoon of powder to a cup of hot water or tea. Take 3 times a day for 3 days.
Ocimum gratissimum Willd.; *Fr*=4	Mujaaja	H	L	Wounds	Make a decoction and se it to wash the wound twice a day.
Rosmarinus officinalis L.; *Fr*=1	Rosemary	H	L	Chest pain	Decoction and drink half glass twice a day for seven days.
Malvaceae					
Hibiscus surattensis L.; *Fr*=1	Nantayitwako musota	S	L	Relieves high blood pressure.	Decoction taken orally. Take half a glass 3 times a day for 7 days.
Meliaceae					
Azadirachta indica A. Juss.; *Fr*=2	Neem	T	L	Dental caries/ yellow fever	Make a decoction and gaggle in the mouth twice a day for 7 days. Boil a handful of leaves and drink half glass a day for 7 days.
Mimosaceae					
Albizia coriaria Welw.; *Fr*=2	Lugavu	T	B	Skin disorders	Boil a handful of bark in about 6 l of water till half way and bathe.
Myrtaceae					
Psidium guajava L.; *Fr*=1	Mupeera	T	L	Relieves bloody diarrhea.	Decoction taken orally. Take half a glass 3 times a day for 7 days.
Poaceae					
Cymbopogon citratus Stapf.; *Fr*=2	Kisubi	G	L	Dental caries	Make a decoction and gaggle in the mouth 3 times a day for 7 days.
Zea mays L.; *Fr*=1	Luyange Lwakasoli	CG	F	Boosts immunity	Decoction taken orally. Take half a glass 3 times a day for 7 days.
Sapindaceae					
Blighia unijugata Baker; *Fr*=1	Nkuzanyana	T	B	Vomiting/skin problems/wounds	Decoction and drink half glass twice a day for seven days and bathe decoction incase of skin rush and wounds.
Solanaceae					
Datura stramonium Thunb.; *Fr*=1	Amadudu	H	L	Abdominal pains/ Ulcers	Decoction taken orally. Half a glass thrice a day for one week.
Physais peruviana L.; *Fr*=6	Ntuntunu	H	L	Chest pain	Boil a handful of leaves. Take half a glass 3 times a day for 7 days.

Key: Column 1: *Fr*=Frequency of mention of use
Column 2: Vernacular names in Luganda
Column 3: C=climber, T=tree, H=herb, S=shrub, G=grass, CG=cereal grass
Column 4: WP=whole plant, R=root, B=bark, L=leaf, AP=aerial parts, F=Flower

TMPs said they are trying to overcome some of the challenges like preparing powders for long storage periods and also planting their own herbal gardens to have enough of the HMs.

The computed FIC value is 0.8 implies that there is mutual agreement amongst the TMPs of Prometra on the plant species they use in malaria treatment. Since the FIC value is close to one, it's an indication of good information sharing and quality control in as far as administration of the herbal remedies is concerned.

5. Conclusions

Several plant species have been documented for treatment of malaria by the TMPs of Prometra-Uganda. Some of them like *Vernonia amygdalina* and *Bidens pilosa* have already proved to be efficacious against *Plasmodium falciparum*.

TMPs of Prometra Uganda understand and treat malaria using the available plant diversity from their huge forest and the herbal gardens they prepare themselves within Buyija forest and in their homesteads. They are very keen on plant conservation which is a good practice by these healers. Species like *Justica betonica* can be investigated further for antiplasmodial assays to justify its efficacy and consequently develop a herbal product which can contribute to antimalarial drug discovery on the drug resistant malaria parasites.

The knowledge the TMPs have on malaria as well as the control measures is a good indication that they will help in the prevention and mitigation of malaria incidences and prevalence in the areas where they live.

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