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Plants used to treat malaria in Nyakayojo sub-county, western Uganda

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ABSTRACT

Aim of study: We performed an ethnobotanical study of plants used to treat malaria in Nyakayojo sub-county in south western Uganda because malaria in this region, and in Uganda at large, is still the single most important reason for ill health and mortality. Two of the most vulnerable groups affected by malaria are young children and pregnant women and plants are commonly used in their treatment.
Materials and methods: Twenty-eight traditional birth attendants were interviewed about how they used plants to treat malaria. Review of the literature available on all species identified was undertaken.
Results: Altogether 56 plant species were used by the informants, 48 of which have been identified to species level. Thirty-two (67%) of the species used by the respondents are documented for antimalarial use in other studies, and nearly half (44%) have documented anti-plasmodial activity. Fifty-five percent of the species were used by 2 or more of the respondents. The most commonly used species were *Vernonia amygdalina*, the indigenous *Aloe* species, *Justicia betonica*, *Vernonia adoensis* and *Tithonia diversifolia*. It was common to use more than one plant in a recipe (43%). The respondents had good knowledge of the symptom of malaria, and fairly good understanding of the causes.
Conclusion: The interviews show that the group of traditional birth attendants has an extensive and diverse knowledge on plants used in the treatment of malaria. The literature survey may indicate a possible explanation for the use of several plants.

1. Introduction

Malaria is the single most important cause of ill health, mortality and poverty in Africa south of the Sahara. The disease has become more severe as the parasite causing most of the infections in Africa, *Plasmodium falciparum*, has developed resistance towards the most common and affordable synthetic medicines used to treat malaria. People with reduced immunity like pregnant women and children below five years are the most affected by the disease. Around 1 million people die from malaria each year, the majority being young African children (WHO, 2009). Some studies indicate that malnutrition and deficiency of iron, vitamin A and zinc are connected to increased malaria mortality, still births and underweight at birth (Caulfield et al., 2004; Lartey, 2008). A few African countries like Rwanda, Zambia, Eritrea and Zanzibar have managed to reduce recorded deaths caused by malaria by 50% due to adequate coverage of key interventions like insecticide treated bed nets and intensified treatment of cases. However, the international disbursement to malaria-endemic countries is still far from what has been promised and is needed according to WHO (2009). In order to make Africa less vulnerable to international financial problems, it is important to find solutions that build on local knowledge and resources. In East Africa there is a long tradition of treating disease with medicinal plants, and this knowledge is still practiced, although the trust in the tradition is in some cases decreasing (Tabuti, 2008), as is the knowledge. However, in many rural areas the health centers are poorly equipped both with personnel and medicines, so people have to use what is available. In this situation WHO (2008) urges developing countries to include traditional medicine (TM) in their primary health care, although it is important to find out which of the traditional medicinal plants and treatments are effective and safe to use.

Most villages have a traditional birth attendant (TBA) and often several traditional healers (THs). Cooperation between the different health care systems in villages and districts is difficult, but possible (Ragunathan et al., 2010) and has the potential to give better health service to the public. We cooperated with a group of traditional birth attendants and healers in Nyakayojo sub-county, as well as the local health centers (HC) from 2007 to 2009. We have had three workshops with reproductive health care and income generating activities on the program. The workshops were held at a health center, and some of the HC staff was always present. We urged the TBAs to cooperate with the HC, and to report deliveries. Young children and pregnant women are the two groups most heavily affected

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by malaria, and the TBAs all had knowledge of plants to use for the treatment of malaria. We decided to use this group as informants for our interviews, and they very generously shared their knowledge and recipes with us. In this study we wanted to gather detailed information about how the TBAs and THs use plants to treat malaria.

2. Materials and methods

2.1. Study area

Mbarara district is located in Western Uganda about 270 km southwest of the capital city, Kampala. The fieldwork was mainly done in Nyakayojo sub-county (0°40′S and 30°33′E). The area has a mean annual maximum temperature of 25–27.5 °C, and a mean annual rainfall of 900–1000 mm (Anonymous, 1967). The area is hilly and the main economic activity is mixed farming, cultivation of crops and grazing cattle and goats. Prior to this study one of the colleagues in the NUFU medicinal plant project had worked with traditional birth attendants (TBAs) to document their use of plants in reproductive health care (Kamatenesi-Mugisha and Oryem-Origa, 2007). The informants are organised in "Nyakayojo Traditional Healers and Traditional Birth Attendants Association" and come from many villages in the sub-county. They are 27 women and one man.

2.2. Collection of ethnomedical information

Fieldwork to collect plant samples and perform the interviews was carried out in March and April 2009. Permission to perform the study was granted by Ugandan National Council for Science and Technology (NS 202). A questionnaire was developed to gather information on how the respondents use plants to treat malaria, and semi-structured interviews were performed by a group of three persons: a botanist, a pharmacologist and a physician.

2.3. Collection of plant samples

In cooperation with the TBAs plant samples mentioned by the respondents were collected in fallows, field and home gardens in Nyakayojo sub-county and the vernacular names were verified by them. Plant specimens were brought to The Norwegian University of Life Science (UMB) for taxonomic identification. Specimens are deposited at the herbarium at Makerere University (MHU) and Botanical Museum in Oslo (O).

3. Results

3.1. Plants used to treat malaria

Twenty-eight traditional birth attendants were interviewed on how they used plants to treat malaria. Fifty-six species, distributed among 47 genera and 23 families, were reported to be used. Forty-eight of the 56 species collected were scientifically identified to species level, another 5 plants were identified to genus level, and 3 plants remained unidentified with only the local name. The species name, family, vernacular name, voucher specimen number, plant part used, and the number of respondents using the plant are presented in Table 1. Review of ethnomedical use relevant to malaria, biological activity and chemical studies of the 48 scientifically identified species are presented in Table 1. More details of the recipes are presented in Table 2.

Vernonia amygdalina was by far the most commonly used plant (86% of respondents), and mainly the leaves were used. The most common mode of preparation was to squeeze juice out of the leaves and add some cool, pre-boiled water. Other commonly used plants included *Aloe* species, *Justicia betonica*, *Vernonia adoensis* and *Tithonia diversifolia* by 68%, 39%, 29% and 21% of the respondents, respectively. More than half (55%) of the plants were used by two or more of the TBAs. It was common to use several plants together in a recipe (43% of recipes). One of the TBAs only used one recipe, but this was a combination of all the most commonly used plants (Table 2, the last of the recipes under *Vernonia amygdalina*). Six of the plants were dried in the shade and stored for later use, while leaf pieces of two *Aloe* species were added as the decoction boiled.

The most common mode of administration was oral, but bath and steam baths were used as well. Leaves were by far the most commonly used plant part (in 85% of recipes); in addition roots, root bark, flowers and seeds were used. Two of the TBAs were growing *Artemisia annua* in their garden and informed us that they had learned about the plant and got young plants from a white man a year earlier.

3.2. Traditional knowledge about malaria

The understanding of malaria among the respondents was good. Most of them recognised one or more of the most frequent symptoms of malaria, as high body temperature, shivering, headache, vomiting (Table 3). All symptoms given can be found in a person with malaria.

The understanding of the cause of malaria was fairly good, as 86% percent of the respondents knew that it is caused by mosquito bites. Some mentioned indirect causes like bad feeding, cold weather (more mosquitoes then), grass around homestead and stagnant water. However, 25% meant that malaria can be caused by drinking un-boiled water (see Graphical abstract). Other reasons like dirty environment, worms, transmition from bad mattress were also given.

3.3. Malaria treatment practices

Some of the informants mainly treated their own family while others had several patients per month. In average 17 patients were treated per month per respondent, ranging from 5 patients per month to 200 per year. The latter was a nurse assistant at a health center and she used both plant and synthetic medicine as treatment for malaria.

The respondents expressed that it had become more difficult to treat malaria; often the disease becomes more severe than earlier. People more often use synthetic medicine, but still some prefer to use plants. Almost all the respondents had more than one recipe for treating malaria, and if the first treatment did not help within two or three days, they tried another or referred to HC or hospital. The informants had no written records of how many patients were cured, but in the interview 54% of them suggested that more than 60% of the patients recovered, and 28% that around 50% of the patients recovered. If the symptoms were severe the patients were referred to HC or hospital straight away. In that case the TBA may give some first aid plants to take down the fever. One of the TBAs said she never treated patients with plants unless in cooperation with health personnel.

4. Discussion

Thirty-six (75%) of the 48 species scientifically identified were found to be documented in the use for malaria or fever in other studies. Another 11 species are reported in the use for related symptoms, and not specifically malaria or fever: 6 (13%) species are reported used to treat cough and/or diarrhoea (*Conyza bonariensis*, *Indigofera emarginella*, *Myrica kandtiana*, *Passiflora edulis*, *Sonchus oleraceus*, *Vernonia* adoensis); and 3 (4%) for abdominal pain or gastrointestinal disorders (*Monechma subsessile*, *Ocimum*

Table 1
Plants used to treat malaria by members of Nyakayojo TBAs and THs assosiation (28 informants).

Plant family Species (voucher specimen number)[a]	Local name	Plant part used[b]	% Inf.	Reported relevant ethnomedical uses elsewhere	Biological activity/chemical constituents
Acanthaceae					
Justicia betonica L. (TS 223)	Quinine/Nalongo	L	39	Malaria (Muregi et al., 2003); diarrhoea (Khare, 2007); cough and diarrhoea (Jeruto et al., 2008); induce labour (Kamatenesi-Mugisha and Oryem-Origa, 2007)	Anti-plasmodium activity in aerial parts (Muregi et al., 2003; Bbosa et al., 2008); justetonin (indole(3,2-b) quinoline alkaloid glycoside) isolated by Subbaraju et al. (2004)
Monechma subsessile C.B.Clarke (TS 332)	Erazi	L	7	Abdominal pain (Mabano and Kakudidi, 2006)	Complement modulating activity (Cos et al., 2002)
Aloeaceae					
Aloe sp., *wild* sp. (TS 336)	Rukaka	L	68	*Aloe kedongensis* used to treat malaria (Njoroge and Bussmann, 2006; Jeruto et al., 2008); root decoction of *Aloe lateritia* against malaria (Haerdi, 1964); leaves of *Aloe* sp. against malaria (Nguta et al., 2010)	Antiplasmodial act. of anthrone C-glucoside homonataloin (van Zyl and Viljoen, 2002); mosquito larvicidal (Matasyoh et al., 2008); polysaccharides, anthraquinones, lectins, proteins (Vogler and Ernst, 1999; Boudreau and Baland, 2006)
Aloe sp., *cultivated*	Enkaka	L	11	Infusion from *Aloe volkensii* used against malaria (Ssegawa and Kasenene, 2007); *Aloe ferox* against malaria (Adriaens, 2006)	Active compounds: polysaccharides, mannans, anthraquinones, lectins, proteins (Boudreau and Baland, 2006; Vogler and Ernst, 1999)
Apiaceae					
Heteromorpha trifoliata Eckl. & Zeyh. (TS 329)	Omume(me)na	L	4	Leaf sap and root decoction drunk to treat malaria (Haerdi, 1964)	Anti-inflammatory activity in saiko-saponins (Recio et al., 1995); major components in oil (Chagonda et al., 2000)
Apocynaceae					
Carissa spinarum Lodd. ex A.DC. (TS 348)	Omuyonza	R	4	Root decoction used to treat malaria (Kokwaro, 1976; Heine et al., 1988; Geissler et al., 2002; Tabuti et al., 2003a; Muthaura et al., 2007)	Anticonvulsant activity (Ya'u et al., 2008); antiplasmodial activity (Clarkson et al., 2004; Koch et al., 2005); saponins (Reed, 1986), sesquiterpenes (Rao et al., 2005)
Aristolochiaceae					
Aristolochia elegans Mast. (TS 364)	Musuja welaba/Kasero	S	4	East coast fever (Tabuti et al., 2003a), abdom. pain and malaria (Neuwinger, 2000), intermittant fever (Milliken, 1997)	Scorpion antivenom effect (Izquierdo et al., 2010); antiviral, monoterpenoids, sesquiterpenoids, diterpenoids (Wu et al., 2004), alkaloids (Shi et al., 2004)
Asteraceae					
Artemisia annua L. (NC)	Sweet Anne	L	7	Long traditional use against fever and malaria in China (Mueller et al., 2004); malaria in Uganda (Adriaens, 2006)	Anti-plasmodial activity (Li et al., 2009); Artemisinin (Kohler et al., 1997)
Aspilia africana (Pers.) C.D.Adams (TS 333)	Ekarwe	L	4	Treat fever and measels (Ssegawa and Kasenene, 2007)	Anti-plasmodial (Waako et al., 2007) and anti-inflammatory (Okoli et al., 2007a) activity, alkaloids, saponins, tannins, flavonoids, resins, sterols, terpenoids (Okoli et al., 2007b)
Bidens grantii Sherff (TS 326)	Ehongwa	L, F	7	Infusion drunk to treat pre-hepatic jaundice and pregnancy disorders (Ssegawa and Kasenene, 2007)	
Bothriocline longipes N.E.Br. (TS 374)	Ekyogayanja	L	18	Used for treatment of ague, fevers, malaria, paludism (Katuura et al., 2007a)	Anti-plasmodial activity (Katuura et al., 2007b) Nine 5-alkylcoumarins elusidated (Jakupovic et al., 1987);
Conyza bonariensis (L.) Cronquist (TS 22, 330)	Ndasha	L	11	Diarrhoea (child) (Giday et al., 2009); body and stomack pain, respiratory ailments, anemia (Adjanohoun et al., 1988)	Gastroesophageal reflux disease treatm. (Omar et al., 2008), sesquiterp. lactones (Fusco et al., 1999), essential oils (Barbosa et al., 2005); glycosides (Zahoor et al., 2010)
Crassocephalum sp. (TS 369)	Nyakabatura	L	4		

Table 1 (*Continued*)

Plant family Species (voucher specimen number)[a]	Local name	Plant part used[b]	% Inf.	Reported relevant ethnomedical uses elsewhere	Biological activity/chemical constituents
Guizotia scabra Chiov. (TS 320)	Ekiterankuba	L	14	Malaria, stomach-ache (Bosch, 2004) DR Congo, Rwanda, Burundi and Uganda HIV/AIDS (Lamorde et al., 2010)	Complement modulating activity (Cos et al., 2002); hepato-protective and hepatotoxic activity (Mukazayire et al., 2010); labdane derivative, lactones, eudesmanoline (Zdero et al., 1991)
Gynura scandens O.Hoffm. (TS 402)	Ekizimya-muriro	L	11	Malaria, febrile convulsions (Moshi et al., 2009)	Pyrrolisidine alkaloids (Wiedenfeld, 1982) Moderately toxic (Moshi et al., 2010)
Microglossa pyrifolia Kuntze (TS 207,334, 375,395)	Omuvugankande/Omuhe	R	11	Malaria (Katuura et al., 2007a; Kokwaro, 1976)	Anti-plasmodial activity (Muregi et al., 2003; Muganga et al., 2010); essential oils (Kuiate et al., 1999)
Pluchea ovalis DC. (TS 328)	Omuneera	L	7	Pesticide to kill insects on cattle (Heine et al., 1988)	Antifungal activity (Mandeel and Taha, 2005); essential oils characterized (Kabera et al., 2005)
Sigesbeckia orientalis L. (TS 392)	Kyaryaho	R	4	Malaria (Wang and Hu, 2006); juice from leaves on wounds (Ssegawa and Kasenene, 2007)	Melampolides (Baruah et al., 1980); diterpenoids and sesquiterpenoids (Wang and Hu, 2006)
Solanecio mannii (Hook.f.) C.Jeffrey (TS 315)	Omusununu/Entarahonda	L	11	Indigestion (Kokwaro, 1976); fever (Adjanohoun et al., 1993); malaria (Heine et al., 1988)	Antimicrobial activity; N-hexacosanol, phytosterols and *n*-alkanes (Mbosso et al., 2010)
Sonchus oleraceus L. (TS 325)	Entahutara	L	4	Whole plant: anemia (Adjanohoun et al., 1993); roots against diarrhoea (Njoroge and Kibunga, 2007); stomachic, tonic (Agra et al., 2007)	Antinociceptive activity in mice (Vilela et al., 2009); antioxidant (Alpinar et al., 2009) and cytotoxic (Yin et al., 2007); depurative (Mouhajir et al., 2001); luteolin, apigenin (Xu and Liang, 2005)
Tithonia diversifolia A.Gray (TS 376)	Ngaro Itano/Komanyoko	L (F)	21	Abdominal pain (Kokwaro, 1976) malaria (Njoroge and Bussmann, 2006); typhoid (Kareru et al., 2008)	Good antiplasmodial activity of main active copmpound tagitinin C (Goffin et al., 2002); sesquiterpene lactones (Baruah et al., 1979)
Vernonia adoensis Sch.Bip. ex Walp. (TS 301, 323, 338)	Nyakajuma	L (F)	29	Diarrhoea, dizziness (Adjanohoun et al., 1993)	Anti-plasmodial activity (Stangeland et al., 2010); glaucolides (Bohlmann et al., 1984); glycocides (Sanogo et al., 1998); polysaccharides (Nergard et al., 2004)
Vernonia amygdalina Delile (TS 111)	Omubirizi	L	86	Fever and malaria (Kokwaro, 1976; Adjanohoun et al., 1993; Asase et al., 2005; Katuura et al., 2007a; Tabuti, 2008)	Anti-plasmodial activity (Masaba, 2000; Tona et al., 2004), steroid glucosides (Jisaka et al., 1992), coumarin (Oketch-Rabah et al., 2000), sesquiterp. lactones (Erasto et al., 2006)
Vernonia lasiopus O.Hoffm. (TS 306, 340)	Omujuma	L	14	Abdominal pain, indigestion (Kokwaro, 1976); malaria (Kakudidi et al., 2000; Ssegawa and Kasenene, 2007; Kareru et al., 2008)	Significant antimalarial activity (Irungu et al., 2007; Muregi et al., 2007); sesquiterpene lactones (Koul et al., 2003); polysaccarides (Nergard et al., 2004)
Bignoniaceae					
Markhamia lutea (Benth.) K. Schum. (TS 398)	Omushambya/Omusha	L	4	Malaria (Vlietinck et al., 1995); cough (Adjanohoun et al., 1993); diarrhoea (Tabuti et al., 2003a)	Phenylpropanoid glycosides (Kernan et al., 1998); anti-parasitic activity, cycloartane triterpenoids (Lacroix et al., 2009)
Caricaceae					
Carica papaya L. (NC)	Ipapali/pawpaw	L	7	Malaria (Bhat and Surolia, 2001; Adriaens, 2006); diarrhoea (Njoroge and Kibunga, 2007); jaundice (Betti and Lejoly, 2009)	Antimalarial (Bhat and Surolia, 2001); antimicrobial (Anibijuwon and Udeze, 2009); immunomodelatory (Otsuki et al., 2010); high ascaricidal effect; alkaloids, tannins, saponins, glycosides (Wasswa and Olila, 2006)

Table 1 (*Continued*)

Plant family Species (voucher specimen number)[a]	Local name	Plant part used[b]	% Inf.	Reported relevant ethnomedical uses elsewhere	Biological activity/chemical constituents
Cucurbitaceae					
Momordica foetida Schumach. (TS 322)	Orwihura	L	7	Fever, malaria, cough (Adjanohoun et al., 1993; Tabuti et al., 2003a)	Moderate in vitro antimalarial activity (Gessler et al., 1994), but in vivo effect on mice (Waako et al., 2005), moderate ascaricidal effect (Wasswa and Olila, 2006)
Euphorbiaceae					
Clutia abyssinica Jaub. & Spach (TS 305, 335)	Omubarama	L	14	Fever, malaria (Glover et al., 1961; Kokwaro, 1976; Njoroge and Bussmann, 2006; Matu, 2008); diarrhoea (Yineger et al., 2007)	Anti-fungal and anti-bacterial activity (de Boer et al., 2005); diterpenes (Waigh et al., 1990)
Tetrorchidium didymostemon (Baill.) Pax & K.Hoffm. (TS 327)	Ekiziranfu	L	7	Gastrointestinal disorders (Ssegawa and Kasenene, 2007); jaundice (Betti and Lejoly, 2009); bark used as enema to treat malaria (Toirambe, 2008)	Saponins and traces of alkaloids (Toirambe, 2008)
Fabaceae					
Arachis hypogea (NC)	Ebinyobwa	L	4		Leaves rich in dietary fibre, vitamine C (Uusiku et al., 2010)
Cajanus cajan (L.) Druse (TS 377)	Entondaigwa	L	7	Diarrhoea (Adjanohoun et al., 1993); malaria (Njoroge and Bussmann, 2006; Tabuti, 2008); pain relief and sedative (Nicholson et al., 2010)	Pinostrobin act as sodium channel inhibitor (Nicholson et al., 2010); antimicrobial activity and chemical composition (Zu et al., 2010); high content of luteolin (Fu et al., 2006)
Indigofera arrecta Hochst. ex A.Rich (TS 324)	Omushoroza	RB	4	Malaria (Vlietinck et al., 1995) Abdominal pain (Bally, 1937)	Blood sugar lowering (Nyarko et al., 1999)
Indigofera emarginella Steud. ex A.Rich. (TS 224, 318)	Omunyazabashumba	RB	4	Cough (Ssegawa and Kasenene, 2007)	Significant in vitro antiplasmodial activity (Waako et al., 2007)
Macrotyloma axillare Verdc. (TS 396)	Akihabukuru	L	4	Dizziness (Haerdi, 1964), impotence (Kamatenesi-Mugisha and Oryem-Origa, 2005)	Bowman–Birck inhibitors with poss. prev. of stomach cancer (Santos et al., 2007); inositol, possible panic disorder treatment (Morris, 2003), D-pinitol (Morris, 2008)
Pseudarthria hookeri Wight & Arn (TS 205, 378)	Omukongorani	L	7	Malarial fever (Adjanohoun et al., 1993; Kakudidi et al., 2000; Tabuti et al., 2003a)	May have estrogenic activity (Njamen et al., 2008)
Rhynchosia viscosa DC. (TS 400)	Kashaka-Karyoya/Omutegansi	L	7	Induce labour, abortifacient (Burkill, 1985)	
Senna didymobotrya (Fresen.) H.S.Irwin & Barneby (TS 307)	Omugabagaba	L	4	Malaria (Glover et al., 1961; Maundu et al., 2001; Mabano and Kakudidi, 2006; Njoroge and Bussmann, 2006; Katuura et al., 2007a)	No anti-plasmodial acvtivity found (Ramalhete et al., 2008), Quinones (Alemayehu et al., 1989)
Lamiaceae					
Hoslundia opposita Vahl (TS 107, 208)	Esitaimwe	F	4	Malaria (Haerdi, 1964; Weenen et al., 1990; Adriaens, 2006); roots and leaves for fever (Kokwaro, 1976)	Antimalarial activity (Gessler et al., 1994), antimalarial compounds (Achenbach et al., 1992); antibacterial activity; alkaloids, tannins, saponins (Ojo and Anibijuwon, 2010)
Ocimum lamiifolium Hochst. (TS 389)	Omwenyi	L	4	Abdominal pain (Kakudidi et al., 2000); leaves burnt as mosquito repellant (Weiss, 1979)	Moderate antimicrobial activity, and components of oil identified (Kifle et al., 2007; Runyoro et al., 2009)
Plectranthus cf. forskohlii (TS 341)	Ekizera	L	7	Malaria (Katuura et al., 2007a)	
Plectranthus sp. (NC)	Akayondo-akakye	L	4	Genus of 300 species, 20 reported used medicinally in East Africa (Lye et al., 2008)	
Tetradenia [*or Plectranthus*] (NC)	Omuravunga	RB	4	*Tetradenia urticifolia* used to treat malaria (Adjanohoun et al., 1993; Kakudidi et al., 2000; Ssegawa and Kasenene, 2007)	Antimalarial activity and 35 components in essential oil identified (Campbell et al., 1997)
Meliaceae					
Azadirachta indica A.Juss. (NC)	Neem	L	14	Fever, malaria (Tabuti et al., 2003a; Adriaens, 2006; Njoroge and Bussmann, 2006; Ssegawa and Kasenene, 2007; Muthaura et al., 2007)	Over 100 compounds isolated: isoprenoids and a wide range of others, several compounds are antipyretic and antimalarial (Biswas et al., 2002)

Table 1 (*Continued*)

Plant family Species (voucher specimen number)[a]	Local name	Plant part used[b]	% Inf.	Reported relevant ethnomedical uses elsewhere	Biological activity/chemical constituents
Musaceae					
Musa paradisiaca (NC)	Kabalagala/Endere/Banana	L	7	Jaundice (Ssegawa and Kasenene, 2007; Betti and Lejoly, 2009)	Insecticide extracts from banana leaf (Gonzales-Curbelo et al., 2011)
Myricaceae					
Myrica kandtiana Engl. (NC)	Omujeeje	L	4	Diarrhoea, vomiting (Adjanohoun et al., 1993)	Inhibit growth of several microorganisms (Maïkere-Faniyo and Puyvelde, 1989)
Myrsinaceae					
Maesa lanceolata Forssk (TS 390)	Omuhanga	L	4	Febrile convultions in children (Adjanohoun et al., 1993); malaria (Kiringe, 2006; Katuura et al., 2007a)	High antiplasmodial activity (Katuura et al., 2007b); extracts highly toxic towards Schistosoma
Passifloraceae					
Passiflora edulis Sims (TS 399)	Akatunda	L	7	Cough, diarrhoea (Adjanohoun et al., 1993; Kakudidi et al., 2000; Tabuti et al., 2003a)	Sedative and anticonvulsant (Bum et al., 2004); flavonoids, glycosides, alkaloids (Dhawan et al., 2004); triterpenoids and saponins (Yoshikawa et al., 2000)
Poaceae					
Cymbopogon citratus Stapf (NC)	Omuteete	L	11	Influenza (Tabuti et al., 2003a); malaria (Bidla et al., 2004; Aiyeloja and Bello, 2006); mosquito-repellent (Oyedele et al., 2002)	Antiplasmodial (Bidla et al., 2004), antibacterial (Ojo and Anibijuwon, 2010), antileishmanial activity; essential oils: citral, geranial, neral and beta-myrcene (Santin et al., 2009)
Rubiaceae					
Pentas longiflora Oliv. (TS 316)	Ishagara	L	4	Fever, malaria (Glover et al., 1961; Kokwaro, 1976; Adjanohoun et al., 1993; Kakudidi et al., 2000; Njoroge and Bussmann, 2006)	High antiplasmodial activity (Wanyoike et al., 2004) Several quinone type compuonds isolated (El-Hadi et al., 2002)
Rutaceae					
Toddalia asiatica Lam. (TS 391)	Kabakura	R	4	Malaria (Katuura et al., 2007a; Muthaura et al., 2007); cough, abdominal pain (Kokwaro, 1976; Adjanohoun et al., 1993)	Significant anti-plasmodial activity (Katuura et al., 2007b), quinoline alkaloids (Ishii et al., 1991), active cpd-nitidine (Gakunju et al., 1995)
Salicaceae					
Trimeria grandifolia ssp. *tropica* (Hochst.) Warb. (TS 393)	Omwatanshare	L	4	Malaria (Njoroge and Bussmann, 2006; Katuura et al., 2007a)	Significant anti-plasmodial activity (Katuura et al., 2007b)
Solanacaea					
Physalis peruviana Mill. (TS 310)	Amantuntunu	L	4	Febrile convultions (Adjanohoun et al., 1993); vomiting (Tabuti et al., 2003a), malaria (Wu et al., 2005)	High antioxidant activity in EtOH extract (Wu et al., 2005) Withanolides (Fang et al., 2009); potent and selective activity against cancer cell line (Fouche et al., 2008)
Verbenaceae					
Lantana trifolia L. (TS 311)	Omuhukye	L	7	Malaria (Haerdi, 1964; Vlietinck et al., 1995; Maundu et al., 2001; Katuura et al., 2007a; Moshi et al., 2009)	Anti-inflammatory and antinociceptive activity (Silva et al., 2005); essential oils (Filho et al., 2010)
Unknown					
Unknown (NC)	Omuhumuza	L	4		
Unknown (TS 304)	Omukuraijo	L	4		
Unknown (NC)	Orujwamate	L	4		

[a] NC, not collected.
[b] L, leaves; R, roots; S, seeds; F, flowers; RB, root bark.

lamifolium, *Tetrorchidium didymostemon*) and 2 species (4%) are used for jaundice (*Bidens grantii*, *Musa paradisiaca*). To our knowledge 4 of the species are not earlier documented in use for malaria or related symptoms: *Pluchea ovalis*, *Arachis hypogea*, *Macrotyloma axillare* and *Rhynchosia viscosa*. Most of the species in this study have been previously analysed for biological activity and/or bioactive compounds. Twenty-one (44%) species have proved to have anti-plasmodial activity in other studies (Table 1), while 6 others have shown anti-microbial or anti-inflammatory activity.

Table 2
Recipes used to treat malaria by members of Nyakayojo TBAs and THs association.

No.	Scientific name (number of recipes for species)[a]	Plant part used[a,b]	Mode of preparation[c]	Added substances	Mode of admin.[d]	Special uses/comments
1	*Vernonia amygdalina* (29)	L (11)	J	Cooled, preboiled water	O	Deworming
		L (4)	D		O	
		DLP (2)	M	Cooled, preboiled water	O	
		L (1)	J	Water	B	Reduce temperature
		L (1)	J	See recipe with *Bothriocline longipes*	B/Sq	
		L (1)	J	See recipe with *Aloe*		
		L (1)	D	See recipe with *Bothriocline longipes*	SB	
		L (1)	I	*Justica betonica and Vernonia adoensis* lvs	O	
		DLP (2)	D		O	
		L & R (1)	D		O	
		L & R (1)	D	*Vernonia lasiopus*, *Guizotia scabra* lvs and *Markhamia lutea* roots (little water)	O	
		R (1)	D	*Tetradenia* root bark	O	
		R (1)	D	*Sigesbeckia orientalis* roots	O	
		RB (1)	D		O	
	Vernonia amygdalina recipe from respondent 9 (1)	L & R (1) (dry)	D	Lvs & flr of *Vernonia adoensis*, *Tithonia diversifolia*, *Bidens grantii*, flr of *Guizotia scabra*, lvs of *Musa paradisiaca* and *Aloe* (indigenous and cultivated)	O	Six plant are dried and stored while *Aloe* lvs are added fresh
2	*Aloe* sp. 'Rukaka' (indigenous) (18)	L (11)	D		O	Jaundice
		L (2)	J	Cold water	O	
		L (1)	B	Banana juice	O	
		L (1)	D	Lvs of other plant (unknown)	O	
		L (1)	I	*Bidens grantii* leaves when in flower	O	Yellow eyes
		L (1)	J	*Vernonia amygdalina* and *Vernonia lasiopus* lvs	O	
		L (1)	D	See recipe 9 with *Vernonia amygdalina*		
3	*Vernonia adoensis* (12)	L (2)	D		O	
		L & F (1)	D		O	
		L & F (1)	D	*Vernonia amygdalina* and *Justica betonica* lvs	O	
		L & F (1)	D	See recipe 9 with *Vernonia amygdalina*	O	
		L (1)	I		O	
		L (1)	J	Water	O	
		L (1)	I	*Vernonia amygdalina* and *Justica betonica* lvs	O	
		L (1)	D	See recipe with *Clutia abyssinica*	O	
		L (1)	D	*Guizotia scabra* lvs,	O	
		L (1)	D	See recipe with *Bothriocline longipes*	SB	
		R (1)	D		O	Splenomegaly
4	*Justica betonica* (10)	L (4)	D		O	Flatulence
		L (1)	D	Omuhumusa	O	Cough
		L (1)	D	*Bothriocline longipes* lvs	O	
		L (1)	I		O	Worms
		L (1)	I	*Vernonia amygdalina* and *Vernonia adoensis* lvs	O	
		L (1)	J	Cooled, preboiled water	O	
		DLP (1)	D		O	
5	*Tithonia diversifolia* (5)	L & F (2)	D		O	
		L & F (1)	D	See recipe 9 with *Vernonia amygdalina*	O	
		L (2)	D		O	
6	*Guizotia scabra* (5)	L (1)	I		O	
		L (1)	D	See recipe with *Vernonia amygdalina*	O	
		L (1)	D	*Vernonia adoensis* lvs	O	
		L (1)	D	See recipe with *Bothriocline longipes*	SB	
		F (1)	D	See recipe 9 with *Vernonia amygdalina*	O	

Table 2 (*Continued*)

No.	Scientific name (number of recipes for species)[a]	Plant part used[a,b]	Mode of preparation[c]	Added substances	Mode of admin.[d]	Special uses/comments
7	*Azadirachta indica* (5)	L (3)	D		O	
		L (1)	D	See recipe with *Aloe* (Enkaka)	O	
		L (1)	I		O	
8	*Bothriocline longipes* (5)	L (1)	D	See recipe with *Musa paradisiaca*	SB	
		L (1)	D	*Aspilia africana* lvs	O	
		L (1)	D	See recipe with *Justica betonica*	B	
		L (1)	J	*Vernonia amygdalina*, *Gynura scandens*, *Tetrorchidium didymostemon* lvs, cold water	B	
		L (1)	D	*Vernonia amygdalina*,*Vernonia adoensis*, *Guizotia scabra*	SB/Sq	
9	*Aloe* sp. 'Enkaka' (cultivated) (4)	L (1)	J		O	
		L (1)	D		O	
		L (1)	D	*Azadirachta indica*	O	
		L (1)	D	See recipe 9 with *Vernonia amygdalina*	O	
10	*Clutia abbysinica* (4)	L (1)	I	See recipe with *Physalis peruviana*	O	Splenomegaly
		L (1)	D	*Vernonia adoensis*, *Trimeria grandifolia* lvs, lemon peel	O	
		L (1)	J	Cooled, preboiled water	O	
		L (1)	D	*Heteromorpha trifoliata* lvs	O	
11	*Vernonia lasiopus* (4)	L (1)	D		O	
		L (1)	J		O	
		L (1)	D	See recipe with *Vernonia amygdalina*	O	
		L (1)	J	See recipe with *Vernonia amygdalina*, *Aloe*	O	
12	*Gynura scandens* (4)	L (2)	J		B + O	Reduce temperature
		L (1)	J	See recipe with *Bothriocline longipes*	B	
		L (1)	D	See recipe with *Bothriocline longipes*	B	
13	*Cajanus cajan* (3)	L (1)	M	*Rhynchosia viscosa*	O	Splenomegaly
		L (1)	M	2. Milk, *Rhynchosia viscosa*	O	Diarrhoea
		L (1)	M		O	
14	*Conyza bonariensis* (3)	L (2)	D		O	Overdose: diarrhoea
		L (1)	J	Cooled, preboiled water		
15	*Cymbopogon citratus* (3)	L (1)	D		O	Reduce temperature
		L (1)	D	See recipe with *Hoslundia opposita*	O	
		L (1)	D	*Carica papaya* lvs	O	
16	*Momordica foetida* (3)	L (1)	D	Banana and *Bothriocline longipes* lvs	SB	
		L (1)	D	See recipe with *Musa paradisiaca*	SB	
		L (1)	J	*Lantana trifolia*, *Solanecio mannii* lvs, water	O	
17	*Pluchea ovalis* (3)	L (1)	D		O	
		L (1)	M	Rock salt	O	Increase appetite
		DL	D			Diarrhoea
18	*Solanecio mannii* (3)	L (1)	J	See recipe with *Momordica foetida*		
		L (2)	I		O	Constipation
19	*Artemisia annua* (2)	L (1)	D		O	Prophylactic: drink once
20	*Carica papaya* (2)	L (1)	D	*Cymbopogon citratus*	O	
		R	D			
21	*Lantana trifolia* (2)	L (1)	J	Water	O	
		L (1)	J	See recipe with *Momordica foetida*	O	

Table 2 (*Continued*)

No.	Scientific name (number of recipes for species)[a]	Plant part used[a,b]	Mode of preparation[c]	Added substances	Mode of admin.[d]	Special uses/comments
22	*Markhamia lutea* (1)	L (1)		*Plectranthus* sp., water	O	Stop vomiting
		R (1)	D	See recipe with *Vernonia amygdalina*	O	
23	*Monechma subsessile* (2)	L (1)	D	See recipe with *Hoslundia opposita*		
		L (1)	I	See recipe with *Physalis peruviana*	O	Splenomegaly
24	*Microglossa pyrifolia* (2)	L (1)	D		O	For constipation
		L (1)	D	See recipe with *Justica betonica*	B	
25	*Musa paradisiaca* (2)	L (1)	D	*Bothriocline longipes* and *Momordica foetida* lvs	SB	
		L (1)	D	See recipe 9 with *Vernonia amygdalina*		
26	*Passiflora edulis* (2)	L (2)	J	Cooled, preboiled water		
27	*Plectranthus cf. forskohlii* (2)	L (2)	D		O	
28	*Rhynchosia viscosa* (2)	unknown	M	See recipe with *Cajanus cajan*	O	
29	*Tetrorchidium didymostemon* (2)	L (1)	J	Cold water	B	
		L (1)	D	See recipe with *Bothriocline longipes*	B	
30	*Pseudarthria hookeri* (2)	L (1)	D	See recipe with *Hoslundia opposita*	O	
		L (1)	D		O	Reduce temperature
31	*Senna didymobotrya* (2)	L (1)	D		O	Children with splenomegaly
		DLP	AF		O	
32	*Arachis hypogea* (1)	L (1)	J	Cooled, preboiled water	O	
33	*Aristolochia elegans* (1)	S (1)	M		O	
34	*Aspilia africana* (1)	L (1)	D	*Bothriocline longipes*	O	
35	*Bidens grantii* (1)	L & F (1)	D	See recipe 9 with *Vernonia amygdalina*	O	
36	*Carissa spinarum* (1)	R (1)	D	*Toddalia asiatica*	O	
37	*Crassocephalum* (1)	L (1)	I		O	
38	*Heteromorpha trifoliata*	L (1)	D	*Clutia abyssinica* lvs	O	
39	*Hoslundia opposita* (1)	F (1)	D	Lvs of *Cymbopogon citratus*, *Monechma subsessile*	O	Abdominal
40	*Indigofera arrecta* (1)	RB (1)	D		O	Reduce temperature
41	*Indigofera emarginella* (1)	RB (1)	I		O	
42	*Macrotyloma axillare* (1)	L (1)		See recipe with *Hoslundia opposita*	O	
43	*Maesa lanceolata* (1)	L (1)	M		B	Yellow fever
44	*Myrica kandtiana* (1)	R (1)	D		O	Too much: stom. pain
45	*Ocimum lamiifolium* (1)	L (1)	D		O	Toxic, little at a time
46	*Pentas longiflora* (1)	L (1)	B J	Water	O	Constipation
47	*Physalis peruviana* (1)	L (1)	I	*Monechma subsessile*, *Clutia abbysnica*	O	Splenomegaly
48	*Plectranthus* sp. (1)	L (1)	J	See recipe with *Markhamia lutea*	O	Stop vomiting
49	*Sigesbeckia orientalis* (1)	R (1)	D	*Vernonia amygdalina*	O	
50	*Sonchus oleraceus* (1)	L (1)	I		O	
51	*Tetradenia* or *Plectranthus* (1)	RB (1)	D	See recipe with *Vernonia amygdalina*	O	
52	*Toddalia asiatica* (1)	R (1)	D	*Carissa spinarum* roots	O	
53	*Trimeria grandifolia* ssp. *tropica* (1)	L (1)	D	See recipe with *Clutia abyssinica*	O	
54	Omuhumuza (1)	L (1)	D	See recipe with *Justica betonica*	O	
55	Omwenyi (1)	L (1)	I	See recipe with *Physalis peruviana*	O	Splenomegaly
56	Orujwamate (1)	L (1)	J	Water	O	

[a] Consensus, as number of citations are written in paranthesis for each species and plant part used. When several plants are used together the whole recipe is given by the plant that is mentioned first in the recipe. For the other plants it is pointed to the recipe.

[b] L, leaves; DL, dry leaves; DLP, dry leaf powder; R, roots; RB, root bark; S, seeds; F, flowers; U, unknown.

[c] J, juice; D, decoction; I, infusion; M, maceration; B, boil; AF, add in food.

[d] O, oral; B, bath; SB, steam bath; Sq, squeezed on patient.

Table 3
Malaria symptoms mentioned by respondents.

Symptom	(%)
High body temp.	75
Shivering	75
Headache	39
Vomiting	29
Pale eyes	25
Loss of appetite	25
Weakness, not active	25
Abdominal pain	21
Diarrhoea	18
Jaundice/yellow skin	14
Yellow eyes	11
Goose pimples	11
Fast heart rate	7
Blisters on mouth	7
Thirst	7
Fluctuating temperature	7
Anaemic	7
Pale skin/hands	7
Mental confusion/hallucinations	7
Backache/stiff neck	7
Dry lips	4
Yellow placenta	4
Red eyes	4
Constipation	4
Change in colour/physical apper	4
Urinating yellow urine	4
Cold feet	4
Dizziness	4
Weak but no fever	4
Nausea	4
Vomiting yellow	4
Sweating	4
Convulsions	4

The high diversity of species used for treatment of malaria, is an indication of the importance of medicinal plants. The reliance on traditional medicine may be due to the perceived potency of the plants. High consensus among users in different countries reflects the significance of medicinal plants to the people. There are different ways to determine the usefulness of a plant as an antimalarial. Willcox and Bodeker (2004) developed an importance value for treatment of malaria (IVmal), where herbal antimalarials were categorised according to how widespread their use is. Species in IVmal category 1 are quoted only in one study, while the ones in category 8 are reported used in three continents. According to Willcox and Bodeker (2004) there were only 11 species in category 8, and none of them are found in our study. However, four species in our study, namely *Carica papaya*, *Tithonia diversifolia*, *Azadirachta indica* and *Sigesbeckia orientalis* are in category 7; species used for malaria or fever in 2 continents (Willcox et al., 2004), while 23 of 48 species or nearly 50% belong to category 6 (used in more than one country in the same continent).

Vernonia amygdalina is by far the most commonly used treatment by this group of traditional birth attendants. Several studies document good antimalarial effect of its leaf extract (Tona et al., 2004; Njan et al., 2008). However, Kamatenesi-Mugisha and Oryem-Origa (2007) found that *Vernonia amygdalina* was one of the plants used traditionally in Mbarara district to induce labour, which may indicate that the plant has abortifacient effects. It is urgent to test antimalarial plants used by pregnant women for effect on smooth muscles to find which of the plants are safest to use. In another Ugandan study Lacroix et al. (2010) found that *Vernonia amygdalina* had the highest anti-plasmodial effect of 28 plant species tested, but strong cytotoxicity towards two cell lines was observed as well.

However, a large number of plants in Aryuverdic medicine are often combined to create synergy, reduce toxicity and increase bioavailability. Boiling *Aconitum* tubers in water converts the toxic aconitine to less toxic aconine. Treating *Commiphora mukul* by boiling and skimming is reported to render it non-toxic (Premila, 2006). In East Africa, practitioners administer some herbs in combination in order to improve efficacy or safety (Kokwaro, 1993; Tabuti et al., 2003b).

One of the respondents used only one recipe, but this tea was a combination of eight of the most commonly reported plants for malaria treatment. Six of the plants were collected, dried, mixed and stored until needed, and fresh aloe was added as the decoction boiled. This seems like a cost-effective solution. In further work we want to evaluate the effect of this and other recipes. We have been able to test three plants used in Uganda for anti-plasmodial activity (Stangeland et al., 2010). Further research on bioassay-guided fractionation, toxicity and clinical trials has been started, but need further funding.

Forty-three percent of the recipes were mixtures of several plants. Azas et al. (2002) found synergistic in vitro antimalarial activity in a mixture of plants traditionally used. Even if it is more difficult to investigate active principles in mixtures, they should be tested for effect, as they might be the best treatments. Sometimes practitioners may use a mixture of plants to hide which plant is the active one.

5. Conclusion

This study shows that there is a great diversity in how a group of traditional birth attendants and healers use plants and modes of preparation to treat malaria, even if they are in the same association. If the same plant is used for the same or similar disease in different parts of Uganda or in different countries or continents it may indicate a good effect of the treatment. Classification shows that 56% of the species in this study belong to IVmal 6 or higher, i.e. used in more than one country or continent. This preliminary study should be followed by a study on the response of herbal treatment on patients with malaria. However, in vitro anti-plasmodial and toxic effect studies of the plants are needed before any clinical trial can be carried out. Many of the recommended plants have proved to have activity against malaria, but a final step is lacking: how to turn the active plants into phytomedicines which are safe and effective. If this kind of research shall have effect on the health and well being of people in Africa, it is of great importance to have time and funding to follow the process until a product is developed. This is possible and has already been done in the West African country Mali where the Improved Traditional Medicine "Malarial-5" has been developed (Diallo et al., 2004). With joint efforts we hope a similar medicine can be developed in East Africa.

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