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PLANTS FOR MALARIA TREATMENT IN SOUTHERN UGANDA: TRADITIONAL USE, PREFERENCE AND ECOLOGICAL VIABILITY

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ABSTRACT.—A study on ethnomedicinal use, preference for species, and ecological viability of plants used for treating malaria was carried out among the communities living around the Sango Bay Forest Reserve in southern Uganda. Semi-structured interviews and informal discussions were used to collect ethnobotanical information. Abundance and demographic patterns of the key forest tree species used to treat malaria were determined, using 45 plots of 0.1 ha. Sixteen species representing 11 families and 14 genera were reportedly used to treat malaria, including four new reports. *Hallea rubrostipulata* (K. Schum.) J.-F.Leroy, *Warburgia ugandensis* Sprague, and *Syzygium guineense* (Willd.) DC. were the most important forest tree species used to treat malaria and were chosen for further study. The three species were found to be highly valued in the treatment of malaria and similarly used by the local people as determined by the clustering procedure. The species generally had an inverse J-shaped curve in their population structures, indicating viable regenerating populations. The recognition of the use of traditional medicine by the local communities as an integral and essential part of their health care system is vital in the conservation and sustainable utilization of these plants.

Key words: medicinal plants, malaria, sustainable use, traditional knowledge, Uganda.

RESUMEN.—Se llevó a cabo un estudio sobre el uso etnomédico, la preferencia y la viabilidad ecológica de las plantas usadas para curar la malaria en comunidades de los alrededores de la Reserva Forestal de la Bahía de Sango, en el sur de Uganda. Para recopilar la información etnobotánica se realizaron entrevistas semiestructuradas y discusiones informales. Se evaluó la abundancia y los patrones demográficos de las especies antipalúdicas arbóreas más importantes, en 45 parcelas de 0.1 Ha. Se registró el uso de 16 especies pertenecientes a 11 familias y 14 géneros, incluidos cuatro nuevos registros. *Hallea rubrostipulata* (K. Schum.) J.-F.Leroy, *Warburgia ugandensis* Sprague, y *Syzygium guineense* (Willd.) DC. fueron las especies más importantes para el tratamiento de la malaria y se seleccionaron para estudios posteriores. Estas tres especies se consideraron las más valoradas en la curación de la malaria y se empleaban de un modo similar por la población local según indica el modelo de agrupamiento. La estructura poblacional de la mayoría de las especies tiene forma de J invertida, lo cual indica poblaciones que se están regenerando. El reconocimiento del uso de la medicina tradicional por las comunidades locales como elemento fundamental de su sistema de salud, es esencial para la conservación y uso sostenible de estas plantas.

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RÉSUMÉ.—Une enquête touchant l'ethnomédecine, la préférence des espèces et la viabilité écologique des plantes utilisées dans le traitement de la malaria a été menée parmi les communautés situées aux alentours de la réserve forestière de Sango Bay au sud de l'Uganda. Des interviews semi-structurées ainsi que des discussions informelles ont été utilisées lors de la récolte de données ethnobotaniques. La structure démographique et l'abondance des essences clés des arbres utilisés dans la lutte contre la malaria ont été déterminées sur 41 parcelles, chacune de 0,1 ha. Seize espèces issues de 11 familles et 14 genres sont reconnues par les communautés pour traiter efficacement la malaria. De ces 16 espèces, 4 d'entre elles forment de nouvelles mentions. Les espèces *Hallea rubrostipulata* (K. Schum.) J.-F.Leroy, *Warburgia ugandensis* Sprague et *Syzygium guineense* (Willd.) DC. figurent au rang des arbres les plus importants utilisés contre la malaria. Aussi, ces espèces feront l'objet d'études ultérieures plus poussées. Lors des analyses de groupement, ces 3 espèces ressortent comme des espèces de grande valeur dans le traitement de la malaria. Elles sont bien connues et leurs utilisations se recoupent amplement parmi la population locale. Ces espèces possèdent généralement une courbe de type J inversé en ce qui a trait à la structure de leurs populations, indiquant ainsi que ces dernières sont viables et ont une bonne régénérescence. Le fait que les communautés locales reconnaissent la médecine traditionnelle comme une part intégrale et essentielle de leur système de santé est vital quant à la conservation et l'utilisation durable de ces plantes.

INTRODUCTION

A vast number of rural communities rely on traditional medicine for treating common and specific health problems (Diallo and Paulsen 2000; Kamatenesi-Mugisha and Oryem-Origa 2005; Stangeland et al. 2005; Tabuti et al. 2003a). In Uganda, malaria remains the major cause of morbidity and mortality, followed by HIV/AIDS, with serious economic and social consequences. It accounts for 29 to 50% of out-patient consultations, 30% of in-patient admissions and nine to 14% of in-patient deaths (20 to 23% of deaths of children under 5 years of age), and kills about 360 people each day, according to the Health Sector Strategic Plan (2003/2004) of the Ministry of Health. Medicines based on traditional knowledge of wild plants serve as some of the most common treatments for malaria in Uganda.

Several plant species are used to treat malaria in Uganda. Katende et al. (1995, 1999), Bukenya-Ziraba et al. (1997) and Anakbongo et al. (1987) reported over 15 species used to treat malaria throughout the country. Kakudidi et al. (2000) and Oryem-Origa et al. (2003) reported *Vernonia amygdalina* Delile and *Senna didymobotrya* (Fresen) Irwin & Barney as two of the most common species used in South Western and Central Uganda. Tabuti et al. (2003b) reported over 20 species used in Bulamogi county, Eastern Uganda, to treat malaria and malaria-related ailments. However, none of these studies report on viability of the species used from the wild.

There are worldwide observations of utilization by many people on non-timber forest products, such as medicines for their health, subsistence and

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economic needs, but many of these may not be harvested in a sustainable manner (e.g., Campbell et al. 1997; Dhillion and Gustad 2004; Gustad et al. 2004; Shrestha and Dhillion 2003; Sinha and Bawa 2002). There are many claims of over-exploitation of the non-timber forest products and there is need for management based on ecological studies. In general, little is known about the viability of harvesting medicinal plants. Few ecological studies have been done, and in most instances, case-by-case evaluations are required (Boffa 1999; Dhillion 2005; Dhillion and Ampornpan 2000; Dhillion and Amundsen 2000; Hall and Bawa 1993; Neumann and Hirsch 2000).

Regeneration is a critical variable for the assessment of the impacts of harvesting on non-timber forest product-generating plants (Hall and Bawa 1993) and it is better assessed over long periods of time (Boot and Gullison 1995). However, an analysis of age or size structure of a population at a single point in time can also provide valuable information. An identification of poorly represented stages of life history could suggest a negative impact of harvesting on regeneration (Dhillion and Amundsen 2000; Hall and Bawa 1993), and this may be particularly useful for slow-growing or long-lived plant species (Dhillion and Gustad 2004).

In this study we report on the medicinal plants used to treat malaria by the communities living around the Sango Bay forest reserves, highlighting local use, importance, and ecological viability of the three most important tree species used to treat malaria. The viability of a population (regeneration potential) is expressed as a characteristic that is determined by the mature population size (adults) and its regeneration (young individuals/recruits) potential (Dhillion and Gustad 2004). The specific objectives of this study were: (1) to determine the plants used and preferred, including the efficacy of treatment reflected by their relative importance; (2) to assess whether there is any difference in the mode of harvesting, administration and use of these species in comparison to other parts of the country; and (3) to examine the ecological viability of the three most important tree species, and if there are any local management practices of medicinal plants.

STUDY AREA

Name, Location and Area.—The Sango Bay Forest Reserve is located in southern Uganda near Lake Victoria and consists of Kaiso, Malabigambo, Namalala, Tero West, and Tero East forest blocks (Figure 1). The Kaiso and Malabigambo blocks are contiguous with the Minziro forest blocks in Bukoba District, Tanzania.

There are three human settlements in the reserve: Minziro, Kanabulemu and Gwanda-Kasensero. The former two are enclaves in the forest reserve, while Gwanda-Kasensero is partly surrounded by the forest. The reserve is located between latitude 0°47 and 1°00′ S and longitude 31°28 and 31°43′ E. The total area of Sango Bay Forest Reserve is 576 km^2 of which approximately 180 km^2 is forested and almost 400 km^2 is grassland. The grassland areas now in the reserved forest lands were public lands until recently when they were gazetted.

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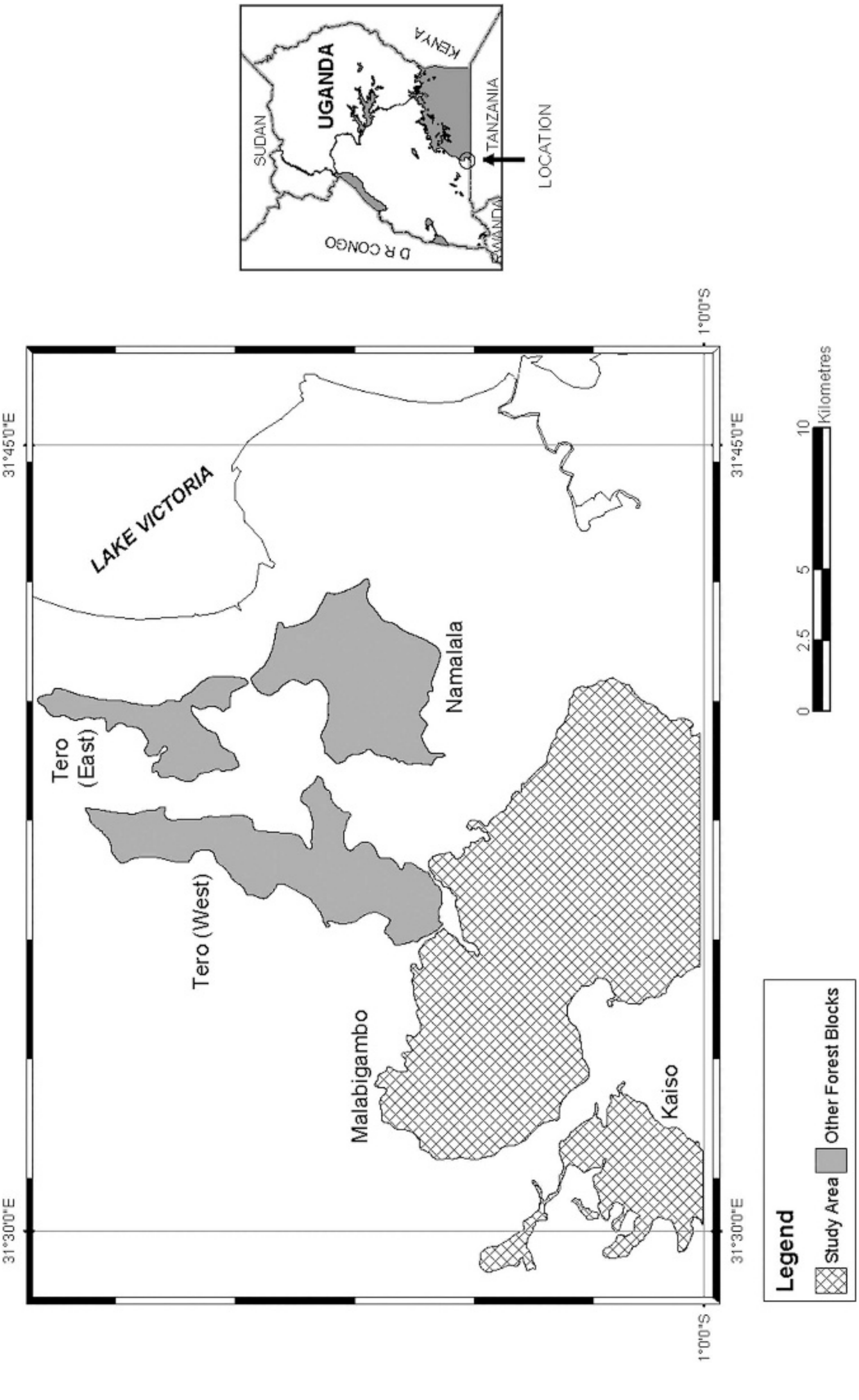

FIGURE 1.—Location of the Sango Bay Forest Reserve (Data source: National Biodiversity Databank at the Makerere University Institute of Environmment and Natural Resources (MUIENR)).

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The study was carried out in the villages of Kanabulemu and Minziro located in Kakuuto subcounty, Rakai district. There are over 150 households and a combined population of about 550 people. The area possesses unique physical, biological and ethnic features. The terrain is characterized by moderate to steep hill slopes. It experiences bimodal rainfall with peaks around April/May and October/November. The major ethnic groups include the Baganda, Banyankole, Barundi, Banyarwanda and the Baziba from northern Tanzania. These are mainly Christian peoples (about 80%), with few Muslims.

The inhabitants are mainly subsistence farmers living in small scattered settlements. Bananas, maize, cassava, sweet potatoes, and beans are the main food crops while coffee and, lately, beans are the main cash crops. There are migrant pastoralists who are mainly Banyarwanda and Banyankole. They graze their cattle in the vast grasslands that comprise part of the forest reserve.

The main diseases afflicting the local communities are gastro-intestinal diseases that primarily affect the children. However, malaria is the principal specific disease that causes the highest mortality rates, especially among children under the age of five years. In most cases, traditional medicine is used in the treatment of the diseases.

Vegetation Types.—The Sango Bay Forest Reserve is a complex forest/wetland ecosystem. The vegetation of the five forest blocks was broadly classified as *Baikiaea-Podocarpus* seasonal swamp by Langdale–Brown et al. (1964). However, significant changes have taken place in terms of mature ecosystem species composition, as a result of several years of commercial logging. Recent surveys by the National Forest Authority indicate that the current canopy species belong predominantly to the genera *Baikiea* and *Cleistanthus*. It is the only site in East Africa for this specialized community where *Afrocarpus dawei* (Stapf) C.N. Page and *Podocarpus milanjianus* Rendle are known to grow at such a low altitude. The grasslands, which form some two-thirds of the reserve, are predominantly tussocks of *Miscanthus violaceus* (K. Schum) Pilg., *Loudetia kagerensis* (K. Schum.) Hutch., and *Themeda triandra* Forssk. The tussock-like nature of the grasslands is a result of seasonal flooding accompanied by erosion. *Syzygium cordatum* Hochst. is the major tree species along wetter drainage areas.

METHODS

Ethnobotanical Survey.—Field work for this study was carried out between January and October 2003. Semi-structured interviews, questionnaires, and direct observation were the main forms of data collection. Two local assistants helped in establishing rapport with the local communities and with data gathering. One of the assistants was a forest ranger and had considerable knowledge of the forest.

A pilot study over one week was conducted at the beginning of the study to gather a general understanding and test the questionnaire. Following the pilot study, a detailed survey using a mixture of open-ended and close-ended questionnaires during face-to-face interviews was conducted. Interviews were conducted in the local language, the Luganda (Buddu dialect). Household respondents were selected randomly, although we never interviewed anyone

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under 18 years old because they were presumed to have limited knowledge of traditional medicine, and did not generally partake in the preparation and administration of medicines. We interviewed either the head of the household, wife or older children. In some cases we interviewed both the head of the household and his wife, if during the course of the interview we discovered that the wife had good knowledge of medicinal plants (possibly served as a traditional herbalist). Effort was made to get key informants, either in the form of traditional herbalists ($n = 2$ male) and the elderly respected people ($n = 3$ male/ 1 female) to verify the information gathered from the households. Informal discussions were also held with the local people to get additional information. This would help verify and corroborate information gathered (Briggs 1986; Crane and Angrosino 1992).

During the interviews, respondents were asked to rank the species in order of importance in the treatment of malaria, regardless of their abundance or availability. This would help identify the three key forest tree species considered most important by the people in the treatment of malaria. These were studied further to assess their ecological viability (see below). Altogether, 102 respondents (63 males and 39 females) from 69 households in the villages of Kanabulemu and Minziro were interviewed in the survey. Eighty respondents (78.4%), 54 male and 26 females, acknowledged that they use traditional medicine to treat malaria. The questions in the questionnaire included what plants they used against malaria and the parts they used, frequency of use, and local/traditional plant management measures. The interviews were supplemented by direct observations and walks. During the walks, plants used by the people were identified using local languages and scientific names ascertained from voucher specimens.[1]

Plant Population Structure: Layout of Transects and Sample Plots.—Plots of 20 × 50 m (0.1 ha.) were used to census trees for diameter at breast height (DBH), saplings, poles, and mature trees of the three key species in 45 plots (Tchouto 2004). Recording of seedlings was also done in the plots, and presence of mother trees called for a more rigorous search for the seedlings. It was relatively easy to census the seedlings because we targeted the key species only. Stems in the plots were categorized in different classes up to over 60 cm DBH. Plots were located along transects that varied from 1400 m to 2000 m at intervals of 250 m. Diameter of each tree was measured at breast height (1.3 m above the ground) using a diameter tape. Diameters of trees with buttresses were measured at a point just above the buttresses. For each species, seedlings (diameter < 5 cm), and diameter classes of (5 – 19.9 cm), (20 – 39.9 cm), (40 – 59.9 cm) and (DBH > 60 cm) were identified and counted, and diameter was determined. There were no stumps of the target species that could be identified.

To provide an indication of the degree of exploitation, and therefore intensity of harvesting of bark or mutilation, the debarked section on the stem of each mutilated tree was categorized. The extent of debarking was determined in relation to diameter and size of debarked section of the tree (1= small section of stem debarked; 2= big section of stem debarked; 3= very big section of stem debarked) (see Dhillion and Gustad (2004) for this approach). To minimize errors

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in identification, voucher specimens for the lesser known species were collected and each was given a specific number.

Data Analysis.—Ethnobotanical data was analyzed both qualitatively and quantitatively. Responses from the open-ended questions were grouped into classes that expressed similar ideas while percentages, based on valid responses only, were calculated from close-ended questions. Selection of the most important tree species used to treat malaria was based on the frequency of reporting and preference ranking, as used by Noweg et al. (2003). The Friedman test (Ludwig and Reynolds 1988; Zar 1984) was used to determine whether there were significant differences in the use of plants by respondents. We evaluated for significant differences in use of medicinal plants to treat malaria with education level and marital status through the use of the non-parametric Kruskal-Wallis one-way analysis of variance test.

Cluster Analysis: Similarities in the Use of Species.—We used cluster analysis to sort objects (such as sampling units) into groups or clusters based upon their overall resemblance to one another (Ludwig and Reynolds 1988). To place species into meaningful groups, the Simple Matching Coefficient (SM) for all combinations of site pairs were summarized into a 16 $\times$ 80 similarity matrix. An agglomerative clustering technique (weighted centroid) provided in the Multivariate Statistical Package of Kovach (1999) was used to produce a dendrogram containing all 16 species.

A minimum SM of 0.2 was used for defining clusters. Other measures of similarity and also measures of distance between sites were attempted along with several different methods of clustering (single-linkage and complete-linkage techniques). All techniques provided similar results, with the SM and weighted centroid clustering being most meaningful from the ethnoecological point of view.

Significance of Clusters.—To determine whether there were significant differences between the use of the different species and also whether there was significant differences between the clusters of species generated using cluster analysis, the Friedman test was used.

RESULTS

Socio-demographic Attributes of the Respondents.—The majority of the respondents (67.5% of respondents) were males and had basic primary level education (83.8% of the respondents) as shown in Table 1. Seventy-five percent of respondents were under 38 years of age and the majority were married (88.8% of the respondents). Their income was so low that the majority were characterized as poor (66.3% of the respondents). Being poor meant that you could earn about US$ 1 per day, living in temporary houses constructed from mud and thatched with grass (26.3% of the respondents).

Since the majority of them were married, this can imply that they may have children who may fall sick of malaria and/or related ailments. This necessitates the parents, in particular the head of the household, to look for the medicinal

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plants in the forests and adjacent grasslands as the wives do the domestic chores. Neither the level of education (K = 0.782, df = 2, $P > 0.05$ Kruskal-Wallis test) nor marital status (K = 1.091, df = 2, $P > 0.05$ Kruskal-Wallis test) seemed to influence the choice of use of medicinal plants against malaria, but rather the need to treat malaria.

Medical Practices.—Most of the respondents used malaria medicinal plants two to four times per month (67.5% of the respondents), traveling over 1 km (57.5% of the respondents) in search of the medicinal plants in grasslands, abandoned fields or forest (Table 1). However, the health centers were reportedly further from residential homes, with a majority reporting that they are over 1 km away (70% of the respondents).

Many of the respondents argued that they would only go to health centers if the traditional medicine failed (87.8% of the respondents), while others would only go there with acute cases of malaria because traditional medicine does not act as quickly as modern medicine (Table 1).

Traditional Medicinal Plant Management.—Very few respondents cultivate medicinal plants used to treat malaria (Table 1, 6.6% of the respondents). Cultivation was mainly practiced by the few traditional herbalists. However, many preserved those medicinal plants that grow in home gardens and abandoned fields (47.1% of the respondents). These were primarily herbaceous medicinal plants, as shown in Table 2. There was a tendency to nurture valued but rare medicinal plant species, especially in the wooded grasslands adjacent to the forest, such as *Warburgia ugandensis* (25.1% of the respondents).

Plants Used to Treat Malaria.—During the ethnobotanical survey, 16 plant species were reported by the respondents to treat malaria (Tables 2 and 3). These represented 11 families and 14 genera. Four species belonged to the family Fabaceae. Asteraceae and Myrtaceae were represented by two species each, whereas the other families were represented by a single species each. Eight species (50%) were trees, two species (12.5%) were shrubs and six species (37.5%) were herbaceous plants. Eight (50%) of the species recorded were typical forest species, whereas the others also occur in grassland and other vegetation types. The most important species used was *Hallea rubrostipulata* (tree) ranked by 51 (63.8%) of the respondents followed by *Vernonia amygdalina* (shrub), *Warburgia ugandensis* (tree) and *Syzygium guineense* (tree) being ranked by 40%, 28.8% and 16.3% of the respondents, respectively. Only tree species were chosen for ecological viability studies, so *Vernonia amygdalina*, a shrub, was excluded.

Local Use and Importance of Medicinal Plants.—*Hallea rubrostipulata, Warburgia ugandensis* and *Syzygium guineense* were ranked as the most important forest tree species used in the treatment of malaria (Table 2). The majority of the plants have been reported in earlier studies to treat malaria and other ailments (Tables 2 and 3). *Vernonia amygdalina* (a shrub) has been reported to be widely used in the country to treat malaria and other ailments (Adriaens 2005; Bukenya-Ziraba et al. 1997; Kakudidi et al. 2000; Katende et al. 1995, 1999; Ogwal-Okeng 1998; Oryem–Origa et al. 2003; Tabuti et al. 2003b). This study reports the use of four species for

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TABLE 1.—Socio-demographic attributes and traditional medicinal plant management practices of the respondents.

Characteristic	Frequency (%)
1. Sex	
Male	67.5
Female	32.5
2. Age	
18 – 27 years	40
28 – 37 years	35
38 – 47 years	8.8
48 – 57 years	2.5
Over 57 years	13.8
3. Education	
No formal education	10
Primary level	83.8
Secondary level	6.3
4. Marital status	
Single	3.8
Married	88.8
Widowed	7.5
5. Primary occupation	
Farmer	87.5
Trader	2.5
Other [1]	2.5
6. Type of dwelling	
Temporary	26.3
Semi-permanent	42.5
Permanent	31.3
7. Household income	
Comfortable	31.3
Poor	66.3
Very poor	2.5
8. Frequency of use of malaria plants	
A few times a week	12.5
A few times in a month	67.5
A few times in a year	20
9. Distance travelled to collect herbal medicine	
Under 500 m	17.5
Between 500 m and 1km	25
Between 1 km and 2 km	36.3
Over 2 km	21.3
10. Distance to health centers from residential homes	
Under 1 km	30
Between 1 km and 2 km	35
Over 2 km	35
11. Circumstances under which they would go to health centers (n=74)	
Acute cases of malaria	6.3
When traditional medicine fails	81.3
Use of both traditional and modern medicine	5

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TABLE 1.—Continued.

Characteristic	Frequency (%)
12. Cultivation of malaria medicinal plants	
Cultivate	6.6
Do not cultivate	71.3
13. Preservation of malaria medicinal plants in gardens etc	
Preserve	47
Do not preserve	53

Only the frequencies of valid responses are represented here.
[1] Other occupations include fisherman, hunter, etc.

the first time: *Hyptis pectinata* Poir., *Indigofera congesta* Baker, *Manilkara obovata* (Sabine & G.Don), and *Sopubia ramosa* (Hochst.) Hochst.

The majority of respondents used more than one plant for malaria treatment (60%). Some respondents used up to four plant species as a combination (6.3%), although the majority used two species (35%) and others three (18.8%). The most frequently used combinations of plants included at least two of the following plants: *Pseudarthria hookeri* Wight & Arn., *Indigofera congesta* Baker, and *Senna didymobotrya* (Fresen) Irwin & Barneby. The other combinations involved *Pseudarthria hookeri* Wight & Arn., *Hyptis pectinata* Poir., *Entada abyssinica* Steud. ex A.Rich. including *Erythrina abyssinica* Lam. ex DC.

Plant Parts Used and Methods of Application.—The bark was the most widely used plant part, accounting for 37.5% of the plant uses (Table 3). A majority of the remedies were prepared in the form of decoctions from the bark; the bark was collected and boiled in water (Table 3). All the remedies were taken orally. To improve the acceptability of certain remedies, they were mixed with an additive: sugar could be added to *Vernonia amygdalina* infusion to reduce the bitterness; lemon (*Citrus limon*) was added to *Senna didymobotrya* to improve the taste; or the powder of the bark of *Warburgia ugandensis* was placed in a piece of sweet banana and swallowed. Sometimes the contents of orthodox medicine drug capsules bought from drug shops were removed and replaced with the powder of the bark of *Warburgia ugandensis* and swallowed. This was done as a measure of 'dosage', and also because *W. ugandensis* has a hot peppery taste and, if taken in an 'overdose', can cause stomach upsets, vomiting and diarrhea.

In some parts of the country the same plant parts of a species, as recorded in this study, were also used to treat malaria. For example, according to Adriaens (2005), the bark powder of *Warburgia ugandensis* was prepared and administered in the same way as the people of the Rwenzori region in western Uganda (Table 3). In some instances, the same or different plant parts of a particular species, as recorded in this study, were used to treat a different ailment. This is evident, for example, with the use of the leaves and bark of *Senna didymobotrya* to treat stomach ache, asthma, measles and as a purgative in western Uganda (Table 3), as reported by Kakudidi et al. (2000) and Adriaens (2005). The root infusion was also used to treat diarrhea in Eastern Uganda (Tabuti et al. 2003b).

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TABLE 2.—Species used to treat malaria by the local communities showing their respective importance through ranking. Gr = Grassland, SF = Secondary fallow, Fo = Forest, Ga = Garden.

Voucher	Latin binomial	Family	Habit	Local name	Habitat	I. Index[1]	References[2]
SP 988	*Entada abyssinica* Steud. ex A. Rich.	Fabaceae	Tree	***Mwoloola***	Gr	1.3 (8)	b, c, e
SP 959, 978	*Hallea rubrostipulata* (K.Schum.) J.-F.Leroy	Rubiaceae	Tree	***Muziku***	Fo	63.8 (1)	e, h, i
SP 1130	*Hyptis pectinata* Poir.	Labiatae	Herb	***Bongoloza***	Gr/SF/Ga	1.3 (8)	-
SP 987	*Indigofera congesta* Baker	Fabaceae	Herb	***Namasumi***	Gr/SF	2.5 (7)	-
SP 1121	*Justicia ansseliana* (Nees) T. Anderson	Acanthaceae	Herb	***Kwiniini omuganda***	Gr/SF	3.8 (6)	c
SP 1114	*Manilkara obovata* (Sabine & G.Don) J.H.Hemsl.	Sapotaceae	Tree	***Nkunya***	Fo	2.5 (7)	-
SP 1119, 1128	*Pseudarthria hookeri* Wight & Arn.	Fabaceae	Herb	***Kikakala***	Gr/SF	3.8 (6)	b, f, g
SP 1006	*Senna didymobotrya* (Fresen) Irwin & Barneby	Fabaceae	Herb	***Kivumuzi***	Gr/SF	1.3 (8)	b, d, f, i, g, j
-	*Shirakiopsis elliptica* (Hochst.) H.–J. Esser	Euphorbiaceae	Tree	***Musasa***	Fo	3.8 (6)	b, e
SP 1097, 1122	*Sopubia ramosa* (Hochst.) Hochst.	Scrophulariaceae	Herb	***Kakulunkanyi***	SF/Ga	3.8 (6)	-
SP 987, 991, 998	*Syzygium cordatum* Hochst.	Myrtaceae	Tree	***Mugeege***	Fo	1.3 (8)	e
SP 889, 976	*Syzygium guineense* (Willd.) DC.	Myrtaceae	Tree	***Kalunginsanvu***	Fo	16.3 (4)	e
-	*Vernonia amygdalina* Delile	Asteraceae	Shrub	***Mululuuza***	Gr/ FE/Ga	40.0 (2)	a, b, c, d, e, f j
SP 1109	*Vernonia lasiopus* O. Hoffm.	Asteraceae	Herb	***Kaluluuza akakazi***	Gr/SF	2.5 (7)	d, f
SP 951, 997	*Warburgia ugandensis* Sprague	Canellaceae	Tree	***Muya***	Fo	28.9 (3)	b, c, d, e, i, j
SP 901	*Zanthoxylum chalybeum* Engl.	Rutaceae	Tree	***Ntale ya ddungu***	Fo	8.8 (5)	d, e, f, g

[1] Ranking based on the importance of species as used by Noweg et al. (2003) where the Importance Index (I.I.) is calculated from the percentage of the number of respondents who reportedly regard the plant as important in the treatment of malaria, divided by total number of respondents (n = 80); figure in bracket represents rank.

[2] Earlier studies that have reported the use of the species indicated.

References cited: a = Katende et al. (1999), b = Kakudidi et al. (2000), c = Oryem–Origa et al. (2003), d = Bukenya-Ziraba et al. (1997), e = Katende et al. (1995), f = Ogwal-Okeng (1998), g = Tabuti et al. (2003b), h = Köhler et al. (2002), i = Kamatenesi-Mugisha and Oryem-Origa (2005), j = Adriaens (2005)

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TABLE 3.—Methods of preparation and application of medicinal plants used to treat malaria

Latin binomial	Part used	Mode of preparation	Earlier studies [1]
Entada abyssinica	Leaves	Leaf decoction	Bark decoction used to treat cough[b]
Hallea rubrostipulata	Bark	Bark decoction	Bark decoction[b.d,e]
Hyptis pectinata	Whole plant	Decoction	
Indigofera congesta	Twig	Infusion	
Justicia ansseliana	Twig	Decoction	Leaf decoction[d]
Manilkara obovata	Bark	Bark decoction	
Pseudarthria hookeri	Whole plant	Decoction	Shoot decoction[b,d]; Leaf decoction used to treat scabies, quicken delivery[b]; Root infusion to treat snake bites[g]
Senna didymobotrya	Twig	Decoction	Twig decoction[b, d, e]; leaves and bark decoction used to treat stomachache, purgative, measles, Asthma[b, j]; root infusion to treat diarrhea[g]
Shirakiopsis elliptica	Bark	Bark decoction	Bark decoction[b.d.e]; bark infusion applied topically to treat scabies[b]
Sopubia ramosa	Whole plant	Decoction	
Syzygium guineense	Bark	Bark decoction	Bark decoction[b]
Syzygium cordatum	Bark	Bark decoction	Bark and root infusion to treat cough[e]
Vernonia amygdalina	Leaves, Roots	Leaf infusion, root decoction	Leaf infusion, root decoction[b.d.e,f,g]; root decoction used to treat measles, hernia, bilharzias, diarrhea[g, j]; Leaf, root and bark decoction to treat stomachache, cough[b]
Vernonia lasiopus	Leaves	Leaf decoction	Shoot and leaf infusion drunk[d,f]
Warburgia ugandensis	Bark	Bark powder swallowed 'wrapped'	Bark powder consumed, wrapped[b.d.e]; also used to treat candidiasis, gastroenteritis, cough[b, j]
Zanthoxylum chalybeum	Roots	Root decoction	Bark and root decoction[b, d, e]; root infusion to treat pyomyositis[g]

References cited: a = Katende et al. (1999), b = Kakudidi et al. (2000), c = Oryem–Origa et al. (2003), d = Bukenya-Ziraba et al. (1997), e = Katende et al. (1995), f = Ogwal-Okeng (1998), g = Tabuti et al. (2003b), h = Köhler et al. (2002), i = Kamatenesi-Mugisha and Oryem-Origa (2005), j = Adriaens (2005)

[1] Earlier studies showing the mode and methods of application in comparison with the findings of this study. Here, the mode and method of application are in reference to the treatment of malaria unless otherwise stated.

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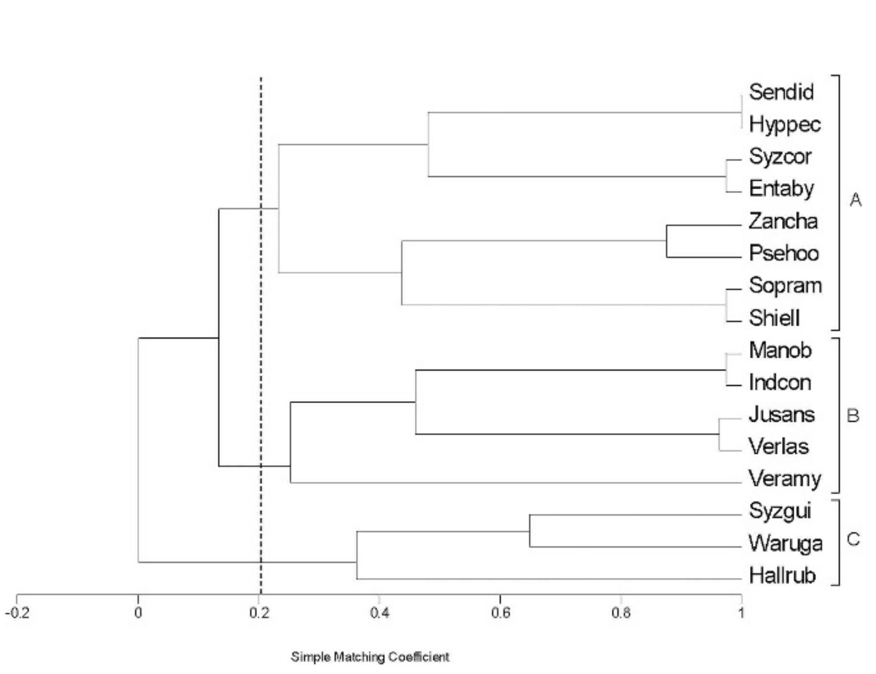

FIGURE 2.—Dendrogram based on the similarity matrix and showing clustering of 16 species used to treat malaria according to the respondents. The species are *Senna didymobotrya* (Sendid); *Hyptis pectinata* (Hyppec); *Syzygium cordatum* (Syzcor); *Entanda abyssinica* (Entaby); *Zanthoxylum chalybeum* (Zancha); *Pseudarthria hookeri* (Psehoo); *Sopubia ramosa* (Sopram); *Shirakiopsis elliptica* (Shiell); *Manilkara obovata* (Manobo); *Indigofera congesta* (Indcon); *Justicia anselliana* (Jusans); *Vernonia amygdalina* (Veramy); *Vernonia lasiopus* (Verlas); *Syzygium guineense* (Syzgui); *Warburgia ugandensis* (Waruga); *Hallea rubrostipulata* (Halrub). Species assemblages (A – C) were defined using a simple matching coefficient of 0.2 (dashed line).

Cluster analysis: Similarities in the Use of Species.—Using a minimum simple matching coefficient of 0.2 as an arbitrary cut-off point for defining clusters (Figure 2), three species assemblages were produced by the cluster analysis. Assemblage A included mainly those species that predominantly grow in seasonally flooded wooded grasslands, farmland, and disturbed areas, and are fairly common. The plant parts used were generally bark or the entire plant. Assemblage B had those species that are predominantly herbaceous and grow in disturbed areas, gardens and secondary regrowth. The main plant part used were whole plant or leaves. Assemblage C included those species that are typically forest tree species and main plant material used was the bark.

The Friedman test (Zar 1984) showed that there was a highly significant difference between the use of species by respondents and also between clusters $\chi^2_{.001\ [2]} = 21.393$, $P < 0.001$ (Figure 2). In terms of the species present within each cluster, these were considered unique from all others for analyses of the respondents associations. Cluster C constituted the most important forest tree species used to treat malaria (Table 2). They also had a similar plant part harvested (bark) and are typical forest species, hence a subject of further investigation in this study.

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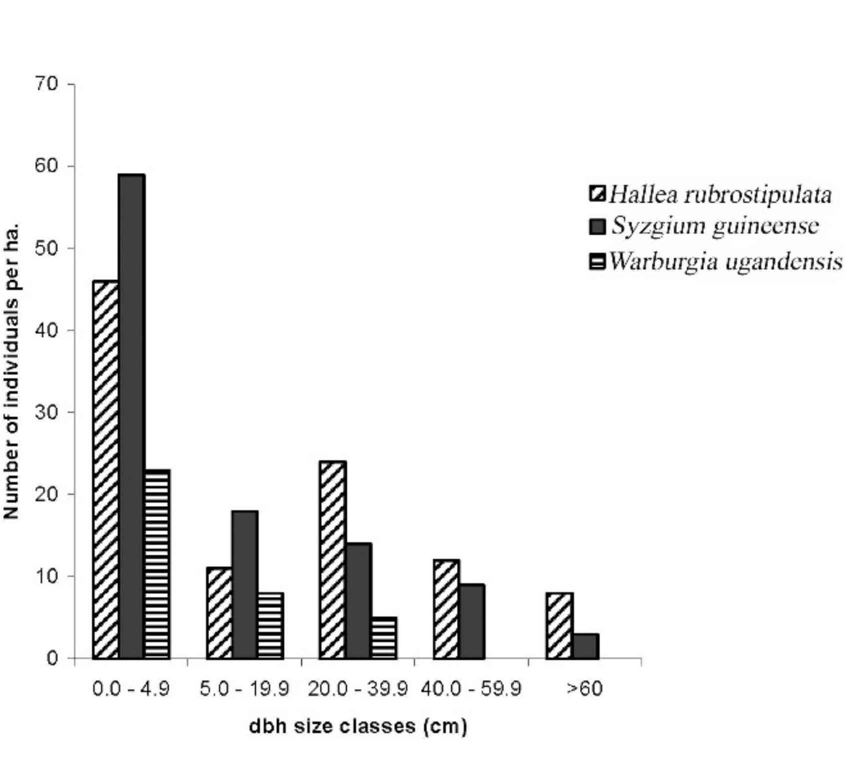

FIGURE 3.—Number of individuals per hectare (ha) in a range of diameter size classes measured at diameter at breast height (dbh) for *Hallea rubrostipulata, Syzygium guineense* and *Warburgia ugandensis.*

Tree Density of the Key Species used to Treat Malaria.—*Hallea rubrostipulata* was the most abundant species and *Warburgia ugandensis* was the least abundant. *Hallea rubrostipulata* had the highest mean density of 14.8 stems ha^{-1} (SD = 6.534) while *Syzygium guineense* had the least mean stem density of 8.4 ha^{-1} (SD = 4.277). The number of mature individuals ($\geq$ 40 cm DBH) per sampled plot ranged from zero in *Warburgia ugandensis* to two in *Hallea rubrostipulata*. Very few (4.1%) sampled plots had more than one stem of mature target tree species.

Diameter Size Classes of the Tree Species.—The frequencies of tree species in each DBH class from the forest are presented in Figure 3. The diameter size classes of *Hallea rubrostipulata, Syzygium guineense* and *Warburgia ugandensis* generally show a similar pattern. They represent a 'reverse J-shaped', suggesting a continuous recruitment. Three size classes defined were: (DBH $<$ 10 cm), medium (DBH 10 – 40 cm) and large (DBH $>$ 40 cm).

Degree of Mutilation through Exploitation by Debarking.—It can be seen that there was a higher degree of mutilation of *Hallea rubrostipulata* (63.8% of the respondents) for malaria treatment as compared to the other species as shown in Table 2 and Figure 4. *Hallea rubrostipulata* also had the highest stem density of 14.8 stems ha^{-1}. *Warburgia ugandensis* was the least mutilated, and therefore, least utilized as a medicinal tree species for the treatment of malaria and also had the lowest stem density. According to the local communities, these species were also

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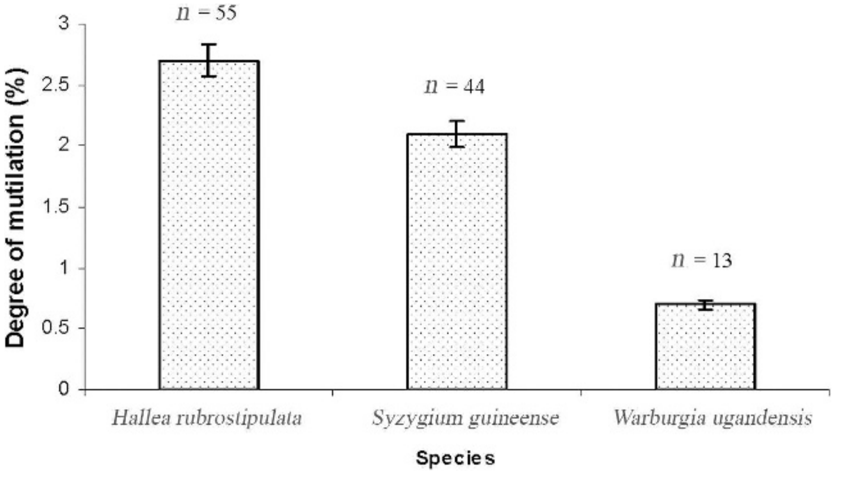

FIGURE 4.—The degree of mutilation of trees expressed by percentage (%) of stem debarked of the most important forest tree species used to treat malaria.

increasingly being harvested for commercial purposes, particularly *Hallea rubrostipulata* and *Warburgia ugandensis*.

Habitat, Current Status and Trend of Medicinal Plants.—This study shows that there is little practice of cultivating medicinal plants in the area (6.5% of respondents), as shown in Table 1. Most of the medicinal plants were, therefore, harvested from the wild. A few species, for instance, *Sopubia ramosa, Indigofera congesta, Hyptis pectinata* and *Vernonia amygdalina*, were preserved in home gardens or farm plots for medicinal purposes (47.1% of the respondents). Most of the species were collected from the forest or adjacent grasslands at varying distances from residential homes (Table 1). *Warburgia ugandensis* is so rare in the forest that only those people who know the exact locations of these few individuals are normally sent to collect the bark material. Most of the herbaceous medicinal plants are commonly or occasionally found in the area. Most of them are wild herbs that grow in disturbed areas such as secondary vegetation, abandoned farmland, roadsides and around home gardens (Table 2). Fuelled by the continually increasing habitat disturbance, the abundance of some of the plants is reportedly increasing over years.

DISCUSSION

People, their Dependence on and use of Traditional Medicine to Treat Malaria.—This study clearly shows that the reliance on medicinal plants to treat malaria by the local communities is high, and that a number of species are used. Reliance on traditional medicine has been demonstrated in earlier studies, but this study further highlights the importance of traditional medicine in the daily lives of the people of Sango Bay, and the preferences for particular species over others in the treatment of malaria in southern Uganda. Some of these species are reported for the first time. Shrestha and Dhillion (2003) report that such significant attachment

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to the use of traditional medicine can be attributed to, among other reasons, the traditional belief in its effectiveness.

Relevance of Traditional Medicine in the Treatment of Malaria.—Sixteen species of plants were recorded to be used to treat malaria. These occur in different habitat conditions and have varying life forms. The diversity of species used for the treatment of a single disease, malaria, can be an indication of the importance of these medicinal plants in primary health care. It also highlights the significance of malaria as a disease that afflicts both young and old, just as HIV/AIDS. Kakudidi et al. (2000), Tabuti et al. (2003b) and Oryem-Origa et al. (2003) reported over fifteen species used in the treatment of malaria in different parts of the country.

The reliance on the use of traditional medicine can be attributed to the perceived potency of these plants in the treatment of malaria, particularly for *Hallea rubrostipulata.* The absence of multiple health centers means that people must travel longer distances to health centers than to collect traditional medicine. This probably influences their choice of preference for traditional medicine to Western/orthodox medicine. In many cases, the health centers lack drugs that could be used. Therefore, people resort to the use of traditional medicine and only go to health centers when traditional medicine fails (Table 1).

Some species were reportedly used in combination with other species. Combining different species is believed to enhance their potency, especially among those known locally to be less potent. However, species including *Hallea rubrostipulata* and *Vernonia amygdalina* were never used in combination because they are known to be effective even when used individually.

Medicinal Plants and Associated Knowledge.—*Hallea rubrostipulata, Warburgia ugandensis* and *Syzgium guineense* are the most important tree species used to treat malaria in the area. The high consensus on the use of traditional medicine against malaria shows the importance of these plants to the people. The high salience or familiarity of *Hallea rubrostipulata, Warburgia ugandensis* and *Syzygium guineense* (cited by 63.8%, 28.8% and 16.3% of the respondents, respectively) for use as remedies against malaria might indicate their efficacy. According to Trotter and Logan (1986), pharmacologically effective remedies are expected to have greater respondents' consensus. According to Johns et al. (1990), however, confirmation is not a single true measure of the potential efficacy of any remedy. There is great probability of a common plant, reported to treat a common disease, to be cited more frequently that a rare plant that is used to treat a disease of limited occurrence.

Most of the reported plants are also used elsewhere in Uganda for their medicinal value (Table 2). Eight species (*Hallea rubrostipulata, Vernonia amygdalina, Warburgia ugandensis, Syzygium guineense, Zanthoxylum chalybeum, Justicia anselliana, Shirakiopsis elliptica,* and *Senna didymobotrya*) are in many instances used in the same way as they are used by the local communities in Sango bay (Kakudidi et al. 2000; Tabuti et al. 2003b). The fact that some traditional medicine is used for the same purpose by more than one community might indicate the pharmacological effectiveness of these remedies.

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The fact that four additional species have been reported for the first time as anti-malarial medicinal plants highlights the significance of malaria as a disease, among the people and the role of traditional medicine in primary health care of the local people of Sango Bay area.

Densities of the Most Important Tree Species Used to Treat Malaria.—The results of the botanical survey show that the target species were among those species categorized as rare, with the exception of *Syzygium guineense. Hallea rubrostipulata* and *Warburgia ugandensis* occurred in 6.3% of the plots, whereas *Syzygium guineense* occurred in 52% of the plots. Rarity in forest ecosystems is a natural phenomenon, as most species are categorized as rare and very few are abundant or dominant (Magurran 1988). This is likely to influence the access and use of these species to treat malaria. The destruction of plants and extreme opening of canopy gaps often stimulate growth of dense, herbaceous and semi-woody intertwined vegetation that restrains tree regeneration (Omeja et al. 2004). This is true in this forest where the harvesting of *Afrocarpus dawei* has been going on until recently. This can probably explain the general poor regeneration of the species.

Although *Syzgium guineense* is relatively more abundant than *Hallea rubrostipulata* and *Warburgia ugandensis*, this study shows that *Hallea rubrostipulata* is more often used than *Warburgia ugandensis*. This could be related to the perceived potency of the different species in which *Hallea rubrostipulata* is more potent than the others. Potency of a traditional medicine can be a crucial factor in determining the relative use and importance attached to a species (Bukenya-Ziraba et al. 1997). Although there was evidence to suggest that these plants are being preserved in home gardens (Table 1), this is done at a very minimal scale. There is need to have them propagated in nurseries and encourage people to plant them. This is due to methods and intensity of exploitation threatening the populations of these species in the forests. In all the three species, the bark is harvested and several individuals had been excessively debarked. The use of alternative species, especially from the adjacent grassland, fallow land and abandoned fields, to treat malaria also eases the pressure on these species as observed during this study (Table 2).

Regeneration Characteristics.—Unlike *Hallea rubrostipulata* and *Syzygium guineense*, the regeneration characteristics of *Warburgia ugandensis* are relatively poor compared to the other target species because of relatively fewer individuals in the seedlings stage. Although plenty of fruit was observed below some individual trees, there were very few seedlings in the vicinity. Studies have shown that forest disturbances, such as tree mortality, logging, alterations in tree phenology, and modifications in plant-animal interactions such as seed dispersal, can have a profound effect on the regeneration characteristics of a species (Bierregaard et al. 1992; Chen et al. 1992; Didham et al. 1996; Esseen 1994). When disturbances reduce animal dispersal, plants that depend on animals to carry their seeds will be affected. This results in the failure to ensure the regeneration of plants on other potential sites (Primack 1992). Whitmore (1991) also argues that many tropical tree species have poor dispersal capacities and hence are unable to ensure good regeneration.

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Although *Warburgia ugandensis* was not represented by any individuals with over 40 cm DBH, there is good recruitment into the sapling and pole stages. It is probable that it rarely grows to attain a diameter over 50 cm naturally, although it grows up to a height of 25 m (Eggeling and Dale 1952; Katende et al. 1995). *Hallea rubrostipulata* and *Syzygium guineense* are represented in diameter classes over 40 cm DBH. This implies that there are enough mature reproductive individuals providing seeds for regeneration.

Human Exploitation of Key Plant Species through Debarking.—*Hallea rubrostipulata* was the most utilized among the three species, probably due to its relatively high abundance. Harmful harvesting may affect the physiology and vital rates of individuals, change demographic and genetic patterns of populations, and alter community- and ecosystem-level processes (e.g., Dhillion and Amundsen 2000; Dhillion and Gustad 2004; Peters et al. 1989). More of the bark of *Hallea rubostipulata* is harvested compared to that of the other species, and therefore experience higher harvesting intensity. Another probable reason is that it is locally perceived to have higher potency compared to either *Warburgia ugandensis* or *Syzygium guineense*, as argued by Bukenya-Ziraba et al. (1997), for important medicinal plants recognized in a community.

Local Conservation Initiatives: Habitat and Status of Traditional Medicine.—Most of the plants utilized by the local people are obtained from the wild. This is also true in many other parts of the country (Bukenya-Ziraba et al. 1997; Kamatenesi-Mugisha and Oryem-Origa 2005; Tabuti et al. 2003b). Some of the plants are preserved in the home gardens, such as *Hyptis pectinata*, for their medicinal value. The fact that most of the remedies are only found in the wild poses a significant threat to their existence if the destruction of their habitats continues. Continued growth of farmland, without leaving land to fallow because of shortage of land, can also be a threat to the continued use of herbal medicinal plants growing in agricultural fields.

Analysis of data collected from the forest shows that most of the forest medicinal tree species are rarely encountered. All the three species are typical forest species. They mainly occur in the forest and are rare even within the forest. However, we observed one individual of *Warburgia ugandensis* in farmland near the forests. It had been overly debarked but was still standing alive. However, no tree species were cultivated in the gardens except for the herbaceous species. This probably implies that the supply from the forest is sufficient to meet current needs, or the ecological conditions in farming systems do not allow the natural regenerations of the species. However, the continued degradation of the forest cannot guarantee the survival of these species. Therefore, this calls for the management regimes geared towards the protection of specific species such that they ensure a continuous supply of materials to use to treat malaria. This is being encouraged in other forests (e.g., in the Mpanga forest, Omeja et al. 2004) through a Collaborative Forest Management program.

Suggestions and Perspectives for Further Research.—However, it should be noted that in many situations, the preparation methods of herbal medicine are not hygienic and need to be controlled to ensure that the medicines are safe to use.

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The therapeutic claims of these herbal medicines have not yet been evaluated for efficacy. These claims must be validated through further studies to validate effectiveness and safety of use of these plants as antimalarials by analyzing extracts for active compounds alongside toxicity determination. A good understanding of the active components would allow the development of extraction procedures and standardization of doses for treatment. This would raise self-assurance among the people who use the traditional medicine, as suggested by Tabuti et al. (2003b). This would also help create markets for some of the malaria herbal medicines. The marketing of herbal medicines would require detailed assessment of resource quantities, domestication possibilities, evaluation of market potential for promising species and setting up of equitable benefit sharing regimes (Dhillion and Amundsen 2000; Shrestha and Dhillion 2003; Tabuti et al. 2003b). There is need for continued monitoring of the harvesting regimes, as well as assessing the abundance and distribution of the key malaria medicinal plants so as to ensure sustainable exploitation of the plants.

The government of Uganda also recognizes that malaria continues to be the major cause of ill health and killer of Ugandans, followed by HIV/AIDS. Government, through the Ministry of Health, has put in place measures to combat the disease. These include formulation of a malaria treatment policy to enable the population at risk of malaria access to safe, good quality, effective and acceptable antimalaria drugs in order to: (1) ensure a rapid and long lasting clinical cure for individual malaria patients; (2) prevent progression of uncomplicated malaria to severe disease and death; (3) shorten clinical episodes of malaria and reduce occurrence of malaria-associated anemia in high malaria transmission areas; (4) reduce consequences of placental malaria infection and maternal malaria-associated anemia through chemoprophylaxis or intermittent preventive treatment during pregnancy; and (5) delay development and spread of resistance to antimalaria drugs.

The government has also developed various strategies intended to counter the malaria disease. These include the Home-Based Management of Fevers (HBMF) strategy aimed at increasing awareness about malaria symptoms and danger signs. It has helped caretakers and volunteers in taking appropriate action to treat malaria and increased access to treatment within 24 hours. The HBMF primarily takes place at community level and involves several key components: sensitization of members of the community and leaders; selection of community volunteers and mobilizers; and capacity building through training of volunteers and provision of anti-malarial drugs to volunteers and supervisors. The strategy aims at faster delivery of treatment and reducing the economic and human cost of malaria.

Mosquito-proofing of houses was one of the key methods for vector control in the 20th century (Fullerton and Bishop 1933; Hackett and Missirolli 1932) and it should be effective against malaria in Africa since the majority of people receive infective bites indoors at night. Recent studies provide credible evidence that house screening is associated with protection against malaria transmission, infection and morbidity (Lindsay et al. 2002). Screening has the added advantage of protecting everyone in the room, and avoiding issues of discrimination and bias within the household. A pilot study conducted in the Gambia using

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experimental huts established that netting ceilings reduced exposure to malaria vectors by 80% (Lindsay et al. 2003), but more studies in actual houses are necessary to authenticate these findings and to assess the acceptability of house screening to communities.

Due to increased resistance of malaria parasites to chloroquine and sulfadoxine/pyrimethamine, a new and highly effective drug called artmether/lumefantrine (COARTEM) has been introduced as the first-line treatment for uncomplicated malaria, and artesunate/amodiaquine combination (ACT) as the alternative. In addition measures such as early treatment, using insecticide-treated nets and improved environmental management, the government intends to use indoor residual spraying with approved insecticides. The strategies outlined above, coupled with validated traditional medicine used to treat malaria, will contribute to increased control, and perhaps the reduction, of the malaria problem in Uganda.

NOTE

[1] Specimens were deposited at the Makerere University Herbarium (MHU) - Department of Botany, for identification and confirmation of identifications and cataloguing.

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