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Antiplasmodial and cytotoxic activities of medicinal plants traditionally used in the village of Kiohima, Uganda

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ABSTRACT

Aim of the study: In Uganda, malaria is the most common disease and Ugandan people largely rely on traditional medicine. In this context, we carried out an ethnobotanical study on the Kiohima village, located close to the Kibale National Park in South-Western Uganda and investigated *in vitro* the antiplasmodial and cytotoxic activities of selected medicinal plants.

Materials and methods: Seventy-five plants-using adults (men and women) were interviewed to find out their plant use. From these information, 48 plants used in traditional medicine were identified and according to their reported uses and to bibliographic data, several parts of 28 plants (leaves, barks, roots), were selected and collected for biological evaluations. These samples were dried, extracted with ethyl acetate and the crude extracts were assayed for *in vitro* antiplasmodial and cytotoxic activities at 10 μg/mL.

Results: One third of the screened plants showed a significant antiplasmodial activity with inhibition greater than 50% at 10 μg/mL.

Conclusion: These results may indicate a possible explanation of the use of some medicinal plant against malaria in the village of Kiohima and have also allowed to highlight a plant with potent antimalarial activity: *Citropsis articulata* root barks.

1. Introduction

Malaria, the major parasitic infection in many tropical and subtropical regions, is still the largest burden on public health of developing countries (Arrow et al., 2004). Annually, 600 million new infections occur worldwide, and at least 1 million of these infections are fatal. Despite the existence of an array of available antimalarial drugs, the control of this ancient infection is increasingly threaten by the emergence of drug-resistant strains of the malaria parasite, *Plasmodium* (Craft, 2008). In view of these developing resistances, most of these drugs, when used in monotherapy are rapidly losing their efficacy. The re-emergence of malaria as a public health problem calls for the discovery and development of new antimalarial drugs. The use of medicinal plants, such as the South American "quinine bark" *Cinchona succirubra* and the Chinese "Ginghao" *Artemisia annua*, have a long tradition of use in the treatment of malaria (Schwikkard and Van Heerden, 2002). Identification of the major active metabolites of these plants, quinine and artemisinin, gave rise to the development of numerous antimalarial drugs. Nowadays, 11 of the 15 drugs included in the WHO malaria therapeutic scheme are natural products or derivatives (Bourdy et al., 2008).

In Uganda, malaria is the most common disease and accounts for 25–40% of out-patient attendance at health facilities, and 20% of in-patient admissions. It also kills at least 9 to 14% of all in-patients. Children aged five years and below as well as pregnant women are the most affected. In Uganda, more than 200 children die daily from this disease (Tabuti, 2008) and Ugandan people largely rely on traditional medicine (Ssegawa and Kasenene, 2007). In this context, we carried out an ethnobotanical study in the Kiohima village, located close to the Kibale National Park in South-Western Uganda in order to better know the plants used and their active components. Thus, in the curse of this investigation, 75 plants-using adults (men and women) were interviewed to find out their plant use. From this information, 48 specimens of plants were collected and according to their reported uses and to bibliographic data, several parts (leaves, barks, roots) of 28 plants were selected for biological evaluations. These samples were dried, extracted with ethyl acetate

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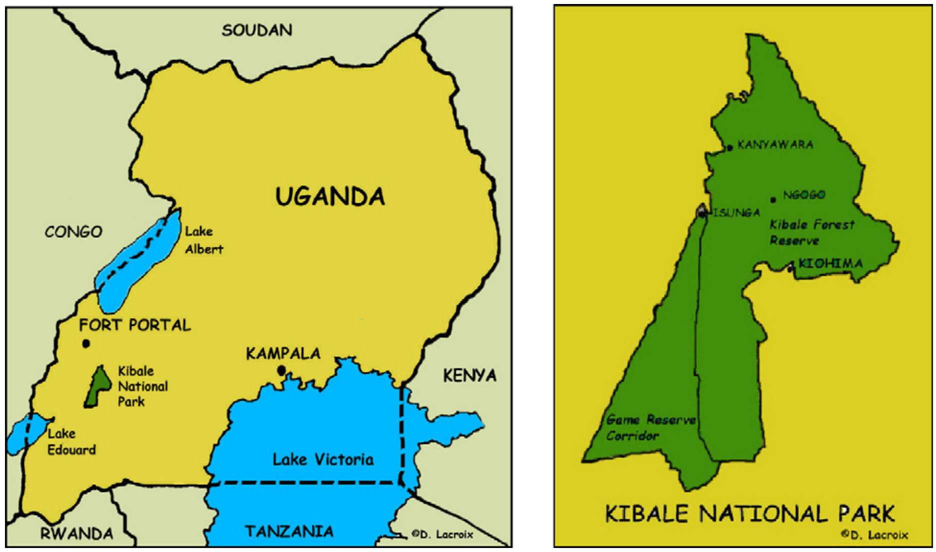

Fig. 1. Maps of Uganda showing the location of the area of study.

and the crude extracts were assayed for *in vitro* antiplasmodial and cytotoxic activities at 10 μg/mL.

2. Materials and methods

2.1. Field program

This ethnopharmacological study was conducted by two of us (DL and FB) in September–October 2008 for 50 days in the village of Kiohima. This village, located close to the Kibale National Park in the South-West part of Uganda (0°26 N; 30°23 E) is about one thousand meters above the sea level and is surrounded by a typical rainforest (Fig. 1). The Kiohima population numbers about 3000 people and is composed of two groups of people. The Batooros, the local population of Kiohima who speak Rutooro and the Bakigas, a migrant population originating from the region of Kabale (South-east of Uganda, about 300 km south of Kibale National Park), and who speak Rukiga. This latter group of population, mainly constituted of farmers and foresters, moved to Kiohima 40 years ago because of the reduction of the lands and forests of their original dwelling. During their stay the investigators have lived daily with the native people, learnt the sociological organization of the village so as to choose the best interpreters and source of information. Because of the coexistence of two different populations speaking two languages (Rutooro and Rukiga), and also with their different traditional cultures, we asked successively for two translators in the course of the discussion with the villagers. This coexistence prompts us to compare the knowledge of each group within the village population and also to find whether they have a common use of plants. Information was obtained from 75 adults of the two populations (41% Batooros and 59% Bakigas) who have been taught in the use of plants for healing or treating different diseases such as malaria, angina and diarrhea. Among them, three types of people could be distinguished, the so-called "witch-doctors" (3 interviewed including 2 Batooros), the so-called "good-doctors" (4 interviewed including 3 Batooros) and the villagers (68 interviewed). The first type, "the witch-doctors", is able to treat bewitched peoples. We have observed that they generally ask the spirit of the dead to know which plant can be used to treat the patient which corroborate with previous observation of et al.Tabuti et al. (2003). The second type, the "good-doctors" or "herbalists", have the knowledge of the medicinal plants and are able to treat usual organic diseases. The third type, composed of all the villagers, but mainly women with children, have some limited knowledge on medicinal plants. The survey was conducted by way of discussions with people from different socio-cultural groups (protestant and catholic, young and old, men and women, chairman and pastor, farmers and forestry worker). First, they were queried on their origin, then their general knowledge of the biodiversity (animals and plants) and finally, they were interviewed for their specific affinity toward plants, animal and for their medicinal or hunting knowledges. To better understand the transmission of such knowledges (either from family tradition, inside a group of one of the two populations or between the two groups) the actual source of the knowledge was also investigated.

2.2. Plant collection and identification

The collecting campaign was realized within the framework of the "Collaborative phytochemical research using selected flora and fauna species in Uganda" (Memorandum of Cooperation between the Centre National de la Recherche Scientifique (CNRS), the Muséum National d'Histoire Naturelle (MNHN), Makerere University (MU) and the Uganda Wildlife Authority (UWA). It was conducted inside the Kibale National Park by DK and JK (MU) and in the village of Kiohima by DL and FB (MNHN).

For each selected and collected plant, herbarium specimens were prepared and kept at the Herbarium of the Makerere University (MU) at Kampala (Uganda) and where they were identified by two of us (DK and JK).

2.3. Plant extraction

The collected plants were dried at the Makerere University Biological Field Station, Fort Portal and grounded at the Makerere University, Kampala. Extraction of different parts of plants was achieved following a standardized protocol at the ICSN. Thus, the powdered parts of plants (30–100 g) were extracted at MU by JN using ethyl acetate (200 mL, 3 times at room temperature) or at ICSN with a Dionex automated extractor using ethyl acetate (four runs each, 100 bar, 40 °C). The extracts were concentrated *in vacuo* at 40 °C to yield crude extracts. A 100 mg aliquot of each crude extract was dissolved in AcOEt–MeOH (1:1), filtered on a polyamide cartridge and evaporated to dryness. The extracts were then dissolved in DMSO and tested *in vitro* at a concentration of 10 μg/mL for antiplasmodial and cytotoxic activities.

Table 1
Medicinal plants used in Kiohima area by Batooros (Rutooro name) and Bakigas (Rukiga name).

Scientific name	Family	Rutooro name	Rukiga name	Human use	Part	Preparation
Acanthus pubescens (Thomson ex Oliv.) Engl.	Acanthaceae	Etojo	NU	Worms/denutrition	Roots	Decoction
Albizia coriaria Welw. ex Oliv.	Fabaceae	Omusesa	NU	Diarrhea	Bark	Infusion
Albizia grandibracteata Taub.	Fabaceae	Omorongo	Omushebeya	Back pain, malaria	Leaves	Decoction
Antiaris toxicaria Lesch.	Moraceae	Mumaka	Mukede	Worms	Bark chewed	Bark chewed
Bidens pilosa L.	Asteraceae	NU	Enyabalashana	Cicatrisation Ring-worms	Leaves Whole plant	Leaves juice Infusion
Blighia unijugata Baker	Sapindaceae	Omwataibare	NU	Worms	Leaves	Infusion
Bridelia micrantha (Hochst.) Baill.	Phyllanthaceae	Ombarakasa	NU	Construction	Leaves	Infusion
Brugmansia candida Pers.	Solanaceae	Omoboyu	NU	Psycosis	Leaves	Infusion
Capsicum frutescens L.	Solanaceae	Kambrali	NU	Food condiment	Fruit	Added to food
Celtis africana burm.f.	Cannabaceae	Ektemazi	NU	Witchcraft, worms, syphilis	Bark	Decoction
Citropsis articulata (Spreng.) Swingle and M.Kellerm.	Rutaceae	Katimboro	NU	Men sexual weakness	Root barks	Root barks powdered and mixed with water
Clerodendron ugandense Prain	Lamiaceae	Eksekeseke	Echeche	Stomach pain, laxative	Leaves	Leaves juice mixed with water
Coffea arabica L.	Rubiaceae	NU	Omwani	Aerophagia, cough	Leaves	Decoction
Crassocephalum vitellinum (Benth.) S.Moore	Asteraceae	Echomoro	NU	Vaginal dryness	Entire plant	Decoction
Cupressus lusitanica Mill.	Cupressaceae	Kapurusi	NU	Magic plant to keep away the bad spirits	Leaves	Smoke of burned leaves
Dracaena fragrans (L.) Ker Gawl.	Asparagaceae	Omugorogoro	NU	Ear pain Denutrition	Leaves Bark	Rainwater from the leaves Decoction
Diospyros abysinica (Hiern) F.White	Ebenaceae	Omohoko	NU	Tropical ulcer	Leaves	Leaves juice
Eucalyptus sp.	Myrtaceae	Kaletusi	NU	Cough	Leaves	Decoction
Erythrina abyssinica Lam. ex DC.	Fabaceae	Omoko	Echuko	Cough, malaria Abortive	Bark Entire Plant	Decoction Decoction
Fagara macrophylla (Oliv.) Engl.	Rutaceae	Omubakampungo	NU	Stomach pain	Roots	Decoction
Fagaropsis angolensis (Engl.) Dale	Rutaceae	NU	Omumara	Snake bite	Bark	Decoction
Flacourtia indica (Burm.f.) Merr.	Salicaceae	NU	Omunyege	Musical instrument	Fruit	Attached to the ankle in marriage
Funtumia latifolia (Stapf) Stapf	Apocynaceae	Omongogwekende	Ekinyamagosi	Increase milk production	Fruit	Decoction with black salt
Galinsoga ciliata (Raf.) S.F.Blake	Asteraceae	NU	Kahunika	Vegetable	Arial parts	Cooked in water
Harrisonia abyssinica Oliv.	Rutaceae	Omurarike	NU	Worms, diarrhea	Leaves	Leaves juice mixed with water
Hoslundia opposita Vahl.	Lamiaceae	Orutataima	NU	Cough fever	Flowers leaves	Infusion leaves juice
Ipomoea batatas L.	Convolvulaceae	Akarandura	NU	Vegetable	Rhyzomes	Cooked in water
Leonotis nepetifolia (L.) R.Br.	Asteraceae	Echumuchumu	NU	Diuretic	Leaves	Leaves juice
Mangifera indica L.	Anacardiaceae	Omuyembe	NU	Cough	Leaves	Leaves decoction
Markhamia lutea (Benth.) K.Schum.	Bignognaceae	Omusambya	NU	Malaria, asthma, syphilis	Leaves	Leaves juice mixed with water
Monodora myristica (Gaertn.) Dunal	Annonaceae	Omuho	Omugema	Witchcraft	Bark	Decoction
Nicotania tabacum L.	Solanaceae	NU	Echimani	Snake bite	Leaves	Leaves juice applied on bite
Parinari excelsa Sabine	Chrysobalanaceae	Ibura	Omubura	Witchcraft	Bark	Decoction
Phoenix reclinata Jacq.	Arecaceae	Ekindo	NU	Mat fabrication	Leaves	Leaves plaited
Physalis minima L.	Solanaceae	Entutu	Orututu	Cough	Leaves	Infusion
Phytolacca dodecandra L'Her.	Phytolaccaceae	Omohoko	NU	Constipation	Leaves	Juice of four leaves
Plantago palmata Hook.f.	Plantaginaceae	NU	Embatabata	Fracture	Roots	Dried roots powdered and mixed with butter as a plaster
Plumeria rubra L.	Apocynaceae	NU	NU	Protection against thunder	Entire plant	Grown in front of the houses

Table 1 (*Continued*)

Scientific name	Family	Rutooro name	Rukiga name	Human use	Part	Preparation
Pseudospondias microcarpa (A.Rich.) Engl.	Anacardiaceae	Babigamba	Nimpyata	Witchcraft	Fruit	Keeped in the pocket to get power
Psidium guajava L.	Myrtaceae	Ipera	Ipera	Aerophagia, laxative	Leaves	Infusion
Rubus pinnatus Willd.	Rosaceae	Encherere	NU	Cold	Leaves	Chew the leaves with black salt
Solanum betaceum Cav.	Solanaceae	Akatunda	NU	Cough	Leaves	Leaves juice mixed with salt
Spathodea campanulata P. Beauv.	Bignoniaceae	Omunyara	NU	Vaginal dryness	Bark	Decoction
Tagetes minuta L.	Asteraceae	Mokazi murofa	Mokazi murofa	Headache, articulation, pain, epilepsy	Leaves and flowers	Leaves and flowers rubbed on the head
Teclea nobilis Delile	Rutaceae	Omuzo	NU	Spears Malaria	Branch Aerial part	Decoction Decoction
Vernonia amygdalina Delile	Asteraceae	Ekivilisi	Omuvilisi	Malaria worms	Leaves roots	Infusion decoction
Vernonia ugandansis S. Moore	Asteraceae	Ektokotoko	Echuganyanja	Against women sterility	Leaves	Infusion
Warburgia ugandensis Sprague	Canellaceae	Omuharumi	Omwiha	Fever, gonorrhea, syphilis, worm	Bark	Bark decoction

NU: not used.

2.4. Biological evaluations

2.4.1. Antiplasmodial assay

The antiplasmodial activity was evaluated against the chloroquine-resistant FcB1/Colombia strain of *Plasmodium falciparum*. The test was performed using the method of Desjardins et al. (1979). Extracts and pure compounds were diluted in DMSO at 20 μg/mL with culture medium to the expected concentrations in 96-well microplates. Asynchronous parasite cultures were then added (1% parasitemia and 1% final hematocrite), and plates were maintained for 24 h at 37 °C in a candle jar. [^{3}H]hypoxanthine (0.5 μCi) was subsequently added to each well, and parasites were maintained for an additional 24 h. After a cycle of freezing and thawing, the cells were harvested from each well onto glass fiber filters, and the dried filters were counted in a scintillation counter. The growth inhibition for each well was determined by comparison of the radioactivity incorporated into the treated culture with that in the control culture maintained on the same plate. Quinine was used as positive control. Experiments were performed in triplicate.

2.4.2. Cytotoxicity on mammalian cells and selectivity index

The human tumor cell lines KB (mouth epidermoid carcinoma) and the human diploid embryonic ling cells MRC-5 were seeded into 96-well microplates at 2000 cells per well. The cytotoxicity assays were performed according to published procedures (Pierre et al., 1991; Tempete et al., 1995). Taxotere® was used as a control compound. Experiments were performed in triplicate.

3. Results and discussion

A total of 48 medicinal plants belonging to 28 families of angiosperms used traditionally by one or the two populations of villagers of Kiohima for medicinal purpose were recorded in an ethnobotanical investigation, identified and characterized for their traditional utilization (Table 1). From these, 28 plants were selected, from their medicinal uses or bibliographic data, to evaluate their biological activity against *Plasmodium falciparum* (Table 2). From a general point of view, it was observed that a larger number of plants were used by the Batooros than by the Bakigas. Indeed as shown in Table 1, a total of 40 medicinal plants are employed by the Batooros whereas 21 plants are used by the Bakigas. This can be explained by the fact that Batooros being the ancestral local population have a better knowledge of the local plants as compared to the Bakigas who are newly arrived population in the Kiohima area. However, the Bakiga population who came from a forest region has a large medicinal plant knowledge, especially the ones working as sawyers in the forest. This can explain the specific use of some medicinal plants by the Bakigas and not by the Batooros such as *Bidens pilosa*, *Fagaropsis angolensis*, *Coffea arabica*. Nevertheless, the majority of plants used by the Bakiga are common with the ones used by the Batooros, which suggested that the Bakigas have rapidly adapted to their new environment. From the 48 identified plant parts, eight (16.7%) are used to treat symptoms related to malaria (fever, cough, shaking, muscle pain). Among these plants, some are very often used in other African countries against malaria. It is notably the case of *Erythrina abyssinica* which is one of the most widely used in African traditional medicine for the treatment of malaria and microbial infections (Yenesew et al., 2004). The aromatic essential oil of *Tagetes minuta*, is also used against malaria, but mainly for its insecticidal activity (Hamill et al., 2000; Batish et al., 2007; Lehman et al., 2007). Leaves of *Vernonia amygdalina* are commonly employed to treat malaria, not only in Kiohima village but more generally in Uganda (Tabuti, 2004) as well as in other East-African countries such as Congo and Zimbabwe (Tona et al., 2004; Mbatchi et al., 2006).

Our investigation also underlined the common use of leaves of *Markhamia lutea* against malaria in the village of Kiohima. Surprisingly, the anti-parasitic activity of the leaves has not yet been investigated until our recent work on the chemistry and Antitrypanosomal activity of cycloartane triterpenoids (Lacroix et al., 2009). The same observation was made for the use of the leaves of *Albizia grandibracteata* against malaria, which was also uncovered in this study. Interestingly, relatively few examples were found in the literature for this use (Krief et al., 2005). The aerial part of *Teclea nobilis* are also used for the treatment of malaria, like in East-Africa (Kuria et al., 2001; Bussmann et al., 2006; Kareru et al., 2007). The leaves of *Warburgia ugandensis* are used against fever in the Kiohima village. This observation corroborates with the previous ones by *M. Adriaens* in the Rwenzori region (Adriaens, 2004); the stem bark of this plant has been widely used in East African ethnomedicine for the treatment of many diseases such as stomach-

Table 2
Antiplasmodial and cytotoxic activities of selected parts of plants.

Scientific name	Plant part	% Inhibition *P. falciparum* FcB1 10 μg/mL	% Inhibition KB cells 10 μg/mL	% Inhibition MRC5 cells 10 μg/mL
Acanthus pubescens	Leaves	28.3 ± 3.2	7.0 ± 5.0	5.0 ± 7.0
Albizia grandibracteata	Leaves	22.0 ± 4.6	21.0 ± 10.0	18.0 ± 8.0
Antiaris toxicaria	Bark	36.4 ± 4.1	96.0 ± 0.0	85.0 ± 1.0
Bidens pilosa	Aerial parts	45.8 ± 6.2	24.0 ± 17.0	14.0 ± 2.0
Blighia unijugata	Leaves	2.3 ± 1.0	4.0 ± 3.0	9.0 ± 3.0
Celtis africana	Bark	37.5 ± 12.9	22.0 ± 18.0	17.0 ± 5.0
Citropsis articulata	Roots bark	77.0 ± 13.0	43.0 ± 5.0	12.0 ± 9.0
Coffea arabica	Leaves	39.7 ± 12.4	20.0 ± 4.0	4.0 ± 3.0
Crassocephalum vitellinum	Leaves	40.6 ± 9.2	26.0 ± 2.0	6.0 ± 4.0
Dracaena fragrans	Leaves	34.76 ± 7.0	44.0 ± 1.0	3.0 ± 3.0
Diospyros abysinica	Leaves	51.3 ± 8.8	1.0 ± 2.0	6.0 ± 5.0
Erythrina abyssinica	Bark	83.6 ± 16.0	89.0 ± 2.0	75.0 ± 7.0
Fagaropsis angolensis	Bark	42.3 ± 11.0	16.0 ± 4.0	27.0 ± 12.0
Funtumia latifolia	Leaves	68.1 ± 9.0	57.0 ± 2.0	22.0 ± 4.0
	Bark	29.3 ± 11.2	13.0 ± 10.0	4.0 ± 3.0
Harrisonia abyssinica	Leaves	35.7 ± 17.8	32.0 ± 3.0	13.0 ± 8.0
Hoslundia opposita	Leaves	66.2 ± 7.8	61.0 ± 4.0	41.0 ± 5.0
	Flower	48.4 ± 6.0	67.0 ± 7.0	64.0 ± 3.0
Leonotis nepaetifolia	Leaves	27.0 ± 0.4	36.0 ± 10.0	17.0 ± 8.0
Markhamia lutea	Leaves	70.8 ± 11.0	4.0 ± 5.0	3.0 ± 0.0
Monodora myristica	Bark	42.1 ± 18.0	26.0 ± 7.0	11.0 ± 6.0
Parinari excelsa	Bark	66.5 ± 9.9	54.0 ± 1.0	21.0 ± 9.0
Phytolacca dodecandra	Leaves	25.8 ± 7.2	29.0 ± 4.0	17.0 ± 5.0
Pseudospondias microcarpa	Leaves	30.8 ± 15.2	6.0 ± 9.0	03.0 ± 4.0
	Bark	24.5 ± 10.8	7.0 ± 6.0	07.0 ± 6.0
Rubus pinnatus	Leaves	20.8 ± 13.4	38.0 ± 9.0	3.0 ± 4.0
Spathodea campanulata	Bark	28.9 ± 6.2	27.0 ± 3.0	6.0 ± 5.0
Tagetes minuta	Leaves	61.0 ± 1.8	NT	NT
Teclea nobilis	Bark	54.7 ± 5.7	36.0 ± 2.0	22.0 ± 2.0
Vernonia amygdalina	Leaves	97.8 ± 0.2	99.0 ± 1.0	83.0 ± 2.0
Warburgia ugandensis	Leaves	26.5 ± 10.5	45.0 ± 5.0	33.0 ± 7.0
Chloroquine	–	98.1 ± 0.3	NT	NT
Taxotere	–	NT	93.0 ± 0.3	NT

NT: not tested.

ache, constipation, toothache, cough, fever, muscle pains, weak joints and general body pains (Wube et al., 2005). Moreover, its use against malaria has been observed in Kenya (Irungu et al., 2007).

Surprisingly, some plants commonly used to treat malaria in other East-African countries were selected and collected during the present study, but mainly for other purposes (diseases) than malaria or symptoms associated with. This is the case for *Hoslundia opposita* which is used against malaria in Tanzania (Achenbach and Frey, 1992; Gessler et al., 1994), as well as *Harrisonia abyssinica* (Chhabra et al., 1993; Muthaura et al., 2007).

Some other plants, devoid of malaria employment in Uganda, were collected in the course of this investigation because they have been described in traditional preparations against malaria in other East-African countries. Nevertheless, the use of these plants seems to be less common than those described above. It is notably the case for *Leonotis nepetifolia* (Tabuti, 2008), described as a plant used against malaria in Uganda or *Parinari excelsa* used by traditional healers in Tanzania (Gessler et al., 1995) as well as *Phytolacca dodecandra* (Wilson and Gebre, 1979; Tadeg et al., 2005).

The second part of this study deals with the biological evaluation of the selected plants used in the Kiohima village. Thus, 31 several parts (leaves, barks, wood), of the 28 selected plants were extracted with ethyl acetate and the resulting crude extracts were then assayed for both their antiplasmodial activity against *P. falciparum* FcB1 strain and for their cytotoxicity against KB and MRC5 cells (Table 2). Among the 31 parts of plant extracts, around a third (32%) presented more than 50% of inhibition on the growth of *P. falciparum* FcB1 at 10 μg/mL. It is thus interesting to note that the plants used traditionally in Kiohima village against malaria presented a good activity against *P. falciparum* except for the leaves of *A. grandibracteata* and *W. ugandensis* which had relatively modest activity (22 and 27% inhibition at 10 μg/mL, respectively). Nevertheless these results were of interest because no cytotoxicity was measured at this concentration. However, cytotoxicity on KB cell line of the bark of *W. ugandensis* has been highlighted (Xu et al., 2009). The most active extract was that of the leaves of *V. amygdalina*, but in this case a strong cytotoxicity was observed on the two cell lines (KB and MRC5) at 10 μg/mL and this may account for the antiplasmodial activity against *P. falciparum*. Vernangulides A and B, two sesquiterpene lactones, have been previously isolated from this plant and described to be responsible for the antiplasmodial activity (IC_{50} of 2 μg/mL), nevertheless their selectivity index is very low (from 2 to 5.3) (Pedersen et al., 2009). The leaves extract of *Markhamia lutea* showed 71% inhibition of *P. falciparum* at 10 μg/mL, a significant activity was assigned to some of the cycloartane triterpenes which showed antiparasitical activity not only against *P. falciparum*, but also *Leishmania donovani* and *Trypanosoma brucei* (Lacroix et al., 2009).

Some plants also traditionally used against malaria as previously reported in the literature showed a good activity in our assays against *P. falciparum* FcB1. In particular, the bark extract of *P. excelsa* and the leaves of *H. opposita* displayed respectively 66.5 and 66.2% inhibition at 10 μg/mL. However, these parts of plants were also significantly cytotoxic against the two cell lines tested (average of 50% at 10 μg/mL).

It is noteworthy that one plant used in traditional medicine for other purposes than malaria has a significant antiplasmodial activity. Thus, the EtOAc extract of the roots of *Citropsis articulata* a plant well known and used in Uganda as a sexual stimulant, showed at 10 μg/mL, a *P. falciparum* inhibition growth (77%) associated with a moderate cytotoxicity (43% on MRC5 cell line).

4. Conclusion

Among the 28 plants selected from this ethnopharmacological investigation, collected in Kiohima village and evaluated for their inhibition on *P. falciparum* growth, one third of them showed a significant antiplasmodial activity with inhibition greater than 50% at 10 μg/mL and with a low cytotoxicity for most of them. These results might help to explain the use of these medicinal plants against malaria in the village of Kiohima in Uganda. It is noteworthy that most of the plants used to treat malaria in Kiohima area, are also used for the same purpose in other districts or countries in East-Africa. Indeed, this study has highlighted a promising plant, *C. articulata* for further antimalarial investigations and the determination of its active constituents. Nevertheless, this medicinal knowledge is frail and could be lost if the population is no longer in contact with the surrounding biodiversity. In the last few decades, the creation of National Parks to preserve the biodiversity is often associated with a restriction of its accesses by local people. Thus as the population may gradually loose the contact with the medicinal wild plants and by the same way their knowledge, this issue may question the merits of this interdiction for the sake of biodiversity. It would be thus very important to identify and select the really efficient wild plants in order to cultivate them in medicinal plants gardens, which would be then both plants and traditional knowledges conservatories.

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