Ethnobotanical study of plants used as antimalarial in traditional medicine in Bagira in Eastern RD Congo

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Abstract
This transversal descriptive study was carried out to collect plants and recipes used in Bagira to treat malaria. Direct interview with field enquiries allowed collecting ethnobotanical data. Eighty-four Informants (age 46.9 ± 12.0 years, sex ratio: 2.0, experience 12.1 ± 5.1 years) reported 53 species belonging to 24 families dominated by Fabaceae (22.6%) and Asteraceae (20.7%). Antiplasmodial activity was previously reported for 34 plants and 16 species are first cited as antimalarial plants among which *Ekebergia benguelensis* (18.8%), *Dalbergia katangensis* (14,1%) and *Dialium angolense* (14,1%), are the most cited. From these plants come 83 anti-malarial recipes of which 67 use a single plant and the other combine two to four plants. Leaf (≥52%) and decoction (≥58%) respectively constitute organ and preparation methods most used. Several plants are used in traditional medicine in Bagira against malaria, some of which deserve to be studied more to isolate new antimalarial compounds.

Keywords: Bukavu, phytomedecine, malaria, ethno pharmacology

1. Introduction
Malaria is a major global health scourge [1] responsible for nearly 200 million cases each year. In 2018, 155 million cases, of which 93% in the Africa region, were recorded worldwide and an upsurge was noted with regret in the DRC, with cases ranging from 60.644 million in 2006 [2] to 97,2 million in 2018 [3]. In Bukavu, where the city of Bagira represents 23.9% of the city's workforce, 52,403 cases were recorded in 2017 [4]. In addition to this high prevalence, which is constantly increasing, there is unfortunately a low accessibility to the health care [5] and the emergence of resistance from both vector [6] and parasite [7]. In addition, the RTS, S® vaccine, which is in the process of being marketed, offers only very modest protection in the order of 30% [8]. There is therefore a need to find new drugs that are both effective and accessible.

Apart from the fact that the two current first-line antimalarial compounds, come from traditional medicine: Quinine, isolated from *Cinchona officinalis* L. [9] from traditional Peruvian medicine and artemisinin, isolated from the leaves *Artemisia annua* L. [10], formerly used in traditional Chinese medicine; previous work reports that traditional African medicine has provided improved traditional medicines such as Malarial 50® [11], Malaria® [12] currently use in DR Congo. In addition, traditional medicine offers strong compliance as long as more than 80% of the world population uses it as a first line [13]. It would therefore constitute a very credible alternative in malarial control. Several ethnobotanical studies have been reported in sub-Saharan Africa [14,15], particularly in DR Congo [16] on anti-malarial plants. In Bukavu, the only works reported are those of Kasali et al [17] and Manya et al [18] which, however, did not report all the knowledge of anti-malarial plants in Bukavu, particularly from the Bagira county. In addition to these works, in this study we report the various plants used in traditional medicine in Bagira in the management of malaria by situating them in the overall ethno medical knowledge of the region.

2. Material and Methods
2.1 Study area
With an area of 37.6 km² or 65.9% of the city of Bukavu, the city of Bagira is located between 2° (28-30) south latitude and 28° (48-50) east longitude with an altitude ranging from 1488 to 2008 meters. It is bounded to the north by the Nyamuinha River, to the south by the Tshula River, to the east by Lake Kivu and to the west by the Mbongwe mountain range.
With an average annual temperature of 20 ± 2 °C, it experiences a humid tropical climate with two dry and rainy seasons, the latter being the longest with 7 months. Its predominantly young population (5 to 49 years old), estimated at 123,214 inhabitants in 2014 and distributed in six sectors (Chikera, Ciriri, Kasha, Mulambula, Lumumba and Nyakavogo), has an ethno cultural mixture including Shi (71%) and rega (26%) constitute the majority ethnical groups [19].

2.2 Data collection
Ethnobotanical survey was carried out by direct interview using a guide questionnaire containing socio-demographic characteristics of the informant’s practitioners of traditional medicine (IPTMs), their knowledge of malaria and of the plants informed, as well as the antimalarial recipes based on these plants. All the subjects informed as a plant-based caregiver in the city of Bagira were contacted (n = 111). Data collection was a consequence of the availability of subjects after informed consent (n=84). The harvesting and use of personal data have followed the principle of anonymization as stated in the Helsinki Declaration [20].

2.3 Harvest and identification of species
Plants were harvested in company of IPTMs and identified at the foot of the plant; GPS coordinates were taken, and a specimen was deposited at Kipopo herbarium in Lubumbashi where identification was made.

2.4 Data analysis
Graph Pad Prism version 6 was used where descriptive statistical methods were employed. The data obtained through the survey were analyzed and expressed as a percentage. Ring and sector graphics were used to express the following parameters: Morphological types, biological types, Phytogeographical distribution and harvest site. Fidelity level (FL), an index varying from 0 to 100, was obtained by dividing the number of informants who mentioned using the plants species (Ei) by the total number of informants participating in the survey: N and express in % [21].

3. Results and Discussion
3.1 Socio-demographic profiles of traditional healers and knowledge of malaria
Eighty-four IPTMs, mostly traditional healers (65.9%), age (46.9 ± 12.0; Extremes: 19-79 years) and sex ratio (Male ÷ Woman): 2.0, was interviewed. More than 69% of them have a low level of classical education. They had long experience (12.1 ± 5.1 years Extremes: 3-25) and the knowledge of most of them (63.5%), was transmitted by their ancestors; mashi (70.6%) and Swahili (94.1%) are the most widely spoken languages (table 1).

In most sub-Saharan African societies women are engaged in field work, thus leaving men the latitude to practice traditional medicine [22, 23] and may justify the sex ratio observed during this study (Table 1); the fact that mastering the practice of traditional medicine requires time and concentration, may justify the low level education observed with IPTMs and a long experience enjoyed by IPTMs, as reported in previous works [22, 23], may some extent justify the credibility of information from ethnobotanical surveys.
Table 1: Socio-demographic characteristics of IPTMs

| Class          | $E_i$ | $F_i$ (%) |
|----------------|-------|-----------|
| Age (ans)      |       |           |
| [18-27]        | 4     | 4.7       |
| [27-37]        | 16    | 18.8      |
| [37-47]        | 11    | 12.9      |
| [47-57]        | 45    | 52.9      |
| >57            | 9     | 10.6      |
| Experience (ans) as TPM |     |           |
| [1-5]          | 4     | 4.7       |
| [6-10]         | 16    | 18.8      |
| [11-15]        | 11    | 12.9      |
| [16-20]        | 45    | 52.9      |
| >20            | 9     | 10.6      |
| Gender:        |       |           |
| F              | 28    | 32.9      |
| M              | 57    | 67.1      |
| Studies        |       |           |
| Graduate       | 10    | 11.8      |
| Postgraduate   | 12    | 14.1      |
| Primary        | 28    | 32.9      |
| No one         | 31    | 36.5      |
| Professional   | 4     | 4.7       |
| Category       |       |           |
| Witch          | 2     | 2.4       |
| Healer         | 27    | 31.8      |
| Traditional healer | 56    | 65.9      |
| Dream          | 12    | 14.1      |
| spirits        | 4     | 4.7       |
| Ancestors      | 54    | 63.5      |
| Another healer | 6     | 7.1       |
| Self-Study     | 9     | 10.6      |
| Traditional Medicine learning pathway |   |           |
| Spoken languages |     |           |
| French         | 40    | 47.1      |
| Bangubangu     | 2     | 2.4       |
| Fulero         | 6     | 7.1       |
| Havu           | 23    | 27.1      |
| Nande          | 7     | 8.2       |
| Rega           | 16    | 18.8      |
| Vira           | 9     | 10.6      |
| Lingala        | 20    | 23.5      |
| Shi            | 60    | 70.6      |
| Swahili        | 80    | 94.1      |
| Tshiluba       | 4     | 4.7       |

Mean age 46.9 ± 12.0 (range, 19-79 years); sex ratio: 2.0 in favor of men. Average experience 12.1 ± 5.1 (range: 3-25 years). $F_i$ = citation frequency = $n * 100 / N$, $n =$ simple; $N =$ total workforce.

Shi are the majority (more than 50%) ethic group and in most cases, IPTMs "diagnose" malaria using different signs and symptoms such as aches, fever and headaches (Figure 2). The preponderance of shi can be justified by the fact that they are majority and indigenous ethic group of the region [17, 18]. In addition, the observation of various signs evoked by the IPTMs to diagnose malaria, suggests that they treat simple malaria.

![Fig 2: Signs of malaria diagnoses by IPTMs and ethical group of IPTMs](image.png)
3.2 General characteristics of plants recorded

3.2.1 Morphological types, biological types, Phytogeographical distribution and harvest site

The plants listed in this survey are in most cases trees (32%), Microphanerophytes (32.1%) which are generally endemic to Tropical Africa TA (39%) as previously funding [17]. Few works of accessible literature evoke the question of the biological types of plants used in traditional medicine in the region. It would be difficult to have a definite point of view on the issue. About morphological type, the analysis of several ethnobotanical studies of the region [17, 24, 28] show, as in this study, that most of the plants used in traditional medicine in Bukavu are trees (figure 3).

![Fig 3: Morphological types, biological types, Phytogeographical distribution and harvest site.](image)

3.2.2 Identification of species and their Classification according to the literature data

In our ethnobotanical survey, 53 plants from 43 genera and 23 families were reported as anti-malarial plants used in Bagira. These plants have several vernacular names dominated by mashi (88.7%), Swahili (18.9%), Kinyarwanda (13.2%) and 66% of them are already studied from the point of view of antimalarial activity. It should also be noted that the consensus on use as an antimalarial is higher in Cinchona ledgeriana (Fl = 54.1%) for all plants and in Ekebergia benguelensis (Fl=18%, 8%), Dalbergia katangensis and Dialium angolense with 14.1% of Fl, each among 18 plants not studied, (Table 2).

| No | Species [Synonym] (Family) | Vernacular name (ethnic group) | Reference of use as antimalarial | Evaluated antimalarial activity reference | Fl (N=84) | Herbarium code |
|----|-----------------------------|--------------------------------|---------------------------------|------------------------------------------|----------|----------------|
| 1  | Acacia polyacantha [Senegalia polyacantha (Willd.) Seigler & Ebinger (2013)] (Fabaceae) | Irangi (kihavu); Hibomo (hemb) | [18] | [29] | 3.5 | KIP0012 |
| 2  | Aframomum laurentii [Aframomum giganteum (Oliv. & D. Hanb.) K. Schum.] (Zingiberaceae) | Amatimbiri (kinyarwanda), Ntiru (mashi) | [30] | | 12.9 | KIP0013 |
| 3  | Ageratum conyzoïdes [Chromolaena corymbosa (Aubl.) R.M. King & H. Rob.] (Asteraceae) | Kahyole, (mashi), Ruhera (kinyarwanda). | [18] | [31] | 4.7 | KIP0014 |
| 4  | Artemisia annua [Artemisia gmelinii Weber ex Stechm.] (Asteraceae) | Artemizia (mashi), Atremisia (swahili). | [18] | [32] | 29.4 | KIP0015 |
| 5  | Azadirachta indica [Melia Azadirachta L. (1753)] (Meliaceae) | Maruramu (mashi), Mwarubaini (swahili). | [18] | [33] | 27.1 | KIP0016 |
| 6  | Bidens pilosa [Kerneria pilosa (L.) Lowe (1868)] (Asteraceae) | Kashisha (mashi), Nyasa (regi) | [18] | [34] | 37.6 | KIP0017 |
| 7  | Bobgunia madagascariensis [Swartzia madagascariensis Desv.] (Fabaceae) | Mpampi (tsilulu); Ndake (mashi) | [35] | [35] | 14.1 | KIP0018 |
| 8  | Cajanus cajan [Cyrtisus cajan L. (1753)] (Fabaceae) | Cishimbo c'eluciga (mashi) Ngolisiolo (tabwa). | [18] | [36] | 4.7 | KIP0019 |
9  Carica papaya L.(Caricaceae)  Ipapayi (mashi), Papai (bembe).  [18]  [37]  31,8  KIP0020
10  Cassia occidentalis [Senna occidentalis (L.) Link (1829)] (Fabaceae)  Mushgemanjoka (mashi), Mujangajanga (fulero).  [18]  [38, 39]  14,1  KIP0021
11  Catharanthus roseus [Vincia rosea L. (1759)] (Apocynaceae)  vinylk (swahili); Mwilu (mashi).  [40]  [41]  4,7  KIP0022
12  Chenopodium ambrosioides [Teloxys ambrosioides] (L.) W. A. Weber (Chenopodiaceae)  Mugunduzimu (mashi), Kahusu (reg).  [42]  [43]  14,1  KIP0023
13  Chenopodium opulifolium [Chenopodium erosum] Benth. (1866) (Chenopodiaceae)  Gombe (mashi), Umugome (kinyarwanda).  12,9  KIP0024
14  Cinchona ledgeriana [Cinchona officinalis (L.) Steud. (1846)] (Rubiaceae)  Kankina (shi); Kenkina (swahili).  [44]  [45]  54,1  KIP0025
15  Clematis villosa [Clematopsis scabiosifolia (DC.) Hutch.] (Ranunculaceae)  Kanyiza (mashi); Kizua (shi).  1,2  KIP0026
16  Crossocephalus montuosus [Senecio montuosus] S. Moore (1902) (Asteraceae)  Cifula (shi), Bapamba (bembe), Anata (bembe).  2,4  KIP0027
17  Crossocephalus picridifolium [Senecio acutidentatus] A. Rich.] (Asteraceae)  Mfubwidi (shi).  1,2  KIP0028
18  Cymbopogon citratus [Andropogon citratus] DC.] (Poaceae)  Cahi (shi), Lunyasi (swahili).  [46]  [46]  32,9  KIP0029
19  Dalbergia katangensis Lechenaud (Fabaceae)  Mungobole; Nifu (shi); Munyereza (fulero).  14,1  KIP0030
20  Dialium angolense [Dialium evrardi Steyaert (1960)] (WELW EX BETH) Harms (Fabaceae)  Kizimya (shi), Cituzo (hauv); Mbindula (fulero).  14,1  KIP0031
21  Dialopsis africana RADCK (Sapindaceae)  Munyembe (shi); Mpangula (shi).  1,2  KIP0032
22  Ekebergia benguellensis WELW EX CDC (Meliaceae)  Mutuzya (shi); Ntuli (shi).  18,8  KIP0033
23  Eleusine indica [Cynosurus indicus] L. (1753)] (L) GAERTN (Poaceae)  Mutuzya (shi).  [47]  1,2  KIP0034
24  Entada abyssinica [Entadopsis abyssinica (Steud. ex A. Rich.) G.C.C. Gilbert & Boutique] STEUD. ex A. RICH. (Fabaceae)  Chishangi (shi).  [48]  [48]  11,8  KIP0035
25  Erythrina abyssinica [Chirocalyx abyssinicus (Lam. ex DC.) Hochst. (1846)] LAM. Ex DC (Fabaceae)  Cigohwa (shi); Igiko (reg).  [49]  [49]  14,1  KIP0036
26  Euphorbia hirta [Hamaeyece hirta] (L.) Millsp. (1909)] L. (Euphorbiaceae)  Eforbia (shi) et Dieza di nkandi (kikongo).  [50]  [51]  32,9  KIP0037
27  Fueggea virosa [Phyllanthus virous] Roxb. ex Willd. (1805)] (ROXB. Ex WILLD.) VOIGT (Phyllanthaceae)  Kashugishugi (shi); Mkwama (swahili).  [52]  [53]  11,8  KIP0038
28  Hypoestes triflora [Justicia triflora Forssk.] (FORSKK) ROE, & SCHULT (Acanthaceae)  Mageru (shi); Pindula (swahili).  1,2  KIP0039
29  Isoberlinia angolensis [Berlinia angolensis] Welw. ex Benth. (1866)] (WELW. Ex BENTH.) HOYLE & BRENAN (Fabaceae)  Mahunire (shi), Mboza (swahili).  [54]  1,2  KIP0040
30  Isoberlinia tomentosa [Berlinia tomentosa Harms (1901)] (HARMS) CRAIB & STAPF (Fabaceae)  Mbaru (shi).  1,2  KIP0041
31  Jatropha curcas [Jatropha afrorcurcas Pax (1909)] L. (Euphorbiaceae)  Lubonobono (shi); Umukoni (fulero).  [55]  [56]  9,4  KIP0042
32  Julbernarda paniculata [Berlinia paniculata] Benth. (1866)] (BENTH.) TROUPIN (Fabaceae)  Gigeu (shi) Ashindambuka (fulero).  14,1  KIP0043
33  Lantana camara [Camara vulgaris Benth.] L. (Verbenaceae)  Kashukashuha (shi); makereshe (nande).  [18]  [57]  36,5  KIP0044
34  Leucas martincensec [Clinopodium martincensec Jaq.] (JACQ.) R. BR. (Lamiaceae)  Kanyakafundwe (shi), Namafunfo (fulero).  [58]  [58]  4,7  KIP0045
35  Mangifera indica [Mangifera amba Forssk.] L. (Anacardiaceae)  Mwembe (shi); Hembre (swahili).  [59]  [60]  18,8  KIP0046
36  Moringa oleifera [Hyperanthera decandra Willd.] LAM. (Moringaceae)  Muringa (shi).  [60]  10,6  KIP0047
37  Ochna schweinfurthiana [Diporidium] Musengoseng (shi),  [61]  18,8  KIP0048
Asteraceae and Fabaceae constitute respectively the second and the third family of flowering plants known worldwide [73] and Fabaceae only, the largest family of trees in tropical dry forests of Africa [74]. In addition, ethnobotanical studies carried out in the region [17, 18, 24, 25, 27, 75, 76] report the preponderance of Fabaceae and Asteraceae with very variable frequencies (5-23%); The results observed in this study (table 1) are therefore part of the general trend. Note also that this preponderance of Fabaceae accounts not only for the importance of this family in traditional Congolese medicine for the management of several pathologies such as diabetes [77], sickle cell anemia [78], schistosomiasis [79], dental caries [80] or diarrhea [81].

Regarding vernacular nomenclature (table 1), note that the frequency of Kinyarwanda (11%) sometimes higher than the designation in some languages originating in the province of South Kivu such as Bembe (7.5%) or rega (5.6%) suggests the influence of Rwanda, in the practice of traditional medicine in Bagira and suggests that many other people share the knowledge of the Bagira IPMTs. Names in vernacular languages also report that some names translate the action or the effect of the plant. This is the case of kizimya, designation of Dialium angolense in mashi, which means: "that which extinguishes" or the case of nfuma, designation of Dalbergia katangensis in mashi, which means: "I am cured". On the other hand, other plants such as Artemisia annua or Cinchona officinalis do not have a real name in the vernacular of the region suggesting that they are imported plants. There are also plants that have vernacular names common to other plants. This is the case of Dalbergia katangensis which some informants called "Mungobole", the name given to Dalbergia lactea Vatke (Fabaceae), according to studies carried out in Kivu by the team of Chifundera [26]. This situation constitutes a probable source of confusion in the practice of traditional medicine and reveals that very often the vernacular names of plants in traditional medicine are based more on the genus than on the species thus raising in ethno pharmacological practice, I importance of identification at the base of the plant along with the IPMT during harvest.

According to literature data, these 53 species can be grouped in four class (A to D). Class A comprises 15 plants for which no evaluation of anti-malarial activity has been reported. These plants are Chenopodium opulifolium,
Clematis villosa, Crassocephalum montuosum, Crassocephalum picridifolium, Dalbergia catangensis, Dialium angolense, Diplopsis africana, Ekebergia benguellensis, Hypoestes triflora, Isoberlinia tomentosa, Julbernardia paniculata, Psorospermum corymferum, Rothmannia engleriana, Senecio cineraria and Solanecio cydonitifolius, Class B includes 2 plants, Aframomum laurentii and Isoberlinia angolensis, previously used in traditional medicine as antimalarials but for which no activity has been evaluated to date; Class C comprises a plant, Eleusine indica, known for other ethnobotanical uses than antimalarials and for which no previous study to assess antimalarial activity has been reported and. Class D contains 35 plants for which no pharmacological studies have been reported, compounds with beneficial ethnobotanical antimalarial activity and suggests that studies of these 18 plants were evaluated for anti-malarial activity.

3.3 Ethnopharmacological data collected during the survey

The 53 plants listed in the survey are used to prepare 83 recipes, of which 67 use a single plant (R1-R67) and 16 combine two, three (R68-R83) or four plants (R72 and R75). Overall, one-plant recipes have higher quotient rates than multi-plant recipes. Among the recipes that use a single plant (R1-R67), nine plants have two recipes and are the most cited. Among them, Artemisia annua (R4 and R5) with 10 occurrences is the most cited. In recipes based on several plants, R72 based on the leaves of Ageratum conyzoides, Bidens pilosa, Carica papaya and Senna occidentalis is the most quoted with five occurrences. Several organs are solicited among which the leaf (≥ 52%) constitutes the most organ used, which is taken in the form of handle (65 ± 15 g). There are several ways of preparing the recipe including maceration, infusion, decoction, and decoction (≥ 50%) is the most used. The recipe is administered per os using Kibuyu (1.5 ± 0.2 L) as a dosage unit. These plants are involved in the management of 80 other pathologies including amoebiasis, diarrhea and intestinal worms, with 14 quotes each, constipation with 11 quotes and snakebite with nine quotes, are the most cited. Biden’s pilosa and Mangifera indica with 14 indications each constitute the plants with the highest use values. (Table 3).

| Species                        | Antimalarial Recipe                                                                 | E | Other Indication (organ)                                                                 |
|-------------------------------|-------------------------------------------------------------------------------------|---|-----------------------------------------------------------------------------------------|
| Acacia polyacantha            | R1: Infusion of a tablespoon of the powder of the leaves in 1L of water. Drink 1 glass 3x / day for 7 days. | 1 | Irritation of the skin (F), Pneumonia (F), Diabetes, Toothache (ER), Amoebiasis (ER), Spasms, diarrhea (ER), Hypotension (Fr) |
| Aframomum laurentii           | R2: Infusion of two handles of the aerial parts in 1L of water. Drink 1 glass 3x / day for 7 days. | 1 | Amoebiasis (F), syphilis (F), fungal (F). | **Catharanthus roseus** | R12: Infusion of a handful of fresh leaves in 1.5L of water. Drink 0.5 glass 2 x / d for 4 days. | 1 | Intestinal worms, fever (F), Hemorrhaged, uterine pain (F), Epistaxis (T) and tuberculosis (F) |
| Ageratum conyzoides           | R3: Decoction of two fresh leaves in 1.5x2L of water. Drink 1 glass 3x / day for 7 days. | 1 | Snake bite (PE), helmithin & pneumonia (F) | **Cassia occidentalis** | R11: Maceration of two handfuls of freshly crushed leaves in 1L of water. Drink 1 glass 3x / day for 7 days. | 12 | Diabetes (F), Amoebiasis, indigestion (PE), Diarrhea and gastritis (R). |
| Artemisia annua               | R4: Decoction of two fresh leaves in 1L of water. Drink 1 glass 3x / day for 7 days. | 10 | Cold, pneumonia, Intestinal worms Hepatitis, gonorrhea (F), Intestinal worms (ER), Amoebiasis (ET), Syphilis (ET), Lice (Fl). |
| R5: Infusion of a tablespoon of dried leaf powder into 1L of water. Drink 1 glass 3x / day for 7 days. | 10 | | **Cassia occidentalis** | R11: Maceration of two handfuls of freshly crushed leaves in 1L of water. Drink 1 glass 3x / day for 7 days. | 12 | Diabetes (F), Amoebiasis, indigestion (PE), Diarrhea and gastritis (R). |
| Azadirachta indica            | R6: Maceration of two handfuls of fresh leaves crushed in 1.5L of water. Drink 1 glass 3x / day for 7 days. | 1 | pneumonia, urinary tract infection (F), Amoebiasis, anemia (F), Typhoid fever (F), Poisoning (PE), Amoebiasis, wound, diarrhea (PE), Mycosis, dysentery (PE), Tuberculosis, myomas (PE), Syphilis (PE). |
| Bidens pilosa                 | R7: Infusion of two handfuls of fresh leaves in 1/2x2L. Drink 1 glass 2x / d for 4 days. | 6 | Convulsion, pains (ER), Abdominal, epilepsy, meningitis (ER), Typhoid fever (ER), Gonorrhea, tooth decay (ER). |
| Bobgania madagascariensis     | R8: Decoction of three pieces of crushed root peel in 1.5L of water. Drink 1/2 glass of filtrate 2x / day for 4 days. | 2 | Diarrhea, food poisoning (F), Kwashiorkor, measles (F), Stomach cancer, leukemia (F), Dysentery (ER). |
| Cajanus cajan                 | R9: Decoction of two handfuls of fresh leaves in 1.5L of water. Drink 2 glasses 3x / d for 3 days. | 1 | Bronchitis (Fl), wounds (S), verminosis (Gr), purulent wound (Fr), Dyspepsia, diphtheria (Fr), Snake bite (ET), Amoebiasis: R + F pour Persea americana + PE pour Euphorbia birta, Jaundice and asthma (F) |
| Carica papaya                 | R10: Infusion of two handfuls of leaves in 1L of water. Drink a glass 3x / day for 7 days. | 12 | Constipation, dysmenorrhoea (R), Placental retention (R), Snake bite, fungal, intestinal worms (F), Amoebiasis (F), tuberculosis & pneumonia (Gr) |
| Cassia occidentalis           | R11: Maceration of two handfuls of freshly crushed leaves in 1L of water. Drink 1 glass 3x / day for 7 days. | 12 | Diabetes (F), Amoebiasis, indigestion (PE), Diarrhea and gastritis (R). |
| Catharanthus roseus           | R12: Infusion of a handful of fresh roots in 1.5L of water. Drink 0.5 glass 2 x / d for 4 days. | 1 | Intestinal worms, fever (F), Hemorrhaged, uterine pain (F), Epistaxis (T) and tuberculosis (F) |
| Chenopodium abrosioides       | R13: Decoction of a handful of leaves in 1L of water. Drink 0.5 x 2x day for 4 days. | 1 | Food poisoning (R), Placental retention (R), Childbirth, hemorrhage (R), Snake bite and wounds (F) |
| Chenopodium opulifolium       | R14: Decoction of fresh aerial parts in 1.5L of water. Drink 0.5 glass 2x / day for 4 days. | 8 | Splenomegaly, asthenia (F), Cold, constipation and anorexia (F), |
| Cinchona ledgeriana           | R15: Decoction of 2 handles of the leaves in 0.5x2L of water. Drink: 1/2 glass 2x / day for 4 days. | 5 | Headache, cough (F), Cataract (Fl) |
| Clematis scabiosifolia        | R16: Maceration of two handfuls of freshly crushed leaves in 1L of water. Drink 1 glass 3x / day for 7 days. | 1 | Mental disorders, convulsion (R), Intestinal worms, wounds (F), Gonorrhea, diarrhea, sprain (F), Ulcer and |
| Plant Name                        | Prepared Material                                      | Duration | Uses                                                                 |
|----------------------------------|--------------------------------------------------------|----------|----------------------------------------------------------------------|
| Crassocephalum montuosum         | R17: Maceration of two handfuls of crushed roots in 0.5x2L of water. Drink 0.5 glass 2 x / day for 4 days. | 1        | Stomach, flu, diabetes (F), Hemorrhoids (F), Gonorrhea, hepatitis, goiter (R), Cataract and purulent otitis (R). |
| Crassocephalum picridifolium     | R18: Decoction of a handful of fresh leaves in 1L of water. Drink a glass3x / day for 7 days.                  | 1        | Schistosomiasis, Amoebiasis (F), Intestinal worms, hyper gastralgia (F), Tuberculosis (F) Urethritis and Amoebiasis (F). |
| Cymbopogon citratus              | R19: Decoction of three handles of fresh leaves in 1L of water. Drink 2 glasses3x / d for 3 days.                | 3        | Headache, fever (R), Gastric ulcer, tuberculosis (R), Belly ache (R), Conjunctivitis and wounds (F) |
| Dalbergia katangensis            | R21: Infuse three handfuls of fresh root bark into 1.5 L of water. Drink 1 glass 3x / day for 7 days.             | 2        | Constipation, madness (R), Malnutrition (G), Severe malnutrition (Gr), Angina, kwashiorkor with (F) from mukuzanya: Clerodendrum myricoides + Munyenenyenge: Sessania seshan + Mucumucumu: Leonotis nepataefolia, Snake bite (F), Diarrhea and wounds (R). |
| Dialium angolense                 | R23: Decoction of a handful of fresh leaves in 1.5L of water. Drink 1 glass 3x / day for 7 days.                  | 9        | Vaginitis, bacillary dysentery (ER), Cholera, hyper gastralgia (ER), Round (ER), Furuncle, abscess (ET), Hemorrhoids and wounds (ET), Headache, fever, ulcer (ET), Tuberculosis (ET), conjunctivitis (F), Wounds and stomachaches (ER). |
| Dialopsis africana               | R24: Decoction of a handful of dry root bark in 1L of water. Drink 1 glass 3x / day for 7 days.                   | 3        | Constipation, madness (R), Malnutrition (G), Severe malnutrition (Gr), Angina, kwashiorkor with (F) from mukuzanya: Clerodendrum myricoides + Munyenenyenge: Sessania seshan + Mucumucumu: Leonotis nepataefolia, Snake bite (F), Diarrhea and wounds (R). |
| Ekebergia benguellensis           | R25: Decoction of a handful of fresh root bark in 1.5L of water. Drink 0.5 x 2 / day for 4 days.                 | 16       | Dental caries, sexual asthma, hernia, low back pain 5R, Dysmenorrhea (ET), tily of the valley (F), Hepatitis, goiter (F), Cataracts and purulent otitis (Ft). |
| Eleusine indica                  | R26: Decoction of a handful of fresh roots in 1L of water. Drink 0.5x2x / d for 4 days.                           | 10       | Constipation, madness (R), Malnutrition (G), Severe malnutrition (Gr), Angina, kwashiorkor with (F) from mukuzanya: Clerodendrum myricoides + Munyenenyenge: Sessania seshan + Mucumucumu: Leonotis nepataefolia, Snake bite (F), Diarrhea and wounds (R). |
| Entada abyssinica                | R27: An infusion of 2 handles in 1L. Drink 1 glass 3 x / l d for 7 days.                                         | 2        | Splenomegaly, intestinal worms, and abdominal colic (ER).  |
| Erythrina abyssinica             | R28: Maceration for 48 hours of two handfuls of fresh fruit in 1.5L of water. Drink 1 glass 3x / day for 7 days.   | 3        | Constipation, madness (R), Malnutrition (G), Severe malnutrition (Gr), Angina, kwashiorkor with (F) from mukuzanya: Clerodendrum myricoides + Munyenenyenge: Sessania seshan + Mucumucumu: Leonotis nepataefolia, Snake bite (F), Diarrhea and wounds (R). |
| Euphorbia hirta                  | R30: Decoction of three handfuls of fresh whole plant in 1L. Drink 1/2 glass 2x / d for 4 days.                   | 14       | Constipation, madness (R), Malnutrition (G), Severe malnutrition (Gr), Angina, kwashiorkor with (F) from mukuzanya: Clerodendrum myricoides + Munyenenyenge: Sessania seshan + Mucumucumu: Leonotis nepataefolia, Snake bite (F), Diarrhea and wounds (R). |
| Flueggea virosa                  | R31: Decoction of two handfuls of leaves in 1L of water. Drink 1/2 glass 2x / d for 4 days.                       | 1        | Constipation, madness (R), Malnutrition (G), Severe malnutrition (Gr), Angina, kwashiorkor with (F) from mukuzanya: Clerodendrum myricoides + Munyenenyenge: Sessania seshan + Mucumucumu: Leonotis nepataefolia, Snake bite (F), Diarrhea and wounds (R). |
| Hypoestes triflora               | R32: Maceration of three handles of roots in 1.5L of water. Drink 1 glass 3x / day for 7 days.                   | 1        | Constipation, madness (R), Malnutrition (G), Severe malnutrition (Gr), Angina, kwashiorkor with (F) from mukuzanya: Clerodendrum myricoides + Munyenenyenge: Sessania seshan + Mucumucumu: Leonotis nepataefolia, Snake bite (F), Diarrhea and wounds (R). |
| Isoberlinia angolensis            | R33: Maceration of a handful of fresh roots in 1L of water. Drink 1/2 glass 2x / d for 4 days.                   | 1        | Constipation, madness (R), Malnutrition (G), Severe malnutrition (Gr), Angina, kwashiorkor with (F) from mukuzanya: Clerodendrum myricoides + Munyenenyenge: Sessania seshan + Mucumucumu: Leonotis nepataefolia, Snake bite (F), Diarrhea and wounds (R). |
| Isoberlinia tomentosa             | R34: Decoction of two handfuls of crushed roots in 1.5L of water. Drink 1/2 glass 2x / d for 4 days.            | 1        | Constipation, madness (R), Malnutrition (G), Severe malnutrition (Gr), Angina, kwashiorkor with (F) from mukuzanya: Clerodendrum myricoides + Munyenenyenge: Sessania seshan + Mucumucumu: Leonotis nepataefolia, Snake bite (F), Diarrhea and wounds (R). |
| Jatropha curcas                   | R35: Decoction of three handles of fresh leaves in 1.5L. Drink 1/2 glass 2x / d for 4 days.                      | 1        | Constipation, madness (R), Malnutrition (G), Severe malnutrition (Gr), Angina, kwashiorkor with (F) from mukuzanya: Clerodendrum myricoides + Munyenenyenge: Sessania seshan + Mucumucumu: Leonotis nepataefolia, Snake bite (F), Diarrhea and wounds (R). |
| Julbernardia paniculata           | R36: Take 0.5L of the latex from the root and apply it at the neck 1/2 glass x2 / day for 4 days.               | 1        | Gingivitis, indigestion (ER), Food poisoning (ER), Splenomegaly (ER), Wounds (ER), purulent urethritis (ET), Gastritis (F). |
| Lantana camara                   | R37: Take 0.5L of the latex from the stem barks and apply it at the neck 1/2 glass x2 / day for 4 days.          | 1        | Gingivitis, indigestion (ER), Food poisoning (ER), Splenomegaly (ER), Wounds (ER), purulent urethritis (ET), Gastritis (F). |
| Leucas martinensis               | R38: Infusion of three handfuls of fresh leaves in 1L of water for 20 minutes. Drink 1/2 glass 2 x / day for 4 days. | 1        | Gingivitis, indigestion (ER), Food poisoning (ER), Splenomegaly (ER), Wounds (ER), purulent urethritis (ET), Gastritis (F). |
| Mangifera indica                 | R40: Decoction of three handfuls of fresh whole plant in 1.5L. Drink 1/2 glass 2x / d for 4 days.              | 1        | Gingivitis, indigestion (ER), Food poisoning (ER), Splenomegaly (ER), Wounds (ER), purulent urethritis (ET), Gastritis (F). |
| M. oleifera                      | R41: Decoction of a handful of fresh leaves in 1.5L of water. Drink 2 glasses 3x / d for 3 days.                 | 1        | Gingivitis, indigestion (ER), Food poisoning (ER), Splenomegaly (ER), Wounds (ER), purulent urethritis (ET), Gastritis (F). |
| Ochna schweinfurthiana           | R42: Decoction of a handful of fresh leaves in 1.5L of water. Drink 2 glasses 3x / d for 3 days.                 | 1        | Gingivitis, indigestion (ER), Food poisoning (ER), Splenomegaly (ER), Wounds (ER), purulent urethritis (ET), Gastritis (F). |
| Ocimum gratissimum               | R43: Decoction of a handful of fresh stem bark in 1.5L of water. Drink 2 glasses 3x / d for 3 days.            | 8        | Gingivitis, indigestion (ER), Food poisoning (ER), Splenomegaly (ER), Wounds (ER), purulent urethritis (ET), Gastritis (F). |
| ~ 8 ~                            |                                                        | 4        | Gingivitis, indigestion (ER), Food poisoning (ER), Splenomegaly (ER), Wounds (ER), purulent urethritis (ET), Gastritis (F). |

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| Common Name | Description | Conditions & Other Notes |
|-------------|-------------|-------------------------|
| Phyllanthus muellerianus | Decoction of a handful of fresh leaves in 1.5L of water. Drink 2 glasses 3x/d for 7 days. | Tuberculosis, Gonorrhoea (R), Hemorrhoid (F). |
| Phyllanthus niruri | Decoction of a handful of fresh leaves in 1.5L of water. Drink 2 glasses 3x/d for 7 days. | Gastritis, fever, cough, wounds (ER), Asthenia (ER). |
| Physalis angulata | Decoction of two handfuls of leaves in 1L of water. Drink 2 glasses 3x/d for 4 days. | Snake bite, constipation (PE), Intestinal worms (PE). |
| Piliostigma thonningii | Decoction of a handful of fresh leaves in 1.5L of water. Drink 1 glass of filtrate 3x/d for 7 days. | Headaches, mycosis (ET), Dysmenorrhoea (ET). |
| Psidium guajava | Decoction of a handful of fresh leaves in 1L of water. Drink 1 glass 3x/d for 7 days. | Psoriasis (F), back pain (with Igwara: Cyathula uncinulata), intestinal worms, dermatitis (F), bacillary dysentery (F), Constipation and immunodeficiency (F). |
| Rothmannia englerianna | Decoction of a handful of fresh leaves in 1L of water. Drink 1.5L of water (or immature banana wine: ecibabe). Drink 1 glass 3x/d for 7 days. | Irritation of the skin (F), Pneumonia (F), Diabetes, Toothache (ER), Amoebiasis (ER), Spasms, diarrhoea (ER), Hypotension (Fr). |
| Senecio cineraria | Decoction of a handful of fresh leaves in 1L of water. Drink 1 glass 3x/d for 7 days. | Cold, pneumonia, Intestinal worms (F). |
| Solanecio stuhlmannii | Decoction of a handful of fresh leaves in 1L of water. Drink 1 glass 3x/d for 4 days. | Intestinal worms (ER), Amoebiasis (ET), Syphilis (ET), Hepatitis, gonorrhoea (F), Lice (F). |
| Spilanthes mauritiana | Decoction of a handful of fresh leaves in 1L of water. Drink 1 glass 3x/d for 7 days. | Pneumonia, urinary tract infection (F), Amoebiasis, anemia (F), Typhoid fever (F), Poisoning (PE), Amoebiasis, wound, diarrhoea (PE), Mycosis, dysentery (PE), Tuberculosis, myomas (PE), Syphilis (PE). |
| Syzygium cordatum | Decoction of a handful of leaves in 1L of banana juice. Drink 1 glass 3x/d for 7 days. | Convulsion, pains (ER), Abdominal, epilepsy, meningitis (ER), Typhoid fever (ER), Gonorrhoea, tooth decay (ER). |
| Tagetes minuta | Decoction of two handfuls of leaves in 1L of water. Drink 1 glass 3x/d for 7 days. | Diabetes (F), Amoebiasis, indigestion (PE), Diarrhoea and gastritis (R). |
| Tithonia diversifolia | Decoction of leaves of fresh ground leaves in 1L of water. Drink ½ glass filtrate 2x/d for 4 days. | Intestinal worms, fever (F), Hemorrhage, uterine pain (F), Epistaxis (T) and tuberculosis (F). |
| Trema orientalis | Decoction of a handful of crushed stem barks in 1.5x2L of water. Drink 1 glass 3x/d for 7 days. | Food poisoning (R), Placental retention (R), Childbirth, hemorrhage (R), Snake bite and wounds (F). |
| Vernonia amygdalina | Decoction of a handful of leaves in 1L of water. Drink 1 glass 3x/d for 4 days. | Splenomegaly, asthenia (F), Cold, constipation and anorexia (F). |
| Hypoestes triflora (PE) Ekebergia benguellensis (F) Ageratum conyzoides (F). | Decoction of a handful of leaves of freshwater mixed handles and pounded in proportions 1 ÷ 1 ÷ 2. Filter and drink 1 glass 3x/d for 3 days. | Splenomegaly, asthenia (F), Cold, constipation and anorexia (F). |
| Mangifera indica (F) Azadirachta indica (F). | Decoction of a handful of leaves of each plant in proportions 1 ÷ 1. Pound together and infuse for 25 minutes in 1.5x2L of water. Drink 1 glass of filtrate 2x/d for 4 days. | Splenomegaly, asthenia (F), Cold, constipation and anorexia (F). |
| Catharanthus roseus (F), Cinchona ledgeriana (ER), Senna occidentalis (F). | Decoction of a handful of the organ of each plant in proportions 1 ÷ 1 ÷ 2. Make a decoction in 1x2 liters of water for 30 minutes. Drink 1 glass 3x/d for 3 days. | Splenomegaly, asthenia (F), Cold, constipation and anorexia (F). |
| Tithonia diversifolia (F). | Decoction of a handful of leaves of each plant in proportions 1 ÷ 1 ÷ 2. Filter and drink 1 glass 3x/d for 3 days. | Splenomegaly, asthenia (F), Cold, constipation and anorexia (F). |
These preponderances of leaf and decoction in herbal recipes are reported in several ethnobotanical surveys conducted on antimalarial plants [17, 18, 25, 35, 82]. According to the consulted IPTM, the recourse to the decoction would aim not only the extraction of the active principle but also its activation. It must be remembered, however, that this practice would be as beneficial as it is harmful. Indeed, as much as it could facilitate the release of certain active principles often present in the plant in the glycoside form, as much it could not only release some toxic forms of secondary metabolites like cyanogenic glycosides [83] or deteriorate the active compounds. This practice therefore remains to be assessed on a case-by-case basis and only experimental work could determine its fair value as appropriate.

In addition, ethnobotanical studies carried out in DR Congo [77, 80, 82, 84] whatever the most often oriented towards a specific pathology, do not report plants used as an antidote to poisons, particularly against snake bites with a frequency comparable to that observed in the present study (17%); The population of Bagira would therefore have a particular knowledge of poisons. Note also that the results related to the pathologies treated by these plants are in the same line as that of work carried out in other regions of the country (24,35), which have established that most of the pathologies taken care of in traditional Congolese medicine are of infectious origin.

4. Conclusion

This study identified 53 plants used in traditional medicine in Bagira (DRC) for the treatment of malaria. These plants belong to 43 genera from 24 families dominated by Asteraceae and Fabaceae. They participate in 83 antimalarial recipes of which 67 use a single plant and the other associates two, three or four plants where the leaf is the most used organ in the form of a decoction. This study cites for the first time Chenopodium opulifolium, Clematis villosa, Crassocephalum montuosum, Crassocephalum picridifolium, Dalbergia
katangensis, Dialium angolense, Dialopsis africana, Ekebergia benguellensis, Hypoestes triflora, Isoberlinia tomentosa, Julbernardia paniculata, Psorospermum corymbiferum and Rothmannia engleriana as antimalarial plants and thus constitutes a database for further investigative investigations that may include the isolation of antimalarial compound or the production of improved traditional drugs.

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Competing Interests
Authors have declared that no competing interests exist.

Authors’ Contributions
Bashige chiribagula valentin collected the first data by conducting ethnomedical surveys; designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. ‘Bakari Amuri Salvius and Okusa Ndjolo Philippe managed the analyzes of the study and the literature searches, Kahumba Byanga, Duez Pierre and Lumbo Simbi, supervised project and have corrected the manuscript. All authors read and approved the final manuscript.

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