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Perception of malaria and cultural diversity of antimalarial plants in three sympatric communities: Agni, Akyé and Gwa in the District of Alépé, Côte d'Ivoire

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Abstract. *Diop AL, Malan DF, Kougbo MD. 2022. Perception of malaria and cultural diversity of antimalarial plants in three sympatric communities: Agni, Akyé and Gwa in the District of Alépé, Côte d'Ivoire. Asian J Ethnobiol 5: 1-11.* Each ethnic group has developed its culture expressed through traditional healthcare systems. This study aimed to determine how the communities with different histories perceive and manage malaria, a disease with a high prevalence rate in the Sub-Saharan region. An ethnobotanical survey was carried out in 10 Agni, Akyé, and Gwa communities villages. Two surveys were conducted: a house-to-house survey based on free lists interviews and an individual walk-in-the-woods interview. Frequency of quotation and Smith's index was used to assess antimalarial plants' knowledge level. The Venn diagram, hierarchical clustering, and Spearman correlation test compared malaria perception and the antimalarial plants among the three communities. Six forms of malaria were recognized in the studied communities with various symptoms. Seventy-seven antimalarial plants were used to cure these forms. The proportion of antimalarial plants specific to each community was quite low. This study has revealed the differences and similarities between the antimalarial plants used by communities in the same geographical area. This study has also highlighted new plants in the study area that could treat malaria. Finally, awareness must be made in the studied communities on different forms of malaria for a better understanding of this disease.

Keywords: Alépé, *Alstonia boonei*, *Annickia polycarpa*, Côte d'Ivoire, malaria, medicinal plants

INTRODUCTION

Medicinal plants are one of the most well-known of traditional knowledge. They provide primary health care (De Boer et al. 2012; Mazengia et al. 2019; Nahdi and Kurniawan 2019; Rianawati and Siswadi 2020; Assefa et al. 2021). In addition, traditional medicine is an important source of health care in rural or tribal areas (Maroyi 2013; Farooq et al. 2019; Az-Zahra et al. 2021; Novriyanti et al. 2021). In Sub-Saharan countries such as Côte d'Ivoire (Bla et al. 2015; Kipré et al. 2017), Mali (Diarra et al. 2015), and Guinea (Traoré et al. 2013), rural communities depend basically on medicinal plants. Sometimes, they are combined with modern drugs to cure many diseases like malaria and typhoid fever (Asafo-Agyeitey et al. 2019).

Malaria is among the major vector-borne diseases that kill many communities in Sub-Saharan Africa (Youmsi et al. 2017). Over 300 million acute malaria cases are estimated to occur worldwide yearly, with about 1 million deaths (Asafo-Agyeitey et al. 2019). Approximately 90% of these deaths occur in Sub-Saharan Africa, and most victims are children less than five years old and pregnant women (GHO 2020). This disease constitutes a real public health issue. Malaria is the cause of many consultations and hospitalizations in health centers, hospitals, and clinics (Yetein et al. 2013). However, the high costs of sanitary care lead many rural areas to use traditional medicine as an alternative solution to curing malaria (Ngarivhume et al. 2015; Syahdar et al. 2019; Tamalene et al. 2021).

The perception of malaria is the mode of apprehending this disease according to empiric acquisitions of people. This perception is specific to a given ethnic group (Yaya et al. 2017). Culture is a shared system of knowledge and competence among humans (Gaoue et al. 2017). Thus, cultural diversity refers to the richness and relative abundance of species used in a particular group according to their cultural context and the disease (Jamera et al. 2020). Unfortunately, in West Africa, people transmitted their medicinal knowledge orally from one generation to another (Soelberg et al. 2015). Yet, the knowledge holders die before passing on their knowledge to the younger generations (Asafo-Agyeitey et al. 2019). Therefore, it is necessary to determine the importance of the antimalarial plants to provide new data.

Measuring the knowledge provides information about the level of consensus and the variation in medicinal plants used by the different communities through the same geographical area and distant but culturally similar communities (De Boer et al. 2012; Bhandary 2021). On the other hand, the differences and similarities in traditional knowledge among different cultural communities living in the same area can explain how cultural reflection evolved (Amjad et al. 2020). Unfortunately, comparative ethnobotanical studies among communities within the same area are rare. Nevertheless, such studies help find which species are shared through communities and for which reasons (Hilgert and Gil 2007). Moreover, these studies analyze whether cultural diversity is reflected in folk phytotherapy knowledge (Kujawska et al. 2017).

The targeted study area communities have been in close contact for many centuries. The Agni and the Akyé communities belong to the great Akan ethnic group (Kossonou and Assanvo 2016). In comparison, the Gwa communities were adopted in the great Akan ethnic group (Goly 2010; Aka 2011). Moreover, these communities live in the endemic zone of malaria. For instance, more than 300 confirmed cases per 1,000 inhabitants annually were observed (GHO 2020). In this context, there is a need to have a database to complete the existing antimalarial plants and to determine the perception of malaria in the local medicinal system for better awareness of this disease. To our knowledge, no study has been conducted on botanical knowledge about malaria in these communities. Based on the principle that any plant usage is a cultural expression, we assume that the communities of different origins living in the same geographical area would have different perceptions of malaria and use different plants to cure it. However, we assume that their long proximity allows them to share knowledge about this disease. Therefore, this study aims to determine (i) the perception of malaria through the communities and (ii) the similarity of antimalarial plants and the knowledge surrounding them.

MATERIALS AND METHODS

Study area

An explorative study was conducted in the Southeastern part of Côte d'Ivoire (West Africa), in the Region of La Mé. This region was subdivided into four districts, i.e., Adzopé, Akoupé, Alépé, and Yakassé-Attobrou. The district of Alépé where this research took place is located between 5°13'04.49"-5°55'22.06" N and 3°25'25.25"-3°57'46.64" W (Figure 1). The district's climate is equatorial and humid, characterized by four alternative seasons (two rainy and two dry seasons). The annual rainfall ranges from 1,200 to 1,600 mm, and the annual temperature is 26.4°C. The vegetation of the study area is a Guinean rainforest characterized by *Eremospatha macrocarpa* (G.Mann and Wendl) Wendl and *Diospyros mannii* Hiern (Guillaumet and Adjanohoun 1971).

The study area harbors three sympatric communities: Agni, Akyé, and Gwa. They are unequally spread within five sub-prefectures, i.e., Aboisso-Comoé, Alépé, Allosso, Danguira, and Oghlwapo. These three communities have been settled in their present territory since the beginning of the 18th century, the Agni and the Akyé from actual Ghana (Allou and Gonnin 2006; Diabaté 2013), and the Gwa from Liberia (Goly 2010; Aka 2011). These communities conquer their current geographical area (Bamba et al. 1989). All three communities are essentially farmers.

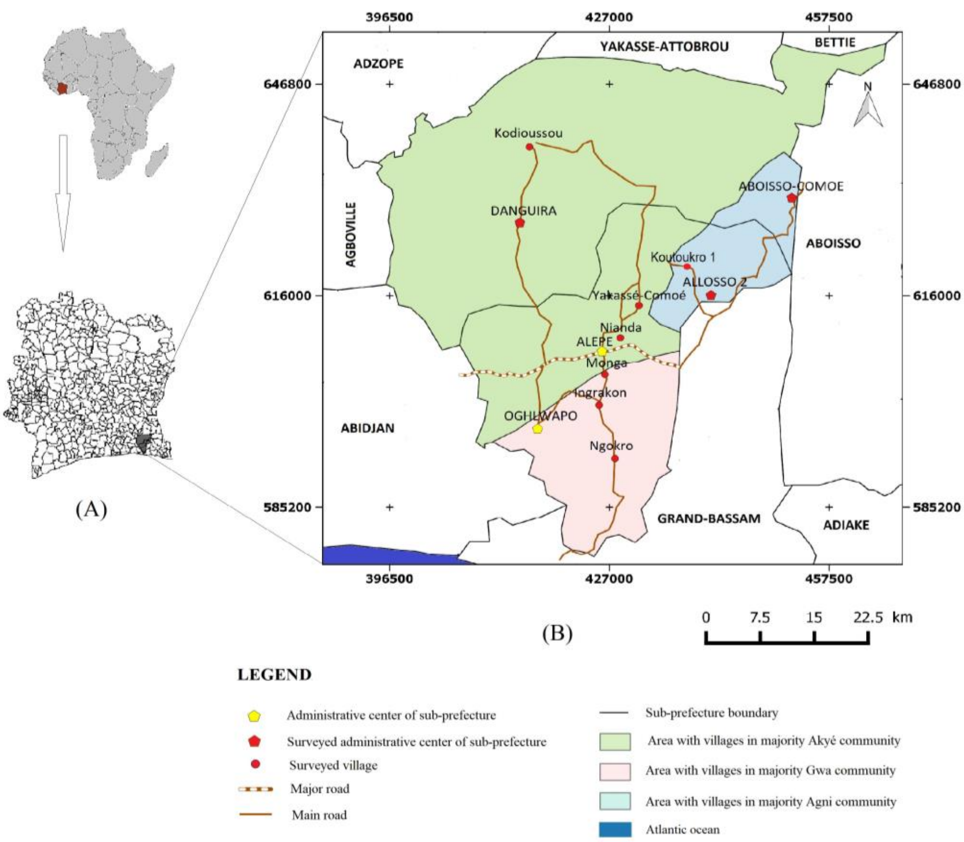

Figure 1. Location of the studied communities: A. Location of the study area in Côte d'Ivoire; B. Location of villages sampled in the study area

Data collection

Ten villages were surveyed (three villages in the Agni community, four in the Akyé community, and three in the Gwa community). The ten villages were visited in 13 trips from September 2017 to August 2019. The survey was carried out in two steps. First, during the survey, we followed the recommendations of the international codes of ethics (ISE 2006).

Step 1. During the house-to-house approach, men and women were interviewed randomly, individually, or collectively (Quinlan 2005). Questions were asked to collect information on the forms, symptoms, and plants to cure malaria. At the end of the interview, we asked for demographic information, including the spouse's marital status and ethnic group.

Step 2. From the previous list of interviewees, eight key knowledge holders were selected (two in the Agni community, two in the Akyé community, and four in the Gwa community) based on the high number of antimalarial plants they mentioned. For this step, knowledge holders were interviewed during a walk-in-the-wood approach in the surrounding bushes (Phillips and Gentry 1993). During these walks, herbarium vouchers of listed plants were collected for identification at the laboratory of Botany of NANGUI ABROGOUA University and were confirmed in the Herbarium of the Floristic National Center.

Data analysis

Distribution of the forms of malaria through the communities

Hierarchical clustering (Weller 2005) was performed using different packages, including *FactoMineR* for data analysis and *factoextra* to visualize the analysis. Hierarchical clustering shows the distribution of the forms of malaria and the antimalarial plants used through the targeted communities.

Similarity of plants used to heal malaria

Jaccard similarity Index (Jaccard 1908) was performed to determine the similarity of antimalarial plants used by the three studied communities. It ranges from 0% to 100% (maximum similarity). In addition, a Venn diagram was plotted to show shared and different species across studied communities. This diagram was obtained using the *Venn diagram* package (Chen and Boutros 2011).

Knowledge level of antimalarial plant and distribution of knowledge in the studied communities

Smith's index (Sutrop 2001) was performed using Anthropac 4.0 to obtain the knowledge level of each antimalarial plant. It is based on cognitive salience (Sa) and the frequency of quotation (Fq). The cognitive salience ranges from 0 (low cognitive salience) to 1 (high cognitive salience). In comparison, the frequency of quotations ranges from 0% to 100%.

Then, the Kruskal-Wallis test was used to compare the antimalarial plants shared through the three studied communities (Kruskal and Wallis 1952). This test determines the intercultural convergence about the antimalarial plants, which are shared through the targeted communities. Finally, the Spearman coefficient was used to test the correlation between gender and the knowledge of antimalarial plants. All statistical analyses were performed with R Studio software (version 4.0.3).

Finally, the fidelity level (FL) index (Friedman et al. 1986) was performed to identify the preferred plants to heal various forms of malaria and to show the proportion of interviewees reporting the usage of specific plants.

RESULTS AND DISCUSSION

Demographic profile of informants

A total of 290 knowledge holders were surveyed. They were distributed among 97 knowledge holders in the Agni community (40 men and 57 women), 97 in the Akyé community (35 men and 62 women), and 96 in the Gwa community (40 men and 56 women). Of the knowledge holders surveyed, 60 (20.7%) were between 18 and 39 years, 161 (55.52%) knowledge holders were between 40 and 62 years, and 69 (23.79%) knowledge holders were between 63 and 87 years. Of the 290 people surveyed, 134 (46.21%) were single, 120 (41.38%) people were married in the same ethnic group, and 36 (12.41%) people were married in other ethnic groups (Table 1).

Perception of malaria according to studied communities

The three communities recognized different forms of malaria: six in each of the Akyé and the Gwa communities and five in the Agni community (Table 2). However, those forms' descriptions differed from one community to another (Table 3), even if Akyé and Gwa were the closest in terms of convergence of symptoms (Figure 2).

Abundance and intercultural relationship of the antimalarial plants

The survey revealed that there are antimalarial plants unique to each community. It also revealed that two communities shared the antimalarial plants. Finally, the survey indicated that the targeted communities shared the same antimalarial plants. 20 (25.97%) were shared with the three communities among the collected plants. Twelve plants were used respectively by the Agni and the Akyé communities, and 15 by the Gwa community (Figure 3). In total, the Agni community mentioned 43 antimalarial plants. In comparison, the Akyé community indicated 44 plants used for malaria care. Finally, the Gwa community identified 48 antimalarial plants.

Knowledge level of the antimalarial plants within each community

Seventy-seven plants used to cure malaria were collected and distributed in 71 genera and 38 families (Table 4). The most represented families were Lamiaceae, Asteraceae, and Fabaceae, with five plants per family. These antimalarial plants comprised 67 trees and shrubs, nine herbaceous plants, and one liana.

Of the 77 antimalarial plants used to heal malaria, only seven (9.09%) have high knowledge levels, including

Annickia polycarpa (DC.) Setten & Maas ex I.M.Turner [Agni (Sa=0.23; Fq=44.33%), Akyé (Sa=0.35; Fq=49.48%), Gwa (Sa=0.19; Fq=28.13%] (Figure 4A), *Gymnanthemum amygdalinum* (Delile) Sch.Bip [Agni (Sa=0.16; Fq=26.8%), Gwa (Sa=0.25; Fq=35.42%)], *Alstonia boonei* De Wild. [Agni (Sa=0.27; Fq=38.14%), Akyé (Sa=0.26; Fq=35.05%)] (Figure 4B), *Nauclea latifolia* Sm. [Agni (Sa=0.16; Fq=21.65%), Gwa (Sa=0.27; Fq=32.29%)], *Harungana madagascariensis* Lam. Ex. Poir. [Agni (Sa=0.17; Fq=28.87%)], *Ocimum gratissimum* L. [Agni (Sa=0.15; Fq=22.68%)], and *Senna occidentalis* (L.) Link [Agni (Sa=0.15; Fq=21.65%)]. In addition, this knowledge level differs from one community to another.

Table 1. Demographic profile of informants

		Age group				
Ethnic group	**Gender**	**[18;39]**	**[40;62]**	**[63;87]**	**No. of informant [n (%)]**	**Total number [n (%)]**
Agni	Men	10	28	2	40 (41.24)	97 (33.45)
	Women	10	37	10	57 (58.76)	
Akyé	Men	12	16	7	35 (12.07)	97 (33.45)
	Women	19	30	13	62 (21.38)	
Gwa	Men	4	19	17	40 (13.79)	96 (33.1)
	Women	5	31	20	56 (19.31)	
		60 (20.7)	161 (55.52)	69 (23.79)	290	

Matrimonial status					
Item	**No. of informant [n (%)]**	**Item**	**No. of informant [n (%)]**	**Item**	**Number of informant [n (%)]**
Single Agni	45 (46.39)	single Akyé	49 (50.52)	single Gwa	40 (41.67)
Agni married to Agni	48 (49.48)	Akyé married to Akyé	43 (44.33)	Gwa married to Gwa	29 (30.21)
Agni married to Akyé	3 (3.09)	Akyé married to Agni	4 (4.12)	Gwa married to Agni	1 (1.04)
Agni married to Gwa	1 (1.03)	Akyé married to Gwa	1 (1.03)	Gwa married to Akyé	26 (27.08)

Note: no: number

Table 1. The local name of malaria and its meanings according to the studied communities

Studied community	Local name	Local perception	Literal meaning
Agni	*Ebunu*	*Ebunu fufue, ebunu kokole, ebunu bile, ebunu ewengo, enwulo*	White malaria, yellow malaria, black malaria, red malaria, bird malaria
Akyé	*Shilo*	*Shilo fi, shilo nin, shilo bi, shilo poin, n'kaka, kpun shilo*	White malaria, yellow malaria, black malaria, red malaria, bird malaria, mystical malaria
Gwa	*Djakoadjo*	*Djakoadjo popon, djakoadjo heni, djakoadjo mlu, djakoadjo nuin, zoku, djakoadjo montinin*	White malaria, yellow malaria, black malaria, red malaria, bird malaria, mystical malaria

Table 3. Forms of malaria and related symptoms according to the studied communities

Form of malaria	Symptoms of malaria according to community	Community (number of the quotation of the symptom)
Yellow malaria	Yellowish eyes	Akyé (18), Gwa (18)
	Yellowish urine	Agni (3), Akyé (18), Gwa (18)
	Fever	Agni (2), Akyé (2)
White malaria	Pale skin	Agni (2), Akyé (10), Gwa (13)
	Edema	Agni (10), Akyé (9), Gwa (4)
Red malaria	Fever	Akyé (1), Gwa (11)
	Reddish eyes	Akyé (8), Gwa (20)
Black malaria	Fever	Agni (1), Akyé (1), Gwa (4)
	Dark skin	Agni (3), Akyé (3), Gwa (9)
Birds malaria	Disjointed movement	Agni (2), Akyé (2), Gwa (5)
	Fever	Agni (2)
	Pale skin	Agni (1), Gwa (1)
Mystical malaria	Unnatural weight loss, madness, sorcery	Akyé (2), Gwa (4)

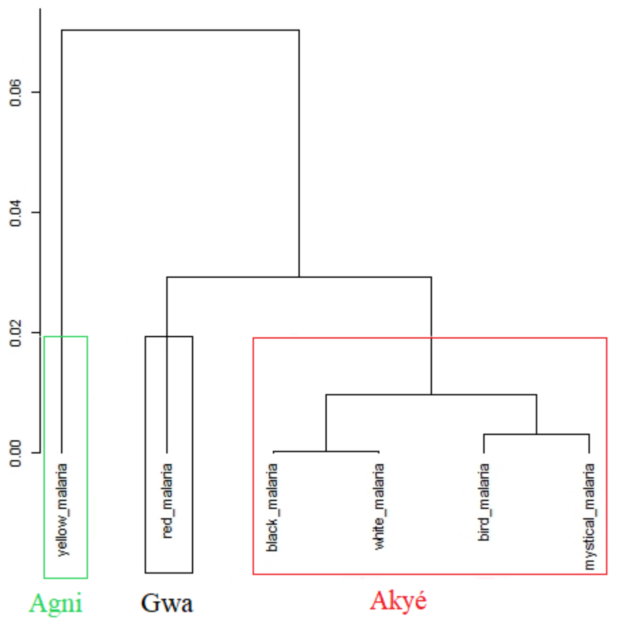

Figure 1. Distribution of the forms of malaria through studied communities

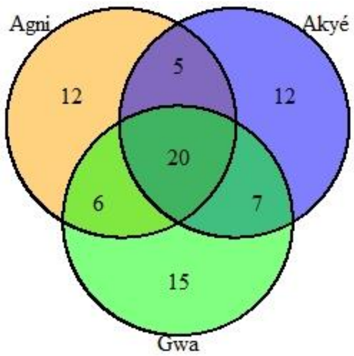

Figure 2. Number of exclusive and shared antimalarial plants among the studied communities

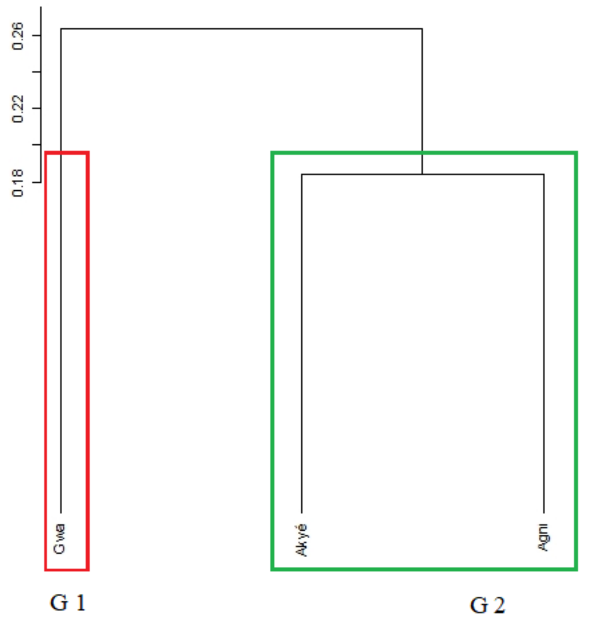

Figure 3. Hierarchical clustering of studied communities based on antimalarial plants

Distribution of knowledge

The distribution of the antimalarial plants subdivided the studied communities into two groups (Figure 5). The first (G1) is characterized by antimalarial plants used by the Gwa community. In addition, the second group (G2) includes antimalarial plants used by the Agni and the Akyé communities.

Similarity of antimalarial plants used in studied communities

The values of the Jaccard similarity index of the antimalarial plants were low in the three communities (Table 5).

Figure 4. Two antimalarial plants well-known by the studied communities: A. Bark pieces of *Annickia polycarpa* (DC.) Setten & Maas ex I.M.Turner collected by a key knowledge holder; B. Tree of *Alstonia boonei* De Wild.

Table 4. Knowledge level of antimalarial plants used by the studied communities

Family	Species	Agni		Akyé		Gwa		Local name (Agni, Akyé, Gwa)
		Fq (%)	Sa	Fq (%)	Sa	Fq (%)	Sa	
Acanthaceae	*Justicia tenella* (Nees) T.Anderson	-	-	-	-	1.04	0.01	-, nvêtza, nglonmpi
	Phaulopsis ciliata (Wild.) Hepper	-	-	2.08	0.02	-	-	-, ntobi, -
Alliaceae	*Allium sativum* L.	1.03	0.01	-	-	-	-	ail, -, -
Anacardiaceae	*Mangifera indica* L.	1.03	0.01	6.25	0.03	3.13	0.02	amango, mangoté, mongodé
	Spondias mombin L.	-	-	2.08	0.02	4.17	0.04	troman, mgba, maga
	Trichoscypha arborea (A.Chev.) A.Chev.	-	-	6.25	0.05	1.04	0.01	-, ndabo, namouhokoyé
Annonaceae	*Annickia polycarpa* (DC.) Setten & Maas ex I.M.Turner	44.33	0.23	49.48	0.35	28.13	0.19	essoubo-kokolè, tsin, poudin
	Monodora myristica (Gaertn.) Dunal	-	-	-	-	1.04	0.00	-, -, m'min
	Xylopia aethiopica (Dunal) A.Rich.	-	-	1.04	0.01	1.04	0.00	-, foutsan, nouébiho
Apocynaceae	*Alstonia boonei* De Wild.	38.14	0.27	35.05	0.26	17.71	0.10	émian, kokpè, obiayé
	Hunteria umbellata (K. Schum.) Hallier f.	2.06	0.01	-	-	-	-	kaklan, -, -
	Picralima nitida (Stapf) T.Durand and H. Durand	-	-	1.03	0.05	1.04	0.00	-, ndémouin, bichi
	Rauvolfia vomitoria Afzel.	14.43	0.09	10.42	0.09	7.29	0.05	bakakpégbé, nguéchébi, ngobiayé
Arecaceae	*Cocos nucifera* L.	-	-	-	-	7.29	0.03	-, -, ochibouo
Asteraceae	*Ageratum conyzoides* L.	-	-	-	-	11.46	0.01	-, -, mpi-souin
	Chromolaena odorata (L.) R.M.King and H. Rob.	5.21	0.05	1.04	0.01	-	-	independenci, poukèkè, -
	Gymnanthemum amygdalinum (Delile) Sch.Bip	26.80	0.16	19.79	0.11	35.42	0.25	aboyoui, tozo, mlipo
	Microglossa pyrifolia (Lam.) Kuntze	-	-	-	-	1.04	0.01	-, -, djon-nounou
	Struchium sparganophorum (L.) Kuntze	-	-	-	-	4.17	0.02	-, -, otchouon
Bignoniaceae	*Newbouldia laevis* (P.Beauv.) Seem. ex Bureau	-	-	-	-	2.08	0.02	-, -, ogoato
Bromeliaceae	*Ananas comosus* (L.) Merr.	-	-	1.04	0.00	2.08	0.01	-, akodin, ndrachi
Cannabaceae	*Trema orientalis* (L.) Blume	2.06	0.01	2.06	0.01	-	-	assia, anacha, -
Cannaceae	*Canna indica* L.	10.31	0.07	-	-	-	-	acounougbou, -, -
Caricaceae	*Carica papaya* L.	18.56	0.09	14.43	0.08	19.79	0.08	blèflè, mbomou, ablè
Combretaceae	*Terminalia catappa* L.	3.09	0.01	-	-	1.04	0.01	cocoma, -, cocoma
	Terminalia ivorensis A.Chev.	-	-	2.08	0.02	-	-	-, gnambi, -
	Terminalia superba Engl. and Diels	1.03	0.01	-	-	-	-	flamlé, -, -
Crassulaceae	*Kalanchoe crenata* (Andrews) Haw.	-	-	1.04	0.01	-	-	-, togbo, -
Cucurbitaceae	*Momordica charantia* L.	7.22	0.05	9.38	0.07	25	0.13	awossongo, atomomou, obiépon
Ebenaceae	*Diospyros sanza-minika* A.Chev.	-	-	-	-	1.04	0.01	-, -, bibliqué
Euphorbiaceae	*Alchornea cordifolia* (Schumach and Thonn.) Müll.Arg.	15.46	0.06	13.54	0.07	11.46	0.07	diéca, nzè, adjèguè
	Macaranga barteri Müll.Arg.	-	-	1.03	0.01	-	-	-, aboh, -
	Manihot esculenta Crantz	6.19	0.05	6.19	0.04	-	-	bèdè, mèdè, -
	Ricinodendron heudelotii (Baill.) Pierre ex Heckel	-	-	-	-	1.04	0.00	-, -, bobochi
Fabaceae	*Distemonanthus benthamianus* Baill.	2.06	0.01	5.15	0.03	-	-	éwrovia, -, adouanga
	Parkia bicolor A.Chev.	4.12	0.02	-	-	-	-	tominda, -, -
	Piliostigma thonningii (Schumach.) Milne-Redh.	-	-	1.03	0.01	-	-	-, kéoukégba, -
	Senna alata (L.) Roxb	-	-	-	-	4.17	0.04	-, -, mgbégbou
	Senna occidentalis (L.) Link	21.65	0.15	16.49	0.11	20.83	0.13	èkendébalouba, kangamonin, gongondjronmié

Hypericaceae	*Harungana madagascariensis* Lam. ex Poir.	28.87	0.17	14.43	0.10	6.25	0.05	cossoua, mgbouana, mgbamlin
	Vismia guineensis (L.) Choisy	6.19	0.04	-	-	-	-	babagamano, -, -
Irvingiaceae	*Irvingia gabonensis* (Aubry-Lecomte ex O'Rorke) Baill.	-	-	3.09	0.02	-	-	-, bé, -
Lamiaceae	*Hoslundia opposita* Vahl.	11.34	0.06	2.06	0.02	3.13	0.02	anoumaliè, anoumaliè, doupa-nounou
	Ocimum gratissimum L.	22.68	0.15	11.34	0.05	14.58	0.09	amagniné, pèhin, nounou
	Plectranthus monostachyus (P.Beauv.) B.J.Pollard	1.03	0.00	-	-	1.04	0.01	nzissiwololo, -, gbrolo
	Tectona grandis L.f.	11.34	0.05	1.03	0.01	3.13	0.02	teckgna, -, teck
	Vitex grandifolia Gürke	-	-	1.03	0.01	-	-	-, leubunh, -
Loganiaceae	*Anthocleista nobilis* G.Don	3.09	0.02	7.22	0.06	-	-	gblogblo, anougbé, -
Malvaceae	*Cola nitida* (Vent.) Schott and Endl.	-	-	-	-	4.17	0.03	-, -, opo
	Sida acuta Burm.f.	-	-	3.09	0.01	-	-	-, dzeugbontchou, -
	Tarrietia utilis (Sprague) Sprague	-	-	3.09	0.03	-	-	-, kpanda, -
	Theobroma cacao L.	2.06	0.01	-	-	-	-	coco, -, -
Meliaceae	*Azadirachta indica* A.Juss.	-	-	-	-	8.33	0.07	-, -, neem
	Khaya ivorensis A.Chev.	-	-	15.46	0.10	4.17	0.03	-, tzapeuchi, noucoumlin
Moringaceae	*Moringa oleifera* Lam.	-	-	-	-	2.08	0.00	-, -, moringa
Musaceae	*Musa x paradisiaca* L.	15.46	0.09	14.43	0.07	5.21	0.02	banan, domou, ngogo
Myrtaceae	*Psidium guajava* L.	-	-	3.09	0.03	1.04	0.01	-, adjama, alama
Ochnaceae	*Lophira alata* Banks ex C.F.Gaertn.	17.53	0.11	10.31	0.04	2.08	0.01	essolè, nonkpè, odoyé
Pandaceae	*Microdesmis keayana* J.Léonard	1.03	0.01	-	-	4.17	0.01	friman, -, adipion
Piperaceae	*Piper guineense* Schumach. and Thonn.	1.03	0.01	-	-	-	-	assian-sian, -, -
Poaceae	*Bambusa vulgaris* Schrad. ex J.C. Wendl.	5.15	0.03	-	-	14.58	0.11	camponi, -, bomblo
	Cymbopogon citratus (DC.) Stapf	2.06	0.02	1.03	0.01	1.04	0.01	tigna, nti,
	Saccharum officinarum L.	-	-	-	-	2.08	0.02	ahanlan, -, nglah
Rhizophoraceae	*Anopyxis klaineana* (Pierre) Engl.	-	-	-	-	1.04	0.00	-, -, ahoubin
Rubiaceae	*Mitragyna ledermannii* (K.Krause) Ridsdale	18.56	0.1	16.49	0.10	13.54	0.10	bèya, -, ogoayé
	Nauclea diderrichii (De Wild. and T.Durand) Merr.	22.68	0.11	-	-	1.04	0.01	bèdou, -, olémlédassin
	Nauclea latifolia Sm.	21.65	0.16	3.09	0.02	32.29	0.27	essoubo, mouleu, odoukwè
Rutaceae	*Citrus aurantiifolia* (Christm.) Swingle	5.15	0.04	3.09	0.02	18.75	0.09	doumouan, ndédé-tintin, mgbébié sacoba
	Citrus aurantium L.	8.25	0.07	4.12	0.01	1.04	0.01	ébolo-domouan, ndékichi, gué-gué
	Zanthoxylum gilletii (De Wild.) P.G.Waterman	1.03	0.01	-	-	-	-	édimoulalè, -, -
Sapindaceae	*Blighia unijugata* Baker	-	-	3.09	0.02	-	-	-, inkaka, -
	Paullinia pinnata L.	4.12	0.04	-	-	-	-	trondi,-,-
Solanaceae	*Physalis angulata* L.	-	-	1.03	0.01	-	-	-, ntototé, -
	Solanum nigrum L.	-	-	3.09	0.02	-	-	-, foué, -
Urticaceae	*Musanga cecropioides* R.Br.	3.09	0.02	-	-	6.25	0.03	édjui, -, m'moyé
	Myrianthus arboreus P.Beauv.	4.12	0.03	-	-	-	-	niangama, -, -
Zingiberaceae	*Aframomum melegueta* (Roscoe) K.Schum.	1.03	0.01	-	-	-	-	essa, -, -

Table 2. Matrix of the similarity of the antimalarial plants

	Agni	Akyé
Akyé	40.3	x
Gwa	40.00	41.5

Note: x: no value

Indeed, the Gwa community was close to the Akyé community geographically, and they married each other. The Kruskal-Wallis test revealed no significant difference (Chi squared= 3.27; p-value= 0.2) in the antimalarial plants shared by the studied communities. However, the Spearman test indicates women's better knowledge of antimalarial plants (S= 24774; p-value= 3.4 10-10; rho= 0.64).

Fidelity level of the antimalarial plants

The fidelity level values were less than 40%, suggesting that none of the antimalarial plants is specific to a particular form of malaria (Table 6). However, the mystical form of malaria is treated only by an animist priest with incantations and substances made with plants which the composition is secretly kept.

Discussion

Perception of malaria according to the studied communities

Different local names were used to refer to the forms of malaria. This difference in perception of malaria is generally transmitted orally in our study area. In Africa, several studies have also shown that the communities distinguished different forms of malaria according to the cultural context. For instance, in Mali, the communities of Sélingué sub-districts recognized five forms of malaria (Diarra et al. 2015), while in Zimbabwe, only two forms were distinguished by traditional healers in the Chipinge District (Ngarivhume et al. 2015). Generally, traditional medicine is a part of people's culture and closely linked to their beliefs which often go beyond explicable realities. Thus, two communities in our study area mentioned a mystical form of malaria with no clear symptoms, such as unnatural weight loss, madness, or sorcery. Indeed, people combine religion, sorcery, and interpersonal conflict into a single form of belief and practice (Gessler et al. 1995). For example, the Amazonian communities of Upper Rio Negro of Brazil associated malaria with spiritual beings and used it to cure the incantations of shamans (Kffuri et al. 2016). However, there are differences among the studied communities regarding forms of malaria and antimalarial plants. That may indicate each community has its way of including the forms of malaria. Furthermore, each community also has a specific inclusion of antimalarial plants. These results could be explained by the fact that the communities have independently explored the environment in search of plants and remedies, as observed in Argentina (Hilgert and Gil 2007).

Abundance and intercultural relationship of the antimalarial plants

Traditional knowledge of the antimalarial plants was widespread in the communities, probably due to the high malaria incidence in our study area. Also, the high costs of sanitary care were noted in some Brazilian rural communities (Kffuri et al. 2016). However, despite this widespread knowledge, the Jaccard similarity index values on antimalarial plants were under 50%. That suggests the knowledge about antimalarial plants is not strongly shared among the communities. Concerning medicinal plants in general, ancestral knowledge is transmitted secretly and vertically from one generation to another or horizontally by sharing knowledge through friendship (Yetein et al. 2013).

Thus, the studied communities share only a few antimalarial plants. This result could be explained by the availability of antimalarial plants in their environment. This result could also be explained by the fact that the community could ignore the antimalarial plants, even though plants are available in their environment. In contrast, Kujawska et al. (2017) observed a high variation in the medicinal plants used by Subtropics communities in Argentina. According to Kujawska et al. (2017), the Guarani, Criollos, and Polish communities have different knowledge of the number of plants per community and plants culturally important. This difference could be explained because the variation of knowledge in communities sharing the same environment depends on cultural background. It can be assumed from the present study that most of the knowledge about malaria is passed down from ancestors.

Table 3. Fidelity level of the antimalarial plants preferred in the study area

Species	FL (%)				
	White Malaria	**Yellow Malaria**	**Black Malaria**	**Bird Malaria**	**Red Malaria**
Alstonia boonei De Wild.	30.14	30.82	26.42	-	23.89
Annickia polycarpa (DC.) Setten and Maas	30.82	38.99	22.64	-	29.2
Carica papaya L.	23.29	16.98	26.42	-	-
Distemonanthus benthamianus Baill.	-	-	-	37.5	-
Gymnanthemum amygdalinum (Delile) Sch.Bip	36.3	21.38	32.08	25	30.97
Momordica charantia L.	19.86	10.69	22.64	-	12.39
Musa x paradisiaca L.	-	-	-	37.5	-
Nauclea latifolia Sm.	-	18.87	-	-	22.12

Note: FL: fidelity level of the antimalarial plant; -: species not mentioned

In addition, the geographical proximity of ethnic groups can influence the local culture in the usage of antimalarial plants. That is also through intercultural marriage and friendship (Teka et al. 2020). For example, in our study, interethnic marriages between the Akyé and the Gwa communities could explain the proximity of knowledge on antimalarial plants. In a similar case, in Pakistan, the communities of Dhirkot, Azad Jammu, and Kashmir, which share the same vegetation, have shared the same knowledge of medicinal plants (Amjad et al. 2020).

In our study, the intercultural relationship between the best-known antimalarial plants was not significantly different. The plants were usually shared and strongly used in the daily life of the studied communities. However, the extent of the knowledge about the antimalarial plants according to the fidelity level was heterogeneous. That indicated no consensus about antimalarial plants used to treat a particular form of malaria. On the contrary, in Benin, different rural communities on the plateau of the Allada use the same plants to treat malaria (Yetein et al. 2013). Also, according to Yetein et al. (2013), many species had the highest fidelity level (FL= 100%) and constituted the most favorite in treating malaria. This difference could be explained by the fact that there is no knowledge sharing on malaria among the studied communities.

Knowledge level of the antimalarial plants and distribution of knowledge

The results highlighted the unequal importance of antimalarial plant species within the studied communities. As mentioned by some authors (Maffi 2005; Menendez-Baceta et al. 2015), the usage of plants depends on the culture. In addition, the doctrine of signatures (Gaoue et al. 2017) has been used to understand the medicinal plant selection process in traditional cultures. Moreover, the organoleptic properties (bitter taste of bark stems and leaves or yellow color of the bark stems and the shape of plant organs) indicate that a given plant has medicinal potential and a therapeutic application (Leonti et al. 2002; Malan et al. 2015). Most salient antimalarial plants had already been mentioned in literature for their antiplasmodial activities (Zihiri et al. 2005; Atindehou et al. 2007; Iwalena et al. 2008; Omoregie et al. 2011; Kayembe et al. 2012). Nevertheless, the antimalarial activities of some plants quoted by the studied communities, including *Blighia unijugata*, *Diospyros sanza-minika*, *Cola nitida*, *Macaranga barteri*, *Parkia bicolor*, *Plectranthus monostachyus*, *Tarrietia utilis*, and *Vitex grandifolia*, are known to cure pains, fever, and anemia (Bouquet and Debray 1974). These plants are frequently associated with the symptoms of malaria.

African traditional medicine has gained renewed interest in health care services throughout the continent. That could probably be due to the increasing awareness of alternative medicine's potential and curative abilities, especially from the usage of antimalarial plants (Lifongo et al. 2014), as well as the difficult access to western medicine and the high cost of modern drugs. However, the distribution of knowledge about antimalarial plants varies considerably between men and women. Indeed, women have a better knowledge of antimalarial plants than men. This result could be explained by the fact that in the study area, women have the charge of the medicinal side of the household, using knowledge about malaria acquired from their parents. Furthermore, Deressa and Ali (2009), in the south-central district of Ethiopia, reported that women have a higher general knowledge of malaria, such as symptoms and treatment, than men. In addition, understanding the influence of gender in the management of malaria depends on several factors, including perception and gender (Lifongo et al. 2014). Therefore, considering the perception and gender in evaluating the knowledge level of malaria could enable a better response to malaria prevention.

In conclusion, this study has highlighted new findings in the area: *B. unijugata*, *D. sanza-minika*, *C. nitida*, *M. barteri*, *P. bicolor*, *P. monostachyus*, *T. utilis*, and *V. grandifolia*, which could be used to treat malaria. However, an awareness of local communities about the perception of malaria must be done to understand malaria symptoms and its treatment better. Furthermore, despite their different migratory histories, this study has revealed the differences and similarities between the antimalarial plants used by communities in the same geographical area.

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