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Original Article

AN ETHNOBOTANICAL SURVEY OF ANTI-MALARIAL PLANTS IN SOME HIGHLY MALARIA AFFECTED DISTRICTS OF ASSAM

NILAKSHI GOHAIN[1], ANIL PRAKASH[2,3], KABITA GOGOI[2], D R. BHATTACHARYA[2], NILANJU P SARMAH[2], CHANDRAJIT DAHUTIA[2], MOHAN CHANDRA KALITA[1*]

[1]Department of Biotechnology, Gauhati University, Guwahati, Assam, India, [2]Regional Medical Research Centre, NE Region (ICMR), Dibrugarh, Assam, India, [3]National Institute for Research in Environmental Health (ICMR), Kamla Nehru Hospital Building, Gandhi Medical College Campus, Bhopal, Madhya Pradesh, India
Email: mckalitagu@gmail.com

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ABSTRACT

Objective: An ethnobotanical survey of potent anti-malarial plants used by different tribes and communities of highly malaria affected seven districts of Assam, India.

Methods: Personal discussions and group interviews were held with the traditional practitioners. Samples were collected and authentically identified. Detailed ethno knowledge on the plant parts used and mode of administration of the plant extracts was documented. Literature survey was carried out on identified plant species and analyzed for their medicinal importance.

Results: A total of 22 plant species belonging to 20 botanical families were collected and identified from different locations of seven districts of Assam. Different plant parts such as leaves, root, flower, bark etc. were found to process through different basic methods (infusion, decoction, direct mechanical crushing and maceration) for extracting the anti-malarial crude phytochemicals by the traditional healers. Extensive literature on the broad spectrum medicinal values other than anti-malarial activity of the plant species suggested a strong scientific background of selecting those particular plants species by the traditional practitioners.

Conclusion: Indigenous plant species with strong claim of the natural source of anti-malarial moieties were identified in the present ethno-botanical survey. All the 22 plant species investigated could be a potential source of new antimalarial therapies.

Keywords: Ethno knowledge, Anti-malarial, Traditional practitioners, Artemisinin Combination Therapy, Oral administration, Therapeutic index.

INTRODUCTION

Malaria is a life-threatening vector-borne disease in the South-East Asian region including India. Around 1.5 million confirmed cases are reported annually by the National Vector Borne Disease Control Programme (NVBDCP), out of which 50% is caused by *P. falciparum* [1]. Five different species *viz. Plasmodium falciparum, Plasmodium malariae, Plasmodium ovale, Plasmodium vivax and Plasmodium knowlesi* have been identified as the malaria causing pathogens in humans. Among the five species, *Plasmodium falciparum* is the main species that causes majority of the fatal cases [2]. About 198 million cases of malaria infection and 5,84,000 deaths were reported by the World Health Organization (WHO, 2014) [3].

One of the prime concerns of malaria treatment is the alarming rate of increasing resistance to different antimalarial drugs. In fact, it has become a recurring problem in the recent time. In the 1970s, resistance of *P. falciparum* to previous generation drugs such as chloroquine and sulfadoxine-pyrimethamine caused difficulties in the prevention and control of malaria epidemics. For instance, in 1973, resistance against chloroquine therapy was reported from the Diphu and Karbi Anglong districts of Assam [4]. Similarly, in 1979, the first instance of resistance to sulphadoxine-pyrimethamine combination therapy was documented in the Karbi Anglong district of Assam. Later, cases of malaria resistance were also reported from Arunachal pradesh, India [5]. To fight against this situation, active research is being carried out worldwide. In general, scientific communities engaged in malarial research are seemed to be inclined towards developing new antimalarial entities from natural sources especially, from plants. After the great discoveries of the two anti-malarial drugs quinine and artemisinin, plant world is being continuously scoured in the quest of new antimalarial compounds [6]. In this regard, ethnobotany has played a crucial role since ancient time. Based on vital traditional knowledge, many antimalarial plant species were identified and validated scientifically [7-9]. Deeper the researchers delved into the knowledge of malarial parasite biology, possibility of developing antimalarial drugs from new plant species is getting higher. For instance, based on ethnobotanical knowledge, 48 Brazilian plant species were selected for an antimalarial study. Out of the 40 species tested, 6 plant species showed strong antimalarial activities against the used rodent malaria model [10]. Neutral and basic alkaloid extract of the plant *Hernandia voyroni* (Hernandiaceae) showed potential *in vitro* antimalarial activity against chloroquine-resistant *P. falciparum* strain, FCM-29 [11]. In another study, *Garcinia gummigutta* (Guttifereae) and *Mammea longifolia* (Guttiferae) exhibited potent antiplasmodial activities [12].

Geographically, North-East (NE) region of India is stretched between 89.46 to 97.30 degree E longitude and 21.57 to 29.30 degree North latitude and comprises of eight states *viz.* Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Tripura and the state of Sikkim. NE is a homeland of people belonging to many ethnic and cultural groups dominated by tribal communities. Like cultural diversity, NE region has rich sources of biodiversity in terms of flora and fauna. The region is characterized by hot and humid conditions, excessive moisture content and tropical forest ecosystems. Various mosquito borne tropical diseases such as malaria, are prevalent in this region. According to NVBDCP, the total malaria cases reported from NE India were 37, 235 and this represented around 10% of the total malaria cases of India. Moreover, as compared to other malaria affected states of India, numbers of cases of *P. falciparum* are higher in NE states (www.nvbdcp.gov.in). People of NE part of India have been fighting against the malaria disease naturally by inculcating ethno knowledge perpetuated through ages. Reaching out to these peoples and extraction of the valuable information is a preliminary but crucial step towards the scientific validation of ethnobotanical knowledge.

Assam is an integral part of flora diversity of high medicinal value of NE India and malaria is one of the prime concerns of ethanobotanical and ethnopharmacological therapies among different tribes and communities. For many decades, there is a high

malaria morbidity rate in Assam [13]. Different international agencies such World Health Organization (WHO), Center Of Excellence in Disaster Management and Humanitarian Assistance (COEDMHA) and Pacific Disaster Management Information Network (PDMIN) have announced Assam as one of the malaria zone of NE India [14]. Although, preventive measures such as early diagnosis and complete treatment are being adopted by state and national authorities, due to the emergence of multiple malaria drug resistance including chloroquine, more challenges are being created [15]. This has drawn attention of the researcher and active research is going on for the exploration of new sources of lead molecules that can be eventually developed into potential alternative antimalarial drugs. There are several reports on the antimalarials plants widely used by the traditional healers of Assam [16-18]. However, many malaria affected areas of Assam where people entirely rely on ethnomedicinal practices, are not yet explored. In the present study, an ethnobotanical survey was conducted in highly malaria affected seven districts *viz.* Goalpara, Baksa, Kamrup, Morigaon, Nagoan, Dibrugrah and Dhemaji of Assam and all the gathered information were scientifically analyzed and validated.

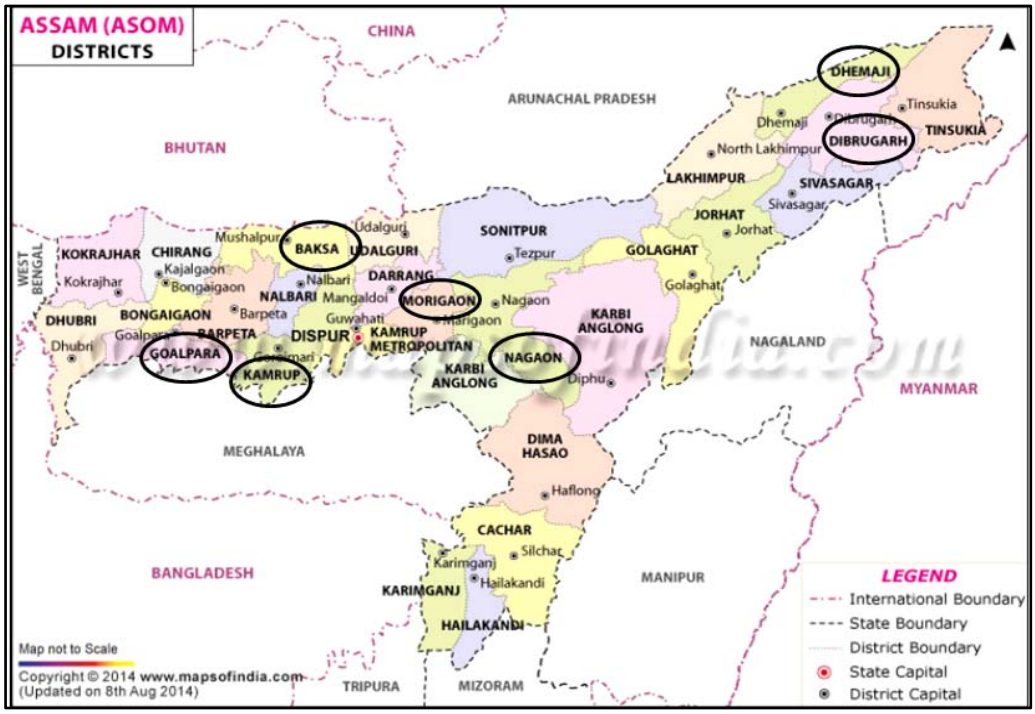

Fig. 1: Locations of the seven districts of Assam covered in the present ethnobotanical survey. Surveyed districts are marked with a black circle (Map courtesy: Adopted from www.mapsindia.com)

MATERIALS AND METHODS

The study areas

A detailed survey was conducted for about two years (July 2011 to April 2013) in the seven districts (Goalpara, Baksa, Kamrup, Morigaon, Nagoan, Dibrugrah and Dhemaji) of Assam (figure. 1). Baksa is one of the highly malaria endemic districts along with other six malaria prone districts of Assam (www.nvbdcp.gov.in). The tribal communities residing in the Baksa district are well known for their rich sources of ethno medicinal knowledge. Morigaon and Dhemaji districts have highly flood affected areas where outbreak of malaria and other water borne diseases are very common. Out of the 7 districts surveyed in the present study, 5 districts (Kamrup, Nagaon, Morigaon, Goalpara and Baksa) come under the 'ACT' (artemisinin combination therapy) covered zone of Assam (table 1).

Malaria cases registered in the Public Health Centers (PHCs) in different places of these districts strongly suggested the severity of the disease. The other two remaining districts (Dibrugarh and Dhemajii) also have many floods affected areas and malaria is prevalent as compared to other vector-borne diseases.

Investigators of the present study pursued different local sources of information such as newspaper, TV channels and reports on herbal remedies published in the local magazines for selecting the survey sites.

Moreover, some previous data published online by the Department of Health and Family Welfare, Government of Assam, on the malaria status of different districts of Assam helped in the proper selection of the malaria affected areas for the present survey.

Table 1: Districts, places and public health centers (PHC) of Assam recognized for artemisinin combination therapy (ACT) as per national vector borne disease control programme (NVBDCP) guidelines of India (source: www.nrhmassam.in)

District	Drug resistant PHC	Cluster PHC/borderingchloroquine resistant state	Total PH	No. of Pf cases	ACT required
Goalpara	No report	Agia, Rongjuli, lakhipur	3	3114	6228
Nagaon	All PHCs	No report	11	5217	10434
Morigaon	No report	Jhargaon	1	1605	3210
Kamrup	Sonapur	Boko	2	3226	6452
Baksa	Tamulpur	Golagaon, Jalah, Massalpur, Tamulpur, Barama, Niz-Kowrbaha	15	16520	33040
			Total = 32	29, 682	59,364

Interactions with the traditional healers and ethical consideration

Investigators interviewed traditional healers and village elders who were practicing antimalarial treatments since long time. Interviewers were selected on the basis of age, experience and reputation. Healers from different tribes and communities at various locations were individually questioned on different aspects such as (a) since how long they have been practicing the healing profession (b) availability of the plant species prescribed for malaria treatment (c) plant parts used (d) mode of administration and doses of the prescribed drug (e) what made them so much confined in disclosing the information to others and (f) their views on the possible advantages of natural healing over modern medicines. Investigators took the help from bilingual persons who could speak both Assamese language (mother tongue of Assam) and other Assamese dialects such as Bodo and Rabha for proper communication with the local peoples of the surveyed areas. Information from the respondent (both healer and patients) was collected on the structured interview forms prepared in local languages. Local peoples who followed the herbal treatment for malaria infection were also cross questioned. Both male and female were taken into consideration. To access the level of faith over traditional medicine for malaria, persons suffering from malaria were also interviewed during the survey.

Collection and authentic identification of the plant samples

Authentic botanical identification of the collected plant samples was done with the help of Botanical Survey of India (BSI), Eastern circle, Shillong, Meghalaya, India. Collected data including botanical names, collection sites, local names, family names, plant part (s) used and mode of administration of the herbal formulations were tabulated.

Literature survey of the collected plants samples

For the verification of medicinal importance, a literature survey of the collected plant samples was carried out. Emphasis was given on finding literature on antimalarial property of the plants. Similarities on the family or genus taxonomic status of the plants were considered as a correlation with already reported data on antimalarial application.

Ethno to modern practice

Although, not covered in the scope of the present ethnobotanical survey, the entire collected plant samples were finally subjected to the modern methodology of antimalarial property authentication. In collaboration with other institutes, our laboratory has been doing extensive survey work, *in vitro* and *in vivo* studies for exploring novel antimalarial lead molecules from different plant extracts (crude and fractions). Some of the findings have been applied for patenting and few are being experimented at *in vitro* and *in vivo* levels.

RESULTS

In the present investigation, 22 no of different plant species belonging to 20 families were collected and identified as the malaria healing plants used by traditional healers in the surveyed areas (table 2). Name of the plants with the local name and family were tabulated (table 3). Leaves, root, flowers, stem bark, rhizome, seeds and sometimes the whole plant were prescribed during malaria fever. Among the all plant parts, leaves were mostly used for treating malaria. Next to leaves was the root part of the plants used for this purpose. Worth mentioning, a particular plant species (*Ocimum gratissimum L.*) was found to be used by different traditional healers at different surveyed areas. This observation was important for further scientific validation of traditional knowledge and is an enduring aspect of ethnobotany in general. Among the 20 botanical families, Asteraceae and Lamiaceae (two species from each family) represented the species that were most commonly cited in this survey work.

Four different basic processes *viz*. Infusion, decoction, direct mechanical crushing and maceration were used by the traditional healers for extracting the pharmacological agents from different plant parts. Oral mode of administration of the plant based formulations was recommended by the healers for treating malaria. However, it was not possible to know how these medicinal practitioners estimated the therapeutic index (the ratio of a substance's minimum toxic dose to its effective medicinal dose) of the prescribed antimalarial plant based formulations without causing any lethal consequences.

Extensive traditional knowledge possessed by these healers could be considered as the secret of the accuracy and efficacy of the prescribed doses of the plant molecules. Prior to prescription, the traditional healers were found to enquire about some basic information such as gender (in case patient was not fit enough to visit the healer), age, alcoholic/non-alcoholic and sign/symptom of the malaria infected person. It was confirmed that healers were not following any documented source for self-learning or perpetuating the traditional knowledge to their next generations.

Table 2: Name of the collected plant species, districts and collection sites covered in the present ethnobotanical survey

Plant sample collected	Name of the district	Collection site
Flemingia strobilifera	Morigaon	Mayong
Cucumis sativus Linn.	Kamrup	Rangiya
Asparagus racemosus wild	Baksa	Ba-raja bathou ashram (Tamulpur)
Impatiens balsamina L.	Baksa	Kumarikata
Ocimum gratissimum L.	Morigoan	Kajoilichok
Spilanthes acmella Murr.	Kamrup	Hajo
Rubus rugosus Sm.	Dhemaji	Jonai
Curanga amara juss	Kamrup	Khetri
Piper longum L	Baksa	Sesapani
Alpinia nigra (Gaertn.) Burtt	Baksa	Naokata
Cedrus deodara (Roxb.) G. Don.	Goalpara	Dhupdhara
Vitex negundo L.	Nagoan	Kamakhyagaon
Stemona tuberosa lour	Kamrup	Khetri (NEDFI)
Swertia chirata L.	Kamrup	Chandrapur
Ichnocarpus frutescens	Morigaon	Borangabari
Clerodendrum infortunatum L.	Kamrup	Mirza
Solanum myriacanthum Dunal	Baksa	Naokata
Ageratum conyzoides L	Morigaon	Manaha
Phlogocanthus thyrsiformis (Hardw.) Mabb.	Baksa	Tanganmara
Dillenia indica L	Kamrup	Baihata chariali
Caesalpinia bonduc (L.) Roxb.	Dhemaji	Jonai
Coptis teeta Wall.	Dibrugarh	Arunachal pradesh border

DISCUSSION

The respondents of the present survey revealed important facts about the ethno knowledge they were practicing in treating malaria. It was a consensus view that peoples belonging to all surveyed areas basically relied on traditional healers for getting cured off malaria. Pertaining to the orthodox belief towards the preservation of socio-cultural importance, modern remedial strategies for malaria treatment were not socially recognized by these communities. This concept is acceptable if is it reconsidered that ethno-knowledge of these peoples practically can cure malaria patient without any intervention of modern medical science. In some of the visited areas, old aged (75-85 years) traditional healers unable to practice were not replaced by skilled descendants. This was a bad sign as it can diminish the possibility of exploring the traditional knowledge system. During the personal interviews with the traditional healers, it became evident that traditional healers were not willing to disclose the name of the plants. In fact, this is a worldwide common major problem in exploring ethno knowledge.

This situation might be caused by several factors such as lack of due acknowledgement in the published reports. Proper acknowledgement to these natural healers and conduction of workshop on ethno practice by gathering the local ethno practitioners from different places could improve the situation. Moreover, ethno botanical research centres where traditional knowledge including the sample species germplams preservation can be practised should be constructed. Worth mentioning, the mode of administration of the entire prescribed antimalarial plant formulations was oral (table 3). This clearly suggested that the traditional healers retained extensive knowledge of botanical toxicology. After practical application for many centuries, the poisonous properties of the plants were well perceived by these practitioners. Safe exploitation of wild plant species for malaria treatment with proper therapeutic index was an excellent display of ethno knowledge practice in modern time. The literature survey conducted on the collected plant samples revealed their well explored medicinal properties (table 4). Most of the plant species have already been reported for their broad spectrum applications against many human disorders. However, except the five plant species viz. *Ageratum conyzoides L., Vitex negundo L., Ocimum gratissimum, Dillenia indica L. and Spilanthes acmella*, reports on larvicidal or antimalarial properties on the other collected plant species were not found. The two facts that (a) all plant species used by the traditional healers for malaria treatment possessed broad spectrum medicinal values and (b) majority of the collected plant species were not explored for antimalarial or larvicidal activities; the findings of the present ethnobotanical survey can be considered significant. It is worth mentioning that many plant species were also prescribed for other human disorders by the traditional practitioners in the surveyed areas. As present study emphasized on the antimalarial aspects of the collected plants, this issue was not highlighted in the present study. The referred literatures on the plant species suggested that many findings on medicinal applications were the results of previously carried out ethno-botanical surveys in different parts of India.

However, the scope of such investigations was not malaria specific. The availability of decade old research findings on the plant samples in both modern and ethno practices undeniably makes sure about the well explored medicinal activities and unexplored status in antimalarial prospective. The present credentials gives additional backdrop support to the existing knowledge about these plants species in malaria prevention and control management. More research inputs towards the validation of the ethno knowledge on antimalarial application of these plant species might provide a strong platform in finding new plant derived drug molecules in future. In particular, natural solutions (plant compounds/crude extracts) to the recent development of resistance against *P. falciparum* will be safer, eco-friendly and target specific as compared to the synthetic drugs.

Table 3: Ethnobotanical details of the plant species covered in the present study

Vernacular name Assamese (Ass),Bodo (B), Rabha (R)	Scientific name	Family	Plant parts used	Mode of preparation and administration
Makhioti(Ass)	*Flemingia strobilifera*	Fabaceae	Leaves	Matured leaves are pounded in water and taken orally
Tioh (Ass)	*Cucumis sativus Linn.*	Cucurbitaceae	Fruit upper layer	Fruit upper layer is soaked in water and extract is prescribed for oral dose
Satmul (B)	*Asparagus racemosus wild*	Liliaceae	Leaves and root	Juices of the leaves and root are taken orally
Kanphuli-phul (R)	*Impatiens balsamina L*	Balsaminaceae	Leaves	Leaves are crushed and mixed with small amount of water and given orally
Ram tulsi (B)	*Ocimum gratissimum L.*	Lamiaceae	Leaves	Decoction obtained by boiling of the fresh matured leaves of the plant in water is prescribed for oral dose
Piraja (Ass)	*Spilanthes acmella Murr.*	Asteraceae	Flowers and leaves	Infusion of the of the flower and leaves are prescribed orally
Jetuli poka (Ass)	*Rubus rugosus Sm*	Rosaceae	Leaves	Infusion of the matured leaves of plant is administered orally
Bhui-tita (Ass,R)	*Curanga amara juss*	Scrophulariaceae	Whole plant	Whole plant juice is prepared in mild hot water and given orally
Pipoli (Ass)	*Piper longum L.*	Piperaceae	Leaves	Infusion of the leaves is given orally
Tora (Ass)	*Alpinia nigra (Gaertn.) Burtt*	Zingiberaceae	Leaves	Matured leaves decoction prepared by boiling in water and given orally
Deodaro (Ass)	*Cedrus deodara(Roxb.) G. Don*	Pinaceae	Stem Bark	Infusion of the bark of the plant is taken orally
Pachatia (Ass)	*Vitex negundo L.*	Verbenaceae	Leaves	Decoction of leaves are taken orally
Tita satmul (Ass)	*Stemona tuberosa lour*	Stemonaceae	Rhizome	Rhizome of the plant are grinded and the juice is prescribed orally
Nagadona (Bodo)	*Swertia chirata L.*	Gentianaceae	Root and flower	Decoction of the root and flower in water is given orally
Lomakandol (Ass)	*Ichnocarpus frutescens*	Apocynaceae	Leaves	Decoction of the leaves of the plant in water is administered orally
Bhetai–tita (Ass)	*Clerodendrum infortunatum L.*	Lamiaceae	Leaves	Leaves of the plant are crushed and the juice is given orally
Kota bengena (Ass)	*Solanum myriacanthum Dunal*	Solanaceae	Root	Infusion of the root is given orally
Jarmany bon (Ass)	*Ageratum conyzoides L.*	Asteraceae	Root	Decoction of root is prescribed orally
Tita bahaka (Ass)	*Phlogocanthus thyrsiformis (Hardw.) Mabb*	Acanthaceae	Leaves	Infusion of the matured leaves prescribed orally
Ow-tenga (Ass)	*Dillenia indica L.*	Dilleniaceae	Fruits	Fruit juice is extracted in water and prescribed orally
Lataguti (Ass)	*Caesalpinia bonduc (L.) Roxb.*	Caesalpiniaceae	Seeds	Seeds are grinded and powder is given orally
Mishimi tita (Ass)	*Coptis teeta Wall.*	Ranunculaceae	Leaves	Leaves juice is taken orally

Table 4: Literature on the medicinal aspects of the plant species covered in the present ethnobotanical survey

Plant name	Medicinal properties reported	References
Flemingia strobilifera	Anthelmintic activity, menstrual irregularities,analgesic activity, anti-inflammatory activity,anti-microbial activity	[19]
Cucumis sativus Linn.	Antidiabetic, antiulcer, moisturizing, antioxidantand analgesic property of the fruit extracts	[20]
Asparagus racemosus wild	Anti-jaundice property and as appetizer	[21]
Impatiens balsamina L	Larvicidal effect against *An. stephensi, Ae. Aegypti and Cx. Quinquefasciatus* mosquito species	[22]
Ocimum gratissimum L.	Larvicidal activities against *Aedes aegypti* mosquitoes	[23]
Spilanthes acmella Murr.	Rheumatism, fever, diuretics, flu, cough, rabies diseases, tuberculosis, antimalarials, Antibacterials	[24]
Rubus rugosus Sm	Useful remedy for the nocturnalmicturition of children	[25]
Curanga amara juss	Anti-hypertensive, antimicrobial, antioxidantand anti-haemolytic	[26, 27]
Piper longum L.	Antiamoebic activity against entamoeba histolytica	[28]
Alpinia nigra (Gaertn.) Burtt	Treatment of hemorrhoids, analgesic and anti-arthritic	[29]
Cedrus deodara(Roxb.) G. Don	Antibacterial activity	[30]
Vitex negundo L.	Anti-inflammatory, analgesic, removes foetid discharges and worms from ulcers, antimalarial	[31]
Stemona tuberosa lour	In the treatment of pertussis	[32]
Swertia chirata L.	Antipyretic, anthelmintic, antiperiodic, cathartic and in asthma and leucorrhoea, as harsh, analeptic, stomachic, mitigate inflammation, relaxing to pregnant uterus and never ending fevers	[33]
Ichnocarpus frutescens	Used in atrophy, bleeding gums,cough and dysentery	[34]
Clerodendrum infortunatum L.	Used in tumors and skin disorders	[35]
Solanum myriacanthum Dunal	Used in dental problem	[36]
Ageratum conyzoides L.	Used in burns and wounds, antiarthritic, fever	[37]
Phlogocanthus thyrsiformis (Hardw.) Mabb	Anti-diabetic.	[38]
Dillenia indica L.	Used as an astringent, anti amphetamine,antimalarial	[39]
Caesalpinia bonduc (L.) Roxb.	Antibacterial, anti-fungal, anti-inflammatory, anti-oxidant	[40]
Coptis teeta Wall.	Hepato protective activity	[41]

CONCLUSION

The present ethnobotanical survey revealed antimalarial property of 22 plant species collected from the different locations of malaria affected seven districts of Assam, India. All the herbal preparations were orally administered either as a plant crude extract, juice and decoction or leaf infusion. Out of the 22 plants, 6 each for decoction and infusion forms were found to be used by the healers. For the rest species, direct mechanical crushing and maceration forms were adopted. Leaves were mostly used followed by root and flowers. Use of whole plant and seed were confined to single species. Worth mentioning, each herbal formulation was sourced from a single plant. This observation was important as isolation of pure antimalarial compound is easy from single plant as compared to mixed herbal formulations. Majority of the plant species covered in this study were investigated before for their different medicinal properties. This was a strong scientific background for correlating ethnoknowledge to modern practices. Of the 22 plant species, only 5 were reported before for their larvicidal or antimalarial properties. Through the present survey work, the ethanobotanical and ethnopharmacological antimalarial potentials of the rest 17 plant species were revealed. An in depth investigation at *in vitro* and *in vivo* level on the antimalarial phytochemical profile of the plant extracts prescribed by the traditional healers can further validate the ethnoknowledge. There is a wide scope of finding potent antimalarial compounds from these plant species. It is anticipated that the findings of the present ethnobotanical survey work will aid in exploring new therapeutically active ingredients for developing antimalarial drugs.

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CONFLICT OF INTERESTS

The authors declare no conflict of interest.

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