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Review Article

Review on Ethnomedicinal Plants of Odisha for the Treatment of Malaria

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ABSTRACT

Malaria is currently a public health concern in many countries in the world due to some factors such as chemotherapy faced by resistance, poor hygienic conditions, poorly managed vector control programmes and no approved vaccines. The survey identified 33 medicinal plant species from 24 families which were used for the treatment of malaria in this study area. Presently, it is important that a developing state like Odisha to document the uses of medicinal plants in all communities, which are still largely unexplored. This is because of old folks areas usually custodians of such information and with the fast disappearance of traditional cultures and natural resources arising from urbanization and industrialization of these areas, such information could be lost forever. Documentation of this kind of information will be beneficial in general healthcare, ecological control, forest conservation of endangered species, research and providing leads to plants with useful medicinal properties.

Key words: Ethnomedicinal Plants, Anti-malaria, Traditional use, Odisha

INTRODUCTION

A number of studies on ethno medicinal plants and herbal medicines have been conducted in the past and plants have been reported for being used medicinal purpose by tribals in several countries. The ethno botanical survey can bring out many different clues for the development of drugs to treat human diseases. Safe, effective, and inexpensive indigenous remedies are gaining popularity equally among the people of both the urban and rural areas, especially in India and China[1]. India is one of the twelve mega-biodiversity countries of the world having rich vegetation with a wide variety of medicinal plants and a tradition of plant-based knowledge distributed amongst a vast number of ethnic groups. The use of ethnobotanical information in medicinal plant research has gained considerable attention in segments of the scientific community and it has become a topic of global importance making an impact on both world health and international trade. The importance of medicinal plants in traditional healthcare practices providing clues to new areas of research[2]. People living in villages and far-flung areas depend completely on forest resources for maintaining their day-today needs like medicine, food, fuel and household articles. The use of traditional medicine remains widespread in developing countries while the use of complementary alternative medicine (CAM) is increasing rapidly. A common belief is that plant remedies are naturally superior to synthetic drugs and that they are not harmful to human beings. This knowledge is however, rapidly dwindling due to changes towards a more Western lifestyle, and the influence of modern tourism. It is expected that thousands of species of medicinal plants are facing threat to their existence in the wild and some of them have become extinct. For meeting the future needs, cultivation of medicinal plant has to be encouraged. There is still much we can learn from investigating herbals available abundantly in the forests particularly those which are less well known. This type of research needs a multidisciplinary approach and this includes expertise in the fields of ethnobotany, ethnopharmacology and phytochemistry. The objective of the present study was to obtain information on the uses of local herbs in the treatment of malaria fever, the plant(s) uses, method of preparing herbal anti-malaria remedies, and how it is administered in some local areas of Odisha. This is with a view to contribute to the search for new and alternative natural anti-malaria medicines.

Malaria As a Global Challenge

Malaria is a parasitic disease transmitted by the bites of anopheles mosquitoes infected with plasmodium species, four of which infect humans: *Plasmodium falciparium*, *Plasmodium vivax*, *Plasmodium malariae* and *Plasmodium ovale*. In Nigeria, malaria is mostly caused by *P.falciparium* and *P.malariae*. The female anopheles mosquitoes transmit these parasites to humans. The disease primarily affects poor populations in tropical and subtropical areas, where the temperature and rainfall are suitable for the development of vectors and parasites[3]. Malaria is a major global health problem. There is an estimated 247 million malaria cases with almost half of the global population at risk and nearly a million deaths each year[4]. April 25 is World Malaria Day-a-day to promote or learn about the efforts being made globally to combat this deadly disease. The WHO, the United Nations,

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Table 1: Year wise Chikugunya/ Dengue cases (2006 -2010)

Year	Positive cases detected/samples tested		Death	Districts affected
	Chikungunya	Dengue		
2006	34/104	1/104	Nil	Sundargarh, Gajapati, Ganjam, Cuttack, Kendrapada, Balasore, Bhadrak, Anugul, Kalahandi, Jharsuguda, Nuapada, Sambalpur, Sonepur
2007	81/399	Nil	Nil	Nayagarh, Cuttack, Jajpur, Kendrapada, Bhadrak, Puri, Jagatsinghpur, Balasore, Khurda, Keonjhar, Ganjam
2008	11/238	Nil/238	Nil	Khurda,Balasore, Ganjam, Puri, Jagatsinghpur, Kendrapada, Cuttack, Jajpur, Bhadrak, Anugul
2009	2/41	Nil/41	Nil	Khurda, Puri, Nayagarh, Ganjam
2010	2/160	34/160	3	Gajapati, Ganjam, Malkangiri, Jharsuguda, Khurda, Sundargarh

government organizations, charities, communities and individuals play a role by putting on events and activities to raise awareness of the disease. Malaria is one of the major tropical parasitic diseases responsible for significant morbidity and mortality especially among children and pregnant women. It is estimates that 1 to 2 million people die yearly as result of malaria[5]. A WHO[4] report stated that Nigeria accounts for a quarter of all malaria cases in Africa. In the southern part of Nigeria, transmission occurs all year round while in the north it is mostly seasonal[6]. Drug resistant malaria has become a major problem in malaria control. Resistance in vivo has been reported against almost all anti-malaria drugs except Artemisinin and its derivatives[7,8]. Resistance to anti-malarias has been reported in both *P. falciparium* and *P. vivax*. Drug resistance in *P. falciparium* is not confined to chloroquine alone, but also to the other currently used anti-malarias and is widespread[9]. Malaria is becoming more resistant to a number of current drugs and is on the increase because of the global warming process[10]. Thus, many communities who live in endemic areas have started to look for malaria remedies in plants in their local environments[11]. It is believed strongly that if the herbs used to treat malaria by our ancestors in Africa hundreds of years ago were not effective, malaria would have destroyed Africa[12]. Ethnobotanical survey is an important step in the definition, selection and development of the therapeutic agents from medicinal plants. According to the WHO[13], 80% of the world population uses natural remedies and traditional medicines and Nigeria is not an exception. In recent times, despite all the advances in modern and orthodox medicines, traditional medicines have gained renewed interest in healthcare services of Cameroonians. This may be attributable to increased unawareness in the potential and curative ability of the alternative medicines and particularly as of the various shortcomings reveled for several synthetic drugs[14].

Malaria in India: Challenges and Opportunities

India contributes about 70% of malaria in the South East Asian Region of WHO. Although annually India reports about two million cases and 1000 deaths attributable to malaria, there is an increasing trend in the proportion of *Plasmodium falciparum* as the agent. There exists heterogeneity and variability in the risk of malaria transmission between and within the states of the country as many ecotypes/paradigms of malaria have been recognized[15]. The pattern of clinical presentation of severe malaria has also changed and while multi-organ failure is more frequently observed in falciparum malaria, there are reports of vivax malaria presenting with severe manifestations. As the second most populous country in the world, with a population exceeding one billion people, India's public health system faces many challenges including implementation of surveillance programs to accurately estimate and control the national malaria burden. Historically, the highest incidence of malaria in India occurred in the 1950s, with an estimated 75 million cases and 0.8 million deaths per year (World Health Organization, Country Office for India). The launch of the National Malaria Control Program (NMCP) in 1953 resulted in a significant decline in the number of reported cases to <50,000 and no reported mortality, by 1961. Despite its near elimination in the mid-1960s, malaria resurged to ~6.45 million cases in 1976[15]. Some climatic diversity influences the distribution of vectors and species of malaria parasite mostly in Goa and Maharashtra in each year; as a result, malaria in India takes a number of different forms, including forest/tribal malaria, urban/slum malaria, industrial malaria, and plains malaria.

The high burden populations are ethnic tribes living in the forested pockets of the states like Odisha, Jharkhand, Madhya Pradesh, Chhattisgarh and the North Eastern states which contribute bulk of morbidity and mortality due to malaria in the country. Urban areas contribute about 15% of the total malaria cases reported in India and are primarily associated with construction activities and migrant population. Most of the malaria attributable mortality is reported from Odisha and other forested areas occupied by ethnic tribes in the country[16]. Drug resistance, insecticide resistance, lack of knowledge of actual disease burden along with new paradigms of malaria pose a challenge for malaria control in the country.

Odisha State Malaria Information System

Odisha state has one of the oldest and richest cultural traditions of using medicinal plants. Ethno medicinal uses of plants in different parts of Odisha are well studied[19-23]. The rural people of the state still depend on the traditional ethno medicine for their day-to-day primary health care. These medicinal plants gain further importance in the region where modern medical health facilities are either

not available or not easily accessible. Odisha state is geographically divided into five regions i.e. Coastal Odisha, Southern Odisha, Western Odisha, Central Odisha and North Odisha[24]. Malaria continues to pose major public health problem in the state of Odisha. Odisha has only 4% land area and 3% population of India respectively. In 2010, Odisha contributed 20% of cases and 17% of deaths due to malaria to the country's burden. There is geographical variation in the distribution of malaria cases within the districts, blocks and sub-centers. The 10 southern districts having only 27% of state's population with more than 50% tribal population, contribute around 64% of deaths due to malaria in the state. Out of total of 6688 sub-centers in the state, 2880 (43%) with a population of 14.3 million (36%) have an Annual Parasite Incidence (API) of more than five. Around 85% of the cases reported from the state are due to falciparum malaria *(Pf).* Due to operational difficulties, the risk of malaria continues to be high in remote, rural, tribal, inaccessible, forested and forest fringed areas. However, other areas of the state are not free from the malariogenic risk factors. In order to expand the malaria surveillance and collect update information from the sub centers those serve as a single window to provide primary health care for malaria; the web based Information system has been developed known as Odisha State Malaria Information System (OSMIS). LEPRA's activities to control malaria are primarily concentrated in Odisha, the highest-prevalence state in the country. In 2009, a startling 24% of the total reported cases in India (375,000) occurred in Orissa, with 198 deaths (again 24% of the reported national total). In 2009 Odisha also had 336,047 *Pf* cases, or 40% of the total *Pf* cases reported in the country (and 88% of the total cases in Odisha), and *Pf* is resistant to chloroquine in many areas (Innovation in Malaria Control, 2010). LEPRA's most significant malaria-control project has been the Mayurbhanj Integrated Community Health Project (MICHP), which ran 2006-2010, covering all 26 blocks of Mayurbhanj district of Odisha. 220 of the 314 blocks in the state are high-burden for malaria, and 20 of the 30 districts. The state annual parasite infection rate (API) is 9.1, compared to a national API of 1.6. 9,466 cases of malaria were reported from Odisha followed by Chhattisgarh which recorded 31,940 cases. Jharkhand reported 26,489 cases, while Maharashtra reported 17,060 cases followed by Gujarat, Assam, West Bengal, and Uttar Pradesh. This paper reports a study from the State of Odisha, on the eastern coast of India, which has a population of 42 million, 3% of the total Indian population (Census of India), but carries over 25% of the national malaria burden, including 42% of *P. falciparum* infections (Malaria Situation in India*).* Malaria remains an important cause of morbidity and mortality in the State, with some estimates in excess of 50,000 deaths per year[25].

Chikungunya and Dengue are the emerging vector borne diseases in Odisha. A number of outbreaks have been reported from various parts of the State and mostly in coastal Districts. Most of the cases were reported from urban or peri-urban settings. Outbreaks of Dengue have been noticed in 2010 mostly in Gajapati and Malkanagiri Districts of Southern Odisha. The well known southern KBK Districts i.e Rayagada, Koraput, Malkangiri, Nawarangpur, Kalahandi, Nuapada, Bolangir and other southern Districts like Kandhamal and Gajapati are traditionally low in human indices and are at high risk of Pf malaria (Table-1). These Districts are surrounded with hills, forest and forest fringed areas which provide favorable climate for the efficient vector *A. fluviatilis*. These Districts are tribal dominated having high level of inaccessibility to avail health care services. The health care infrastructure is also very poor to cater the needs of the most vulnerable population.

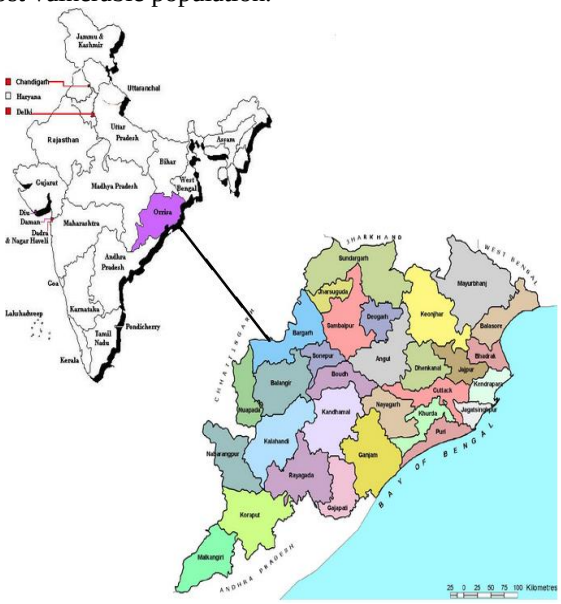

Fig-1: Malaria affected areas in Odisha State

Ethnomedicinal Plants, Malaria and Malaria Vector

Over 1,200 plant species are reportedly used for the treatment of malaria and fevers worldwide, and are potentially important sources of new anti-malarial treatments[26]. As there are very limited funds for research on anti-malarial plants, it is important to prioritize plants for further research, notably for in depth laboratory studies and possibly clinical studies. The Research Initiative on Traditional Anti-malarial Methods (RITAM) was founded in 1999, and its objectives include reviewing current knowledge on traditional anti-malarial methods, to determine research priorities, to design optimal research methodologies, and to avoid replication of research[27]. Plants widely used as anti-malarials by traditional healers are significantly more active *in vitro* and/or *in vivo* against *Plasmodium sp* than plants which are not widely used, or not used at all, for the treatment of malaria[28-32]. A "retrospective treatment-outcome" study has been proposed to prioritize plants as anti-malarials, by studying clinical outcomes of patients who have used specified remedies for treating an episode of malaria[33]. This approach has proved to work well in Mali[34]. There already exists a wealth of published ethnobotanical and pharmacological studies on anti-malarial plants. However, this information has never been reviewed systematically and there is no standard method for doing so. Standard scores and methods have been developed for meta-analysis

of studies of medical interventions and diagnostic tests[35]. There have been attempts at scoring plants according to basic ethnobotanical criteria (for example frequency of citation, or how widely a remedy is used[26,31] but these do not take into account all important factors such as the quality of studies or pharmacological information on efficacy and safety. Others have prioritized plants according to the selectivity index *in vitro*, corresponding to the ratio between cytotoxicity and activity against *Plasmodium falciparum*[36]. The first aim of this study was to design a standard score that could be used to prioritize traditional herbal remedies for further research based on objective criteria and systematic literature reviews, combining all available information from both ethnobotanical and pharmacological studies. The second aim was then to pilot this score and assess its ability to predict results of clinical trials for the few plant remedies that have been tested clinically for the treatment of malaria. The use of plant-derived drugs for the treatment of malaria has a long and successful tradition. For example, quinine isolated from *Cinchona officinalis* and quinghaosu from *Artemisia annua* represent the potential value of investigating traditionally used antimalarial plants for developing pharmaceutical antimalarial drugs[37]. The declining efficacy of classical medication in relation to rapid extension of *Plasmodium falciparum* chloroquine-resistant strains has led to a need for new and efficient antimalarial drugs[38]. Malaria is one of the major causes of morbidity and mortality in the developing countries like India and has a great impact on the socio-economic development of the individual households in various ways. Repellents have an important place in protecting man from the bites of insect's pests and mosquitoes[39,40] and smoke produced by the burning of some herbs such as Artemisia and *Azadirachta indica* has been used for the protection against mosquitoes and biting insects since ancient times. Planting of plant species like *Azadirachta indica*, *Annona squamosa*, *Artemisia vulgaris*, *Cymbopogon citratus*, *Lantana camara*, *Ocimum sanctum* and *Vitex peduncularis* nearby the houses or settlement areas is another traditional method of controlling mosquito borne malaria still in practice by the local community in northeast. Some plants with noticeable ethnopharmacological use in malaria showed only weak or even no activity against Plasmodium *in vitro*[41]. For example, *Mikania glomerata*,*Melampodium divaricatum*, *Galipea multiflora*, *Aspidosperma polyneuron*, and *Coutarea hexandra* had their antimalarial activity confirmed by clinical observations of medical doctors, an information that yields a high probability of accuracy. Some authors have underestimated the traditional plants used for malaria based exclusively on low activity against *Plasmodium in vitro* or in animal models[41]. This can be a mistake of strategy or even methodology. India and polishing of house floor with leaf plant extracts obtained mainly from the species of Azadirachta, Artemisia, Lantana, Ocimum and Cymbopogon is routinely done to drive away mosquitoes and other insect's flies as common tradition among the community members of rural tribal people[42].

There are many explanations for the absence of *in vitro* activity of an effective antimalarial drug. As an example, the active principle could be formed by hepatic metabolism, or as a result of transformation by gut bacteria. Other possible mechanisms of action include immunomodulation or interference with the invasion of new red blood cells by parasites, which can be species specific. Therefore studies in human subjects, as well as the observance of ethnomedical detailed data, are urged in order to exclude or confirm the activity of herbs traditionally used to treat malaria.

Ethno Medicinal Plants of Different Districts of Odisha

In the present literature survey on ethnomedicinal plants for the treatment and prevention of malaria is documented from different districts of Odisha only and specifically plants/formulations are described as per the availability of information (Fig-1).

Bargarh[43,44]

The district is in habitat by tribes like Sahara, Binjhal, Kondh, Gond, Munda, Kuli, Oran, Kisan, Mirdha, Kharia and Parja. Out of these, Sahara, Binjhal, Kondh and Gond are the predominant tribes. The most popularly used medicinal plant for the treatment of malaria by tribals is Neem.

Azadirachta indica A.Juss *(Meliaceae)*
Part use: Seed oil and Whole plant
Local Name: Neem
Method of use: Plant decoction is taken to drink.

Boudh[45-48]

The district of Boudh is one of the centrally located district of Odisha which has 6 million tribals, and about 62 notified scheduled tribes for the state of Odisha. Boudh district is represented by 25 ethnic tribal communities. A careful scrutiny reveal that the bulk of tribal population belongs to Kondh, Gond, Saura, Mirdhas, Mundas, Kharia, Kora, Kolha etc. with Kui as their lingua franca. The most popularly used medicinal plants for the treatment of malaria by tribals are as follow:

Phyllanthus fraternus Webster (Euphorbiaceae)
Part use: Root and leaves
Local Name: Bhuianla
Method of use: Leaf decoction given in 2-3 spoonfuls twice a day for 4 days against Malaria.

Andrographis paniculata (Burm.f.) Wall. Ex Nees (Acanthaceae)
Part use: Root and leaves
Local Name: Bhui nimba

Lantana camara L. (Verbenaceae)
Part use: Leaves
Local Name: Jaikoli
Method of use: Leaf decoction is given in 2-3 spoonfuls twice a day for 4 days against Malaria.

Ganjam[49,50]

The Scheduled Caste populations of the district constitute 18.57% and among them the major caste groups are Bauri (20.87%), Dhoba etc. (20.47%) and Dewar (14.01%). The Scheduled Tribes account for 2.88% population of the district and Khond (49.33%) Shabar (25.46%) and Saora (14.37%) are the largest tribal groups in the district. The

most popularly used medicinal plants for the treatment of malaria by tribals are as follow:
Caesulia axillaris Roxb. (Asteraceae)
Part use: Whole plant
Local Name: Jamjuria
Method of use: Whole plant extract is given to cure malaria.
Lantana camara L. (Verbenaceae)
Part use: Leaves
Local Name: Nagabairi
Jajpur[51]
The Scheduled Caste population is 22.99% of the total population and of these the Pan Pano (48.23%), Kondra (16.83%) and Dhoba (7.83%) are the major castes. The Scheduled Tribe population is only 7.76%. Even among this small segment of Tribes the largest three as indicated percentage to total Tribal population are Munda (28.32%), Shabar (25.27%) and Kolha (14.74%). The most popularly used medicinal plant for the treatment of malaria by tribals is black Tulsi.
Ocimum santum L. (Lamiaceae)
Part use: Leaves
Local Name: Tulashi
Method of use: 3-4 fresh leaves are chewed along with honey daily in the morning in empty stomach to prevent malaria
Kalahandi [52,53,54]
Kalahandi district is predominated by tribals. Tribals like Banjara, Bhatra, Bhunjia, Binjhal, Dal, Gond, Kandha, Mirdha, Munda, Paraja, Saora and Savar etc. are inhabited in the district. The main sub-tribes Kutia Kandha, Dongaria Kandha and Desia Kandhas inhabit in Kalahandi district. The most popularly used medicinal plants for the treatment of malaria by tribals are as follow:
Pongamia pinnata L. (Pierre) (Fabaceae)
Part use: Seed oil
Local Name: Karanj
Method of use: Leaves with an equal amount of leaves of *Azadirachta indica* A. Juss and *Ocimum sanctum* are ground into fine paste and made into tablet forms. One tablet is taken in empty stomach to prevent malaria.
Caesalpinia bonducella fleming (Caesalpiniaceae)
Part use: Seed
Local Name: Gila
Tinospora cordifolia wild. Miers (Menispermaceae)
Part use: Leaf
Local Name: Guluchi
Nyctanthes arbrtistis Linn. (Oleaceae)
Part use: Leaf
Local Name: Kukudahada
Kendrapara[55]
The Scheduled Caste population is 20.52% of total population and major caste group are Kandra (42.91%), Dewar (13.04%) and Dhoba etc. (11.73%) among the Scheduled Castes. Similarly the Scheduled Tribe population is only 0.52% of total and major tribal groups of the total tribes are Santal (27.87%), Shabar (18.44%) and Munda etc. (11.17%). The most popularly used medicinal plants for the treatment of malaria by tribals are as follow:
Piper nigrum Linn. (Piperaceae)
Part use: Seed and leaves
Local Name: Gol maricha
Method of use: 3 tea-spoonful juice of equal amount of leaves of *O. sanctum* and *Piper nigrum* was recommended orally 3 times daily after meal to cure malaria.
Nyctanthes arbortristis L. (Oleaceae)
Part use: Leaves
Local Name:
Method of use: Seven leaves of Gangasiuli are added with five *Piper nigrum* with some honey is taken for seven days for curing for malaria.
Keonjhar[56]
The Scheduled Tribes of Keonjhar district which totaled 4,99,657 in 1981 census increased to 5,95,184 in 1991 census thus registering a growth of 11.90% in a decade (1981-1991). As per 1991 census there were 46 Scheduled Tribes in the district. Out of these the principal tribes were Bathudi, Bhuyan, Bhumij, Gond, HO, Juang, Kharwar, Kisan, Kolha, Kora, Munda, Oraon, Santal, Saora, Sabar and Sounti. These sixteen tribes constituted 96.12% of the total tribal population of the district. The most popularly used medicinal plants for the treatment of malaria by tribals are as follow:
Ocimum santum L. (Lamiaceae)
Part use: Leaves
Local Name: Tulashi
Method of use: 3-4 fresh leaves are chewed along with honey daily in the morning in empty stomach to prevent malaria
Nyctanthes arbortristis L. (Oleaceae)
Part use: Leaves
Local Name: Gangasiuli
Method of use: The leaves of *Nyctanthes arbortristis* L. is boiled and gives to drink daily.
Pongamia glabra (Vent)
Part use: Seed oil
Local Name: Karanja
Khurda[55,57]
The Savaras tribal group, who are still to be found in the district in some pockets, once heavily populated the area. Khurda came into prominence when the first Rajas of the Khordha dynasty, Ramachandra Deva, made it the capital of his kingdom during the last part of the 16th century. The most popularly used medicinal plants for the treatment of malaria by tribals are as follow:
Bacopa monnieri (L.) Pennell (Scrophulariaceae)
Part use: Leaf
Local Name: Bramhi
Andrographis paniculata (Burm. F.) Wall. Ex Nees (Acanthaceae)
Part use: Whole plant
Local Name: Bhui nimba
Method of use: 30 ml leaves decotion is given thrice daily for 5-7 days to treat Malaria fever.
Koraput [58,59]
The district is rich with tribal people. Out of the total population of 24,84,005 of the district, scheduled caste and scheduled tribes are 1,37,255 i.e. 56% and the tribal

communities are like, Bhatora, Bhumia, Godoba, Gond, Kondho, Koya, Kondadora, Ananatya, Paraja, Soura, Kotia Kondho, Jatapu, Didayo, Bonda etc. The most popularly used medicinal plants for the treatment of malaria by tribals are as follow:

Nyctanthes arbortristis L. (Oleaceae)
Part use: Leaves
Local Name: Tulashi
Method of use: The leaves of *Nyctanthes arbortristis* L. is boiled and gives to drink daily.
Pongamia glabra (Papilionacea)
Part use: Seed oil
Local Name: Karanja
Method of use: Seed oil is applied on body for avoiding mosquito bite.

Malkangiri[60,61]

The district is the homeland of various tribal communities with their sub-tribes found in interior part of the forest. Bonda, Didayi, Koya, Paroja, Bhatoda and Khondh are the primitive tribes found in this district (Sachidanada and Prasad, 1998). The most popularly used medicinal plants for the treatment of malaria by tribals are as follow:

Stephania japonica Miers (Menispermaceae)
Part use: Tuber
Local Name: Dadari
Mimosa pudica L. (Mimosaceae)
Part use: Root
Local Name: Lajokuli lata
Method of use:
Milletia extensia Benth. Baker (Millettieae)
Part use: Root
Local Name: Marda, Majja, Birchi
Method of use: The water of root is given for treat malaria.

Mayurbhanj [62,63,64]

In Mayurbhanj district tribes occupy a big chunk of the population constituting 52% of it and fifty three communities both aboriginal and migrated are found in the district glorifying the rich heritage of tribal culture. Among the tribes the chief ones among them are Santal, Kol, Bhomij, Bhuyan, Bathuri, Kharia, Gonds, Mankdias, PauriBhuyan, Saharias, Mahalis and Sounti. Some of these tribes namely Kharias, Mankdias and Saharas are still in primitive state of living. The most popularly used medicinal plants for the treatment of malaria by tribals are as follow:

Achyranthes aspera (Amaranthaceae)
Part use: Root
Local Name:
Method of use: A handful of leaves along with three black pepper taken thrice daily for three days in empty stomach.
Lantana camara L. (Verbenaceae)
Part use: Whole plant
Local Name: Nagabairi
Method of use: Decoction of plant (15ml) is taken for the treatment of tetanus and there is strict prohibition of taking of sour food during treatment and decoction of leaf is taken twice a day for a week after food.
Nyctanthes arbortristis L. (Oleaceae)
Part use: Leaves
Local Name: Gangasiuli
Method of use: A handful of leaves boiled 4 cup of water remains. It is filtered and cooled. This filtrate along with black pepper is taken twice daily for 7 days.
Vitex peduncularis Wall. Ex Schauer in DC (Commmelinaceae)
Part use: Bark
Local Name:
Method of use: The leaves along with the leaves of Nyctanthes and Andrographis are made into paste and the paste is taken twice daily.
Rauvolfia serpentine (L.) Benth. Ex Kurz (Apocynaceae)
Part use: Leaves
Local Name: Patalgaruda
Method of use: Juice extracted from leaves mixed with the juice of Andrographis paniculata and Azadirachta indica and drunk with honey for 7 days continuously to cure malaria.
Cyperus metel L. Pers. (Poaceae)
Part use: Root
Local Name: Mutha
Eclipta alba (L.) (Asteraceae)
Part use: Leaf
Local Name: Bhurusunga
Adhatada vasica Nees (Acanthaceae)
Part use: Leaf
Local Name: Basanga
Method of use: 7 leaves of each species of Adhota vasica, Aegle marmelos and Abutilon indicum and 5 inch roots of Asperagus racemosus were boiled in 11 lit of water and concentrated up to a volume of 500ml. two spoon of the preparation was prescribed to take thrice daily after meal.
Andrographis paniculata (Burm. F.) Wall. Ex Nees (Acanthaceae)
Part use: Whole plant
Local Name: Bhui nimba
Method of use: 10g of powdered dry leaves and 25g of dry seeds of Andrographis paniculata were soaked in 250ml of water for overnight and then thrice a day for 7 days in the treatment of malaria.
Cuscuta reflexa Roxb. (Convolvlaceae)
Part use: Stem
Local Name: Nirmuli
Cyperus metel L. Pers. (Poaceae)
Part use: Root
Local Name: Mutha
Eclipta alba (L.) (Asteraceae)
Part use: Leaf
Local Name: Bhurusunga

Sambalpur[65]

The district population is considered by 34.5% of Scheduled Tribes and 17% of Scheduled Castes. The major tribes enumerated in the district are Kisan (27.8%), Munda etc. (17.5%) and Gond etc. (17.1%) among the total tribal population of the district. Similarly, the castes having highest population are Ganda (40.7%), Pan Pano (12.2%) and Dewar (10.8%) considering the total scheduled caste population. The most popularly used medicinal plants for the treatment of malaria by tribals are as follow:

Sida acuta Burm.F. (Malvaceae)
Part use: Leaves
Local Name: Bajramuli
Method of use:
Pteridocarpus erinaceous Poir
Part use: Bark
Local Name: Piasala
Sundargarh[53,66]
This district has nearly 50.7 % of the rural population consists of tribal population represented by 40 ethnic tribal communities. The numerically important Scheduled tribes are Oraon, Munda, Kharia, Kisan, Bhuiyan and Gond. The most popularly used medicinal plants for the treatment of malaria by tribal are as follow:
Nyctanthes arbortristis L. (Oleaceae)
Part use: Leaves
Local Name: Tulashi
Method of use: The leaves of *Nyctanthes*. is boiled and gives to drink daily.
Andrographis paniculata (Burm.f.) Wall. Ex Nees (Acanthaceae)
Part use: Root and leaves
Local Name: Bhui nimba
Method of use: Water extract of leaf is taken to treat malaria.
Phyllanthus fraternus Webster (Euphorbiaceae)
Part use: Root and leaves
Local Name: Bhuianla
Method of use: Whole plant is pounded to a fine paste and given in malaria fevers
Phyllanthus amarus Schum. & Thonn (Euphorbiaceae)
Part use: Whole plant
Local Name: Badi onla
Method of use: Whole plant is grounded into a fine paste and 5g of this paste is given thrice daily for 5days for curing malarial fever.
Tinospora cordifoia (Wild) Hook.f & Thomas (Menispermaceae)
Part use: Stem, leaf and bark
Local Name: Guluchi
Method of use:
Vanda tessellate (Roxb.) Hook.ex G.Don. (Orchidaceae)
Part use: Leaf
Local Name: Rasna
Method of use: Water extract of leaf is given orally together with honey to prevent malaria.

DISCUSSION AND CONCLUSION

In this review, an attempt has been made to assess the value of some important medicinal plants of Odisha for discussing the traditional uses of anti-malarial treatment, their methods of preparing herbal anti-malaria remedies, and how it is administered in some local areas of Odisha. This survey provides information on 33 medicinal plant species from 24 families from 12 different districts of Odisha state which were used for the treatment of malaria. The families Asteraceae, Menispermaceae, Oleaceae, Amaranthaceae, Commmelinaceae and Asteraceae which contributed maximum number of species. Of the plants species described: monocotyledon (2), dicotyledon (23), herbs (13), shrubs (7) trees (10) and climbers (8). The plant parts used for medical preparations were bark, leaf, seed oil, root, tuber and whole plants. The most frequently used medicinal plants were *Andrographis paniculata, Nyctanthes arbortristis, Tinospora cordifolia, Lantana camara and Phyllanthus fraternus.* Of plant parts used: leaf (9), root (6), seed (4), whole plants (4), bark (3) and tuber (1). The paper presents a brief account of the uses of various ethnomedicinal plants and plant parts against malaria by tribal of different districts of Odisha. The district Mayurbhanja contributed maximum number antimalarial plant followed by Sundargarh, Kalahandi, Malkangiri, Keonjhar, Boudh, Jajpur, Ganjam, Kendrapara, Khurda, Koraput, Sambalpur and Bargarh. Mayurbhanj, Sundargarh and Kalahandi are rich in medicinal plant resources with local most valuable traditional knowledge by different tribes. This type of study will give new impetus to traditional systems of malarial treatment. The fact that the most common parts of the plant species used in the treatment of malaria were leaves and twigs are very encouraging for sustainable harvesting of the plant. Harvesting root and bark can easily threaten local populations of plants unless a sustainable harvesting strategy has been developed[67]. Further research should be done on the comparative anti-malarial activity of the different species to see if the local evaluation of the efficacy of the different species can be scientifically validated.

Most research for antimalarial new drugs is only focused on direct activity against *Plasmodium* species. But attention to ethnomedical information gathered by Monteiro da Silva suggests that other effects should be investigated. For example, some plants are referred to enhance the action of other herbs, which can indicate an increase on permeability of the *Plasmodium* membrane to antiparasitic substances, or an inhibition of pump mechanisms of eliminating the drugs[68-69]. Considering that one of the common mechanisms of drugs resistance is the reduction of permeability, the development of drugs that enhance parasite permeability could be of valuable help in the treatment of infectious diseases[70-71]. Other possible mechanism of action is interference with parasite enzymes used for protection against antiparasitic drugs[72]. Some plants with noticeable ethnopharmacological use in malaria showed only weak or even no activity against *Plasmodium in vitro*[73]. For example, *Mikania glomerata*, *Melampodium divaricatum*, *Galipea multiflora*, *Aspidosperma polyneuron*, and *Coutarea hexandra* had their antimalarial activity confirmed by clinical observations of medical doctors, an information that yields a high probability of accuracy. Some authors have underestimated the traditional plants used for malaria based exclusively on low activity against *Plasmodium in vitro* or in animal models[73]. This can be a mistake of strategy or even methodology.

The development of new antimalarials from the highly active natural products, which have already been discovered, is crucial in order to overcome the increasing resistance of *Plasmodium* to available antimalarial drugs. Therefore, there is a need to advance the work on plants

which have already been shown to have antimalarial activity through further *in vitro* and *in vivo* testing in animal models of malaria followed by sub-acute and chronic toxicity tests. This is likely to reveal suitable candidate molecules which may serve as leads which can be optimized followed by development into new antimalarials. This task will require capacity building in the various facets of such an approach, which capacity is inadequate at the moment. This strategy if pursued from drug discovery research on to preclinical followed by clinical studies will certainly yield the much desired highly efficacious and safe antimalarials. However, further studies including controlled clinical trials are necessary before specific traditional remedies can be recommended on a large scale.

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