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Original Research Article

Indian Plants with Antimalarial Ingredients

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A B S T R A C T

Plants have always been a potential source for the development of new therapeutic agents which have been used for the design of new drugs. The folk medicine and traditional system of medicine prevailing in different parts of the globe have amply proved by the studies. The control of malaria has long been a problem, despite intense research efforts, possibly because of the complex biology of *Plasmodium* and the ability of this organism to conceal and modifies its host cell in several ways to enhance its survival. In India, there has been a strong traditional system of medicine and so many herbs like *Andrographis paniculata* (Kalmegh), *Alstonia scholaris* (Saptparni), *Swertia chirayita* (Chirayita), *Azadirachta indica* (Neem), *Tinospora cordifolia* (Amrita), *Vernonia cinerea* (Sahdevi), etc. and some preparations and formulations such as *Bisam-jwar-har-lauh, Malaria-samharak-vati*,etc. are used by the tribals, medicine men, old people, etc. are being used for the treatment and management of malarial fever. In the present communication 188 plant species are enumerated which are either used in folk, traditional or modern medicine for the treatment and management of malaria.

Keywords

Antimalarials, Plasmodium, Indian plants

Introduction

Malaria in humans is caused by infection with protozoan parasites of the genus *Plasmodium* and transmitted to humans by female *Anopheles* mosquito when they take a human blood meal. There are four types of human malaria- *Plasmodium vivax, P. falciparum, P. malariae, P. ovale* of which the first two types are the most common, and *P. falciparum* is the most virulent as it causes the condition known as cerebral malaria, which is often fatal. The male *Anopheles* feeds on nectar and fruit juices while female primarily on blood and takes a blood meal in order to lay eggs. This feeding occurs every 2 to 3 days thereby allowing the transmission of malaria: initial ingestion of gametocytes, parasite development over 10 to 14 days and subsequent release of sporozoites from salivary gland occurs throughout repeated mosquito blood feeding known as the ovaposition cycle. Transmission of malaria can be interrupted by reducing the lifespan of the adult female so that parasite development (i.e. the sporogonic cycle) can be completed (Day 1999). The sporozoites circulate for a short time in the blood stream, then invade liver cells, where they develop into exoerythrocytic schizonts during the next 5 to 15 days. *P. vivax, P. ovale* and *P.*

cynomolgi have a dormant stage, the hypnozoite, that may remain in the liver for weeks or many years before the development of exoerythrocytic schizogony. This results in relapses of infection. *P. falciparum* and *P. malariae* have no persistent phase. An exoerythrocytic schizont contains 10,000 to 30,000 merozoites, which are released and invade the red blood cells and is dependent on the interactions of specific receptors on the erythrocyte membrane with ligands on the surface of the merozoite and the entire invasion process takes about 30 seconds. The parasite modifies its host cell in several ways to enhance its survival (Fujioka and Aikawa, 1999). The control of this disease has long been a problem, despite intense research efforts, possibly because of the complex biology of *Plasmodium*, and the ability of this organism to conceal itself within host cells. The symptomatic stage of malaria infection concurs with the development of the asexual cycle of the parasites in the red blood cells (Madeira *et al.*, 2008). It is one of the major fatal diseases in the world, especially in the tropics, and is endemic in some 102 countries, with more than half of the world population at risk being extremely high among young children below five years of age (Symth, 1994). The world Health Organisation estimates that there are between 300-500 million new cases of malaria every year, mostly in Africa, Asia, South pacific islands and South America which causes at least 1 million deaths annually. Control of this disease is complex because of the appearance of drug-resistance strains of *Plasmodium.* Plants have always been used for the treatment of such infective diseases since time immemorial, especially the febrifuge or antipyretic medicines because of the symptom of fever in the patients. In traditional system of medicine, *Andrographis paniculata* (Kalmegh), *Alstonia scholaris* (Saptparni), *Swertia chirayita* (Chirayita), *Azadirachta indica* (Neem), *Tinospora cordifolia* (Amrita), *Vernonia cinerea* (Sahdevi), etc. and some preparations and formulations such as *Bisam-jwar-har-lauh, Malaria-samharak-vati*, etc. are being used for the treatment and management of malarial fever. The first anti-malarial lead molecule was quinine, isolated from the stem- bark of *Cinchona* spp. (Fam. Rubiaceae) in 1820 and was used as a template for chloroquine and mefloquine in 1940 but according to Odugbemi *et al.*, (2007) quinine was used as an antimalarial as early as 1632 and by the 19th century, it was still the only known antimalarial agent. Primaquine and quinacrine were produced after the first world war. Now-a-days, when it is used as monotherapies loses its effectiveness very soon due to resistance. Combination therapies mixed with other molecules/ compounds viz. artemisinin and its analogs were tried with different doses which were successful and gave some good results recently.

India is among one of the top seventeen mega diverse countries of the world with 2.5 % of the land mass and 7.8 % of the globally recorded species. The subcontinent encompasses 15 different agro-climatic zones, 10 vegetation zones, 25 biotic provinces and 426 biomes. The ecological habitats of the country vary from humid tropical Western Ghats to the hot deserts of Rajasthan and high mountain ranges of the Himalaya to warm coasts of Peninsular India or Deccan plateau and has representation of almost all the ecological zones found in the world.

While reviewing the literature, the author came across 190 plant species which could be the alternative source for eradication and management of malaria and will help save

the highly valuable/precious plant species from depletion from their natural habitat. The plant species are enumerated alphabetically with family name in parentheses, local, trade names and their mode of administration, etc.

Enumeration

1. *Acacia farnesiana* (L.) Willd. (Mimosaceae): KALAKIKAR. Stem-bark is used in malarial fever (21).
2. *Acacia nilotica* Del. ssp. *Indica* (Benth.) Brenan (Mimosaceae): BABOOL. Stem-bark- insecticidal, antiprotozoal (9). Bark and seeds are used (19).
3. *Acanthospermum hispidum* DC. (Asteraceae). Whole plant or leaves are given (15). Root and leaves are used (19).
4. *Achillea millefolium* L. (Asteraceae): MILLIPEDE. A natural peroxide, α-peroxiachifolid isolated from the herb exhibited *in vitro* schizonticidal activity against *P. falciparum* strain FCH-5 (EC_{50} 1µg/ml) which is weaker than artemisinin (18).
5. *Acorus calamus* L. (Araceae): VACH. Rhizome if taken with quinine stops remittent fever (21).
6. *Adansonia digitata* L. (Bombacaceae): KALPVRIKSHA. A combination of leaves, roots and flowers is taken till cure (17).
7. *Aerva lanata*(L.) Juss. ex Schult. (Amaranthaceae): GORAKHGANJA. The herb is used in malaria and skin diseases (3).
8. *Agave contula* Roxb. (Agavaceae): AMERICAN ALOE. The core of the plant is used as a febrifuge in treating malaria and other fevers (16).
9. *Ailanthus altissima* (Mill.) Sw. (Simaraubaceae). TREE OF HEAVEN, AILANTO. Quassinoids isolated from stem-bark exhibited antimalarial activity (20).
10. *A. excelsa* Roxb. (Simaraubaceae): ARLU, MAHANIMB.Quassinoids isolated from stem-bark exhibited antimalarial activity (20).
11. *Alangium salvifolium* (L. f.) Wang (Alangiaceae): Ankol. Leaf-antiprotozoal (9).
12. *Albizia lebbeck*(L.) Benth. (Mimosaceae): Siris.Fruit- antiprotozoal (9).
13. *Allium cepa* L. (Liliaceae): ONION, PYAJ. Bulb is taken (19).
14. *A. sativum* L. (Liliaceae); LAHSUN, GARLIC. Diallyl disulphide and diallyl trisulphide from essential oil- larvicidal (9). Concoction or tincture of bulb is given in malaria (15; Odugbemi *et al.*, 2007). Bulb is taken (19). Ajoene, a metabolite isolated from the plant was tested for activity against *P. verghei* in mice. This compound was nontoxic and reduced the severity of the infection in mice. When used in combination with chloroquine, at a dose that is usually not effective, the malaria was completely cleared (20).
15. *Aloe vera* L. (Liliaceae): GHRITKUMARI. Leaves are taken (19).
16. *Alstonia macrophylla* Wall. ex G. Don (Apocynaceae): DEVIL'S TREE, MOTHI SAATVEEN. Thirteen indole alkaloids were isolated from the active extract and villastonine was the most active component against malaria (20).
17. *A. scholaris* (L.) R. Br. (Apocynaceae): SAPTAPARNI. One teaspoon decoction of the stem bark of the plant is given for three days in malarial fever (Jain *et al.*, 2010). Infusion of stem-bark is given once a day in malarial fever (21).
18. *Amaranthus spinosus* L. (Amaranthaceae): KATILI CHAULAI. Juice obtained from squeezed roots is mixed with powdered rice and taken with water till cure (17).

19. *Anacardium occidentale* L. (Anacardiaceae): CASHEW NUT, KAJU. Stem-bark is given in malarial fever (15).
20. *Ananas comosus* (L.) Merr. (Bromeliaceae): PINEAPPLE, ANANNAS. Unripe fruits are given (15).
21. *Andrographis paniculata* Wall. ex Nees (Acanthaceae): KALPNATH, KALMEGH. Crushed raw leaves are taken orally for 2 days twice with half glass of milk (21). The butanol fraction of the ethanolic (50%) extract of the plant reduced the level of parasitaemia against *P. verghei* NK65 in a dose dependent manner. The diterpene, neoandrographolide present in the plant also suppressed the parasitaemia level, but not in a dose dependent manner (3). Infusion of whole plant is taken internally for seven days in chikangunia, intermittent fever and malarial fever (13).
22. *Anthemis nobilis* L. (Asteraceae): Natural peroxides, α-peroxiachifolid, 1β-hydroperoxisonobilin, trans-pinocarveylhydroperoxid isolated from the herb exhibited in vitro schizonticidal activity (EC_{50} 5,1 and 5-10µg/ml respectively) against *P. falciparum* strain ECH-5 which is weaker than artemisinin (18).
23. *Anthocephalus chinensis*(Lam.) A. Rich. ex Walp.(Rubiaceae): KADAMB. Cadambine isolated from stem-bark of the plant showed antimalarial activity (IC_{50} value of 6.77µM) on chloroquine-resistant strain of *P. falciparum* (20).
24. *Arachis hypogaea* L.(Fabaceae): GROUNDNUT, MOONGFALI. Seeds are used (19).
25. *Artabotrys hexapetalus* Bhandari (Annonaceae); KANAKCHAMPA. A sesquiterpene peroxide, isolated from the plant is used to treat malaria (20).
26. *Artemisia absinthium* L. (Asteraceae): AFSANTHIN. A natural peroxide, arteinculton, isolated from the plant exhibited schizonticidal activity (EC_{50} 1 µg/ml) against *P. falciparum* strain ECH-5 which is weaker than artemisinin (18).
27. *A. annua* L. (Asteraceae): Qinghaosu, isolated from the herb exhibited in vitro schizonticidal activity (EC_{50} 0.01µg/ml) against *P. falciparum* strain FCH-5. Artemisinin first isolated in pure form in 1972, and some of its more lipophilic (injectable) and hydrophilic synthetic derivatives are used in China to treat tens of thousands of patients without any adverse side effects to treat chloroquine-resistant malaria (20).
28. *A. maritima* L. (Asteraceae): SAFED PURCHA. A natural peroxide, arteinculton isolated from the plant exhibited in vitro schizonticidal activity (EC_{50} 5-10µg/ml) against *P. falciparum* strain ECH-5 which is weaker than artemisinin (18).
29. *A. nilagirica* (Cl.) Pamp. (Asteraceae): Nagdauna. Decoction of leaves is given (21).
30. *A. vulgaris*L. (Asteraceae): Nagdawana Essential oil- larvicidal, insecticidal, antimicrobial, antifungal(9).
31. *Asplenium adiantoides* C. Chr. (Aspleniaceae). Whole plant is used in malaria (21).
32. *Aster amellus* L. (Asteraceae). Root is given in malaria (21).
33. *Azadirachta indica*A. Juss. (Meliaceae): NEEM, MARGOSA TREE. Fruit, leaves and bark are used (19). The bitter stem-bark is reported to be beneficial in malarial fever (16). Four limonoids isolated from leaves of which meldenin was the most active against chloroquine-resistant *P. falciparum* strain K 1 (20).
34. *Balanites aegyptiaca* (L.) Delile (Balanitaceae): HINGOT. Bark is used

(19).

35. *Bauhinia malabarica* Roxb. (Caesalpiniaceae): KACHNAR. Two tetracyclic compounds, racemosol and demethylracemosol isolated and identified as the most active compounds from the plant (20).
36. *Berberis aristata* DC. (Asteraceae): DARUHALDI. Root-bark is used as tonic in malarial fever (21). Barbamine isolated from many species showed in vitro activity against both chloroquine-resistant and sensitive strain of *P. falciparum* and its effect when used in combination with chloroquine and artemisinin. It was active against both the resistant and the sensitive strains of *P. falciparum.* When administered with chloroquine, berbamine had an antagonistic effect to chloroquine on the chloroquine-sensitive strain and a potentiating effect on the chloroquine-resistant strain. Administration in combination with artemisinin had an additive effect on the chloroquine-sensitive strain of *P. falciparum*and a potentiating effect on the chloroquine-resistant strain. The monomer berberine also has an antiplasmodial IC_{50} of less than 1 µM (20).
37. *Betula alnoides* Buch.-Ham. (Betulaceae): Bhojpatra. Decoction of stem-bark is given in malarial fever (21).
38. *Bidens pilosa* L. (Asteraceae). Leaves used for patients that did not respond to quinine (4).
39. *Bidens pilosa*L. var. *minor*(Bl.) Sherff (Asteraceae). Phenyl-1, 3, 5-heptatriyne isolated from hexane extract of leaves showed promising antimalarial activity. The antimalarial activity (IC_{50}) of this test compound against parasite growth was determined spectrophotometrically by measuring the activity of the plDH, in control and drug-treated cultures. The compound showed 50% parasite growth inhibition at 6.0 µg/mL rendering it a potential natural antimalarial (22).
40. *Biophytum sensitivum* (L.) Don (Oxalidaceae): LAJWANTI, LAJJALU. The juice of the plant is reportedly taken as a remedy for malarial fever among the Mahalia in the Chhotanagpur region of Jharkhand (16).
41. *Bixa orellana* (Bixaceae): SINDURI, ANNATO. The hydroalcoholic extract from B. orellona seeds grown in Cuba showed in vitro and in vivo moderate antimalarial activity. Bioassay-guided fractioning will allow identifying the molecules responsible for the exhibited extract activity and re-evaluating the potentialities of this extract.
42. *Brucea javanica* (L.) Merr. (Simaraubaceae). Fruit is given in malarial fever (21). In Thai and Chinese system of medicine, a tea of the fruits of the plant is used to treat malaria often in conjunction with chloroquine and workers found that this tea was antagonistic to chloroquine action and may contribute to the development of chloroquine-resistant strains of malaria. Usually an aqueous extract of fruit would be consumed in the form of a tea. Two compound types quassinoids and triterpenoids with antimalarial activity were isolated. Bruceajavanin and dihydrobruceajavanin (triterpenoids) isolated from stem exhibited moderate activity. Quassinoids bruceine A, B and C isolated from chloroform extract of fruits showed in vitro activity against multidrug- resistant *P. falciparum* comparable to the antimalarial drug mefloquine. Bruceine D and brusatol showed activity against *P. berghei* (20).
43. *Caesalpinia bonduc* (L.) Roxb. (Caesalpiniaceae): KATKARANJ. The seeds are an ingredient of several Ayurvedic preparations, including Ayush-64, used as an antimalarial drug.

In Jammu and Kashmir, the plant juice is prescribed after meals for two weeks to treat intermittent fever (16). Infusion of seed powder is given internally (13).

44. *C. pulcherrima* (L.) Sw. (Caesalpiniaceae): PEAKOCK FLOWER, BARBADOS PRIDE. An infusion of the flowers is used as a febrifuge, and in the treatment of malarial fevers (16).
45. *Cajanus cajan*L. (Fabaceae): ARHAR, PIGEONPEA. Root extract exhibited antimalarial activity (CSIR-CIMAP, Lucknow).
46. *Calotropis procera* (Ait.) R.Br. (Asclepiadaceae): MADAR, AAK. The latex of the plant with boiled milk and sugar is made into a paste by rural inhabitants of Bhavnagar district, Gujarat and is taken internally as an antimalarial drug (16).
47. *Canna indica* L. (Cannaceae). Leaves are used (15).
48. *Capsicum frutescens* L. (Solanaceae): CAPSICUM, MIRCH. Fruits are used (15,19).
49. *Carica papaya* L. (Caricaceae): PAPITA, PAPAYA. Leaves, fruits and roots are used (19). Leaf is given in malarial fever (21).
50. *Cassia fistula* L. (Caesalpiniaceae): AMALTAS. Fruit pulp is taken as an antipyretic, a remedy for malaria and blackwater fever (16). Leaves, stem-bark and seeds indicated as an adjuvant for the treatment of malaria (4).
51. *C. occidentalis* L. (Caesalpiniaceae): KASONDI, THE NEGRO COFFEE. Leaves are taken (19).
52. *C. siamea* Lam. (Caesalpiniaceae). Stem bark is given (15).
53. *C. tora* L. (Caesalpiniaceae): CHAKRAMARD, CHAKWARH. Seeds are taken (19).
54. *Catharanthus roseus* (L.) G. Don (Apocynaceae): SADABAHAR, PERIWINKLE. Aerial part is given in intermittent fever, malaria. Indicated as a substitute for quina (4).
55. *Ceiba pentandra* (L.) Gaertn. (Bombacaceae): KAPOK TREE. Leaves are given (15).
56. *Celastrus paniculatus*Willd. (Celastraceae): MALKANGNI, JYOTISHMATI.In Thailand the root bark of this plant is sold in the form of pressed pills for the treatment of malaria. Chloroform extract of root bark showed significant antimalarial activity against *P. falciparum in-vitro* and the active constituent to be pristimerin (24,20).
57. *Centipeda minima* Br.*et* Asch. (Asteraceae); NAKCHHIKANI. The herb is used by the Chinese to treat colds, nasal allergies, asthma, malaria and amoebiasis. A sesquiterpene lactone, brevilin A isolated from the plant is found to be active against *P. falciparum* (20).
58. *Centratherum anthelminticum* L. (Asteraceae): KALIJEERI. Mixture of root powder and seeds are taken in malarial fever (13).
59. *Chenopodium ambrosioides*L. (Chenopodiaceae). The alcoholic extract of plant exhibited antimalarial activity against erythrocytic stage of *P. berghei in vivo*. Ascaridole, a terpene isolated from the herb is one of the few naturally occurring endoperoxides and exhibits some antiplasmodial activity (3,20).
60. *Chromolaena odorata* (Asteraceae). Root and leaves are given (15).
61. *Chrysanthellum americanum* (Asteraceae). Whole plant is used (19).
62. *Chukrasia tabularis* A. Juss. (Meliaceae): Chikrasi. Extract of leaves showed antimalarial activity against *P. falciparum* in both chloroquine sensitive and resistantstrains (20).
63. *Cinnamomum beljolghota* (Buch.-Ham.): Tejpatta. The stem-bark and

leaves are boiled with the leaves of *Anacolosa crassipes* and water is used for bathing, the steam is inhaled and the water is taken internally (21).

64. *Cissampelos pareira* L. (Menispermaceae): PATHA. The juice of root is used (21).
65. *Citrus medica* L. (Rutaceae): BARANIMBU. Fruit juice is given in malarial fever (21).
66. *Citrus aurantifolia* Swingle (Rutaceae): NIMBU, LEMON. Leaves, twigs, root, bark and fruit is given (15).
67. *C. reticulata* Blanco (Rutaceae). Narangi. The limonin, nomilin and obacunone isolated showed moult inhibiting activity in *Culex quinquefasciatus* (25).
68. *C. paradisi* (Rutaceae): Leaves, stem root and fruits are given (15).
69. *Citrus sinensis* (L.) Osbeck (Rutaceae): Musammi. Decoction of leaf is given (21).
70. *Clausena excavata* Burm. *f.* (Rutaceae): Juice of leaf is rubbed to elleviate muscular pain during fever (21).
71. *Clerodendrumcolebrookianaum* Walp. (Verbenaceae): NEPHAPHU (Assamese). Decoction of leaves is given in malarial fever (21).
72. *C. serratum* (L.) Moon (Verbenaceae): BHARANGI. Root of the plant is given in malarial fever (21).
73. *C. viscosum* Vent. (Verbenaceae): BHANT. Root and leaves are given (21). One teaspoonful leaf juice is taken thrice a day for a week (17).
74. *Coffea arabica* L. (Rubiaceae); COFFEE. Decoction of leaves potentiate other plants with antimalarial activity (4).
75. *Combretum decandrum* Roxb. (Combretaceae): PUNK, RUREL, ROEL. In West Africa, the leaves are used in the treatment of malarial fever (16).
76. *Coptis teeta* Wall. (Ranunculaceae): MAMIRI, MISHMI TEETA. Rhizome/root is administered orally at a dose of 150 g thrice a day in malarial fever (21).
77. *Corchorus olitorius* (Tiliaceae). Seeds are used (19).
78. *Cosmos sulphureus* Cav. (Asteraceae). Aerial parts and fruits used in intermittent fever and exhibited activity against malaria (4).
79. *Crotalaria occulta* Grab (Fabaceae): Plant juice taken with water in malarial fever (21).
80. *Croton tiglium* L. (Euphorbiaceae): JAMALGOTA. Leaves and flowers powder is consumed with a glass of water twice a day till the cure (21).
81. *C. caudatus* Geisel (Euphorbiaceae). Root of the plant is given (21).
82. *Cryptolepis buchanani* (Asclepiadaceae): DUDDHI. Root with stem bark or leaves of NEEM (*Azadirachta indica* Juss.) is taken (12).
83. *Curcuma longa* (Zingiberaceae): HALDI, TURMERIC. Rhizome is given (15).
84. *Cymbopogon citratus* (DC.) Stapf (Poaceae): LEMOGRASS, NIMBUGHAS. Leaves are used (15,19).
85. *Cynoglossum glochidion* Wall. (Boraginaceae): NYUMLI MENTO (MONPA). Root pounded or powdered, mixed with water and 10 g is taken twice a day (21).
86. *Cyperus rotundus*L. (Cyperaceae): MOTHA, MUSTA. Hexane extract of tubers/rhizome from Thailand plant showed good activity against *P. falciparum.* Bioassay guided fractionation resulted in the isolation of four active compounds, of which the most active one was 10,12-peroxycalamenene, a sesquiterpene with an endoperoxide group similar in structure to artemisinin. The

dichloromethane extract of tubers from Tanzania exhibits significant *in vitro* antimalarial activity against the multidrug resistant *P. falciparum* strain K1. α-cyperone shows the highest (IC50, 5.5 µg/ml) activity. However, the activity of β- selinine fluctuated, and it was suggested that it forms peroxides readily by autoxidation, and that these decomposition products are active An alcoholic extract of the same plant (except roots/tubers) also shows antimalarial activity (49.65%) against *P. berghei* (NK 65 strain) *in vivo*(3, 20).

87. *Datura metel* L. (Solanaceae): DHATURA. Seed, leaf and root is given in fever with catarrhal and cerebral complications (21).
88. *Desmodium gangeticum*(L.) DC. (Fabaceae): Salparni. The alkaloids isolated from seeds, stem, fruit-rind and bark are used for thetreatment of malaria (3).
89. *Dichroa febrifuga* Lour. (Saxifragaceae): BASAK (H), KHAWSIK-DAMDAWI (MI). Root and leafy tops are used in malarial fever (21). In China the powdered roots are known as Ch'ang Shan and are used to treat fevers. Two interconvertible, isomeric alkaloids febrifugine and isofebrifugine were isolated. Isofebrifugine was inactive at the maximum tolerated dose when tested on ducks, but febrifugine was a hundred times as active as quinine when tested in monkeys. The toxicity was however also in the region of a hundred times that of quinine when tested on white mice. Clinical trials showed that it was such powerful emetic that it could not be used successfully as an antimalarial drug (20).
90. *Dioscorea hispida* L. (Dioscoreaceae): JATASHANKARI. About one teaspoon powder of rhizome is taken twice a day for seven days in malarial fever (12).
91. *Diospyros montana* Roxb. (Ebenaceae): KANKOHAR. Diospyrin isolated from the plant showed some activity against *P. falciparum in vitro* (IC_{50} 626 µM), and its two derivatives from diospyrin with enhanced (IC_{50} of 2.391 and 5.796 µM)activity (20).
92. *Elephantopus scaber* L. (Asteraceae): MURGACHUNDI. Root is given in malarial fever (10).
93. *Elsholzia blanda* Benth. (Lamiaceae): BANTULSI (A). Leaves are used as mosquito repellent (21).
94. *Enicostema axillare*(Lam.) A. Raynal (Gentianaceae): CHHOTA CHIRAYATA, GUCHHI. The plant is used as a substitute for Chiretta (*Swertia chirayita*) as an effective treatment for malaria (16). The root extract shows antimalarial activity both *in vitro* and *in vivo* (3).
95. *Erythrina variegata* L. (Fabaceae): GADHAPALAS. Bark paste is made into pills and the pills taken till cure (17).
96. *Erythroxylum monogynum* Roxb. (Erythroxylaceae). BASTARD SANDAL, RED CEDAR. A decoction of the leaves is used to relieve malarial fevers (16).
97. *Glinus oppositifolius* L. (Molluginaceae). Two triterpenoid saponins- glinosides results evidenced that fractions had a better antiplasmodial (IC_{50}= 31.80 µg/ml) than pure glinoside A (IC_{50}= 42.30 µg/ml) activity(Traore *et al.,* 2000). Dichloromethane extract of the herb exhibited larvicidal activity against *Culex* and *Anopheles* strains at 500 mg/L (7).
98. *Glycyrrhiza glabra* L. (Fabaceae): LIQUORICE, YASHTIMADHU, MULETHI. Chalcone licochalcone isolated from the roots/rhizome of the plant exhibited good antimalarial activity. In *in vivo*tests against *P. yoelii* in mice, oral doses of 1000 mg kg^{-1}

resulted in the complete eradication of the malaria parasite and no toxicity was noted (20).

99. *Gomphostemma parviflora* Wall. (Lamiaceae). Leaf is used (21).
100. *Gossypium hirsutum* L. (Malvaceae): KAPAS, COTTON. Leaves are given (15).
101. *Gymnema sylvestre* (Retz.) R.Br. ex Schult. (Asclepiadaceae): GUDMAR, AUSTRALIAN COW PLANT. Among the Gonds of Andhra Pradesh, the filtered extract of the ground leaf twigs is taken orally to relieve malarial fever (16).
102. *Haldina cordifolia* (Roxb.) Ridsdale (Rubiaceae): HALDU. The extract of stem-bark is used by the Gonds of Uttar Pradesh for treating malarial fever (16).
103. *Halenia elliptica* D. Don (Gentianaceae): QING YE DAN (Mon). Whole plant is given in malarial fever (21).
104. *Hedyotis scandens* Roxb. (Rubiaceae): BAKRELARA (Nep). Infusion of root and leaves are taken as an effective remedy (21).
105. *Helianthus annuus* L. (Asteraceae): SURAJMUKHI. Decoction of leaves and flowers along with honey is prescribed (21).
106. *Heliotropium indicum* L. (Boraginaceae): HASTISUND. Whole herb is given (15).
107. *Hernandia peltata* Meissn. (Hernandiaceae): JACK IN THE BOX. Bisbenzylisoquinoline alkaloids isolated from the plant exhibited antiplasmodial activity (2).
108. *Hibiscus cannabinus* L. (Malvaceae): PATUA. Leaves are taken (19).
109. *H. sabdariffa* L. (Malvaceae): Flowers are taken (19).
110. *Holarrhena pubescens* Wall. ex D. Don (Apocynaceae): KUTAJ, KURHA. The decoction of stem-bark is taken for malarial fever by Gonds of Uttar Pradesh (16). Decoction of root and fruit is given internally in malaria. Decoction of stem-bark is given internally in high fever (13).
111. *Homonoia riparia* Lour. (Euphorbiaceae): TAIPUI SULHLA (A). Wood infusion is given (21).
112. *Hydrangea macrophylla* (Thunb.) Ser. (Saxifragaceae). Leave and root juice said to be more potent than quinine (21).
113. *Hymenodictyon orixense* (Roxb.) Mabb. (Rubiaceae): BHURKUR, BHAULAN. The tribal inhabitants of eastern Bihar use a decoction of the stem-bark as a prophylactic against malarial fever (16).
114. *Hyptis suaveolens* (L.) Poir. (Lamiaceae): VANTULSI. Leaves are given (15).
115. *Ichnocarpus frutescence* (L.) R. Br. (Apocynaceae): SARIVA. One teaspoon squeezed juice of aerial part is taken orally for five days in malarial fever (12).
116. *Impatiens angustifolia* Bl. (Balsaminaceae). Leaf paste is given (21).
117. *Jatropha gossypifolia* L. (Euphorbiaceae). Seeds are taken with water till cure (17).
118. *Justicia adhatoda* L. (Acanthaceae): ADUSA. The leaves are boiled and water is used for bathing and the leaf paste is applied on the whole body as an effective cure for chronic fever or malarial fever (21).
119. *Kigelia africana*(Lamk.) Benth. (Bignoniaceae): BALAMKHIRA. Plant contains four compounds with antimalarial activity, the most active ones being 2-(1'- hydroxyethyl) naphtha [2,3-*b*] furan-4dione and isopinnatal (20).
120. *Lantana camara* L. (Verbenaceae):

HLINGPANGPAR (Mi). Plant decoctionis given (21).

121. *Leea asiatica* (L.) Ridsd. (Leeaceae): HAISAYA DHAKA. Half teaspoon root extract is taken daily for five days (12).
122. *Leonotis nepetaefolia* (L.) R. Br. (Lamiaceae): HEJURCHEI. The seeds reportedly possess antimalarial activity (16).
123. *Magnolia grandiflora* L. (Magnoliaceae): ANDACHAMPA. Stem-bark is given (21).
124. *Mangifera indica* L. (Anacardiaceae): MANGO, AAM. Stem-bark and leaves are given (15; Odugbemi *et al.*, 2007). Leaves and bark are used (19).
125. *Melia azedarach*L. (Meliaceae): Bakayan. azedarachin and melianonilol exhibited antifeedant activity (24; Rastogi and Mehrotra 1998). The limonoid gedunin isolated from the plant is roughly as active as quinine (20).
126. *Melodinus monogynus* Roxb. (Apocynaceae). Leaf, root and wood used as anitmalarial drug (21).
127. *Mesona wallichiana* Benth. (Lamiaceae). Boiled extract of root is given (21).
128. *Moringa oleifera* Lam. (Moringaceae): SAHJAN, DRUMSTICK TREE. The fresh roots are used in intermittent fever; the juice extracted from the leaves has strong antimalarial properties (16).
129. *Musa paradisiaca* L. (Musaceae): BANANA, KELA. Stem juice potentiate other plants used in malaria and help in recovery of patients (4).
130. *Nasturtium officinale* Br. (Brassicaceae): CHHU- RA (NYISHI). Plant decoction (2-3 teaspoonful) is given twice a day (21).
131. *Nyctanthes arbor- tristis*L. (Nyctanthaceae): HARSINGAR, PARIJAT. The young leaves, rubbed with water and ginger, are useful for relief of intermittent fever; a decoction of the leaves, prepared over a gentle fire, is given in malaria (16). The leaf extract exhibited significant antimalarial activity both *in-vivo* and *in-vitro.* However, root and seed extracts exhibitedantimalarial activity *in-vitro* (3, 24).
132. *Ocimum basilicum* L. (Lamiaceae): BASIL, BABUI TULSI. Leaves are used (19).

132.*O. gratissimum* L. (Lamiaceae): TULSI. Leaves are given (15).

133.*O. tenuiflorum* L. (Lamiaceae): TULSI. A decoction of the root is given as a diaphoretic in the treatment of malarial fevers. The essential oil extracted from the leaves by steam distillation is reported to possess insecticidal property and is particularly effective as a mosquito repellent (16). Decoction of root is given (21).

134.*Passiflora nepalensis* Walp. (Passifloraceae): NAUAWIMU (M). Decoction of root is given (21).

135. *Pennisetum glaucum* (L.) R. Br. (Poaceae): Roots and seeds are used (19).
136. *Pergularia daemia* (Asclepiadaceae). Leaves and root are given (15).
137. *Phyllanthus amarus* Schum. et Thonn. (Euphorbiaceae): BHUMIAMALAKI. One teaspoon decoction of whole plant is taken in malarial fever (12).
138. *P. fraternus*Webster (Euphorbiaceae). BHUIAMLA. The plant juice or a decoction of the whole plant is used as a prophylaxis against malaria and cold by the rural inhabitants of Bhavnagar district, Gujarat (16). InGhana, the whole herb is taken during rainy season to treat skininfections and malaria. Two alkamides, (*E, E*)-octa-2,4-dienamide and (*E, Z*)-deca-2,4-dienamide with moderate*in vitro* plasmodial activity (20).
139. *Physalis angulata* L. (Solanaceae). Whole plant and leaves are given in malarial

fever (15).

140. *P. minima*L. (Solanaceae). The alcoholic extract of the plantshowed antimalarial activity *in vivo* against erythrocytic stages of *Plasmodium berghei*NK-65 strain (3).

141. *Picrasma javanica* Bl. (Simaroubaceae): THINGDAMDAWI. The inner bark is very bitter like cinchona. An infusion of the inner coat of the bark (10 ml) is taken orally in lieu of quinine twice a day (21).

142. *Picrorhiza kurrooa* Benth. (Scrophulariaceae). Rhizome/stolon is pounded in water and used (21).

143. *Piper mullesua* Buch.-Ham. (Piperaceae): PIPPALI (ADI). Dried plant is consumed during malaria (21).

144.*P. nigrum* L. (Piperaceae): BLACK PEPPER, KALI MIRCH. Dried fruits are given as an antiperiodic in malarial fever (16).

145. *Polygala persicariaefolia* DC. (Polygalaceae). Decoction of whole plant is given (21).

146. *Pongamia pinnata* (L.) Pierre (Fabaceae): KARANJ. One or two teaspoon water extract of stem bark is orally taken daily for five days in malarial fever (12).

147. *Psidium guajava* (Myrtaceae): GUAVA, AMROOD. Leaves and stem-bark is given (15,19).

148. Psoralea corylifolia (Fabaceae). BABCHI.Bakuchiol – antimalarial.

148.*Quassia amara* L. (Simaroubaceae). Stem-bark extract showed antimalarial activity in experimental malaria mice (4).

149. *Randia fasciculata* (Roxb.) DC. (Rubiaceae): CHHAWNTAN. Leaf mixed with black pepper (*Piper nigrum* L. (Piperaceae) and their boiled juice/extract is given (21).

150. *Rauvolfia serpentina* Benth. (Apocynaceae): SERPENTINE ROOT, SARPGANDHA. A paste of root and black pepper is administered (dose equal to 4-5 ratis, 1 rati= 1 tola = 11.66 g) till cure (17).

151. *Rubus ellipticus* Sm. (Rosaceae): HMUTAU. Root decoction is given (21).

152. *Satyrum nepalense* D. Don (Orchidaceae). Tuber is consumed as tonic in malarial fever (21).

153. *Schleichera oleosa* (Lour.) Oken. (Sapindaceae): KUSUM, LAC TREE. An infusion or maceration of the bark is prescribed for treatment of malaria (16).

154. *Scoparia dulcis* L. (Scrophulariaceae): GHODA TULSI. Juice squeezed from leaves is taken two teaspoonful daily in the morning and evening for seven days or till cure (17).

155. *Semecarpus anacardium* L. (Anacardiaceae): BHILWA. The seed oil is externally applied on joint pain and finger tips to cure malarial fever (12).

156. *Sesbania grandiflora* (L.) Poir. (Fabaceae): SWAMP PEA, AGATHI, AGAST. An infusion of the bark is recommended in malaria and other eruptive fevers (16).

157. *Sida rhombifolia*L. (Malvaceae): BARIARA. Alcoholic extract of the roots exhibited antipyretic activities and antimalarial activity *in vitro* against erythrocytic stages of *Plasmodium berghei*(3). Root decoction is given (21).

158. *Solanum nigrum* L. (Solanaceae): MAKOI. Leaves are given (15).

159. *Solanum torvum* Sw. (Solanaceae): BAIGUN. Burnt fruits are consumed (21).

160. *S.viarum* Cl. (Solanaceae). Decoction of root is given (21).

161. *Soymida febrifuga* (Roxb.) A. Juss. (Meliaceae): ROHAN, INDIAN REDWOOD. The stem-bark is used in the treatment of intermittent fevers, including malarial fever and as a bitter tonic in general debility (16).

162. *Spathodea campanulata*Beauv. (Bignoniaceae):AFRICAN TULIP TREE. An aqueous alcoholic extract of the leaves

has been reported to have antimalarial properties. The hexane and chloroform extracts of stem-bark showed blood schizontocidal action and antimalarial activity against *Plasmodium berghei berghei* in mice. Some chromatographic fractions of stem-bark extracts are reported to exhibit significant antimalarial activity against *Plasmodium berghei berghei* Keyberg-173-N-strain in mice which was higher than that observed with the crude extracts (3). Ursolic acid and two derivatives, tomentosolic acid and 3-β, 20β-dihydroxyurs-12-en-28-oic acid from the stem bark were found to suppress the disease and to prolong the survival times of mice infected with *P. berghei berghei* (20).

163. *Stephania japonica* Miers (Menispermaceae): RAJPATHA. Sun dried tuber powder is taken orally with boiled water twice a day for more than 4 days till malaria is cured (21).

164. *Sterculia urens* Roxb. (Sterculiaceae): GULLU. Root powder with black pepper is taken with half cup water in malarial fever (12).

165. *Streblus asper* Lour. (Moraceae): SIHOR. Juice obtained from squeezed bark is taken till cure (17).

166. *Strobilanthus auriculatus* Nees (Acanthaceae): RANTING (M); RUM (Ass). Pounded leaves rubbed on the body during the cold stage of intermittent fever (21).

167. *Swertia dilatata* Wall. (Gentianaceae): SIROTA (Ass). Powdered root is administered (21).

168. *Tamarindus indica* L. (Fabaceae): TAMARIND, IMLI. Fruits and leaves are taken (19).

169. *Taraxacum officinale* Wigg. (Asteraceae): DUDAL,DANDELION. Plant powder is used (21).

170. *Terminalia bellirica*(Gaertn.) Roxb. (Combretaceae): BIBHITAK, BAHEDA. Bioassay guided fractionation succeeded in isolating four compounds from the fruit rind, of which two compounds viz. termilignan and anolignan showed antimalarial activity (20).

171. *Thalictrum foliolosum* L. (Ranunculaceae): PILIJARI. Root and whole plant is bitter tonic (21).

172. *Thespesia lampas* (Cav.) Dalz. & Gibs. (Malvaceae). Root powder is given in malarial fever (12).

173. *T. populnea*(L.) Soland. ex Corr. (Malvaceae): Parish Peepal.

Fruit- antimalarial effects due to gossypol (9).

174. *Tinospora cordifolia* (L.) Miers (Menispermaceae): One teaspoon decoction of stem/root/fruit is taken twice a day for five days in malarial fever (13).

175. *Tithonia diversifolia* (Asteraceae): TREE MARIGOLD. Leaves and twigs are used (15).

176. *Toddalia asiatica* (L.) Lam. (Rutaceae): JANGLI KALIMIRCH, FOREST PEPPER. Bioguided fractionation o resulted in isolation of nitidine, which showed good activity against both chloroquine-sensitive resistant strains of *P. falciparum*. Ethyl acetate extract of the plant resulted in isolation of 5,7-dimethoxy-8-(3'-hydroxy-3'methyl-1'-butenyl)coumarin as the active principle against *P. falciparum* (20).

177. *Tylophora indica* (Burm. *f.*) Merr. (Asclepiadaceae): EMETIC SWALLOW-WORT, INDIAN IPECACUANHA, ANTAMUL. The powdered roots are used for treating intermittent malarial fever (16).

178. *Uraria picta* (L.) Desv. (Fabaceae): PRISHNIPARNI. One teaspoon decoction of whole plant is taken twice a day for five or till the cure of diseases (12).

179. *Vandelia sessiliflora* Benth. (Scrophulariaceae). Decoction of whole plant is given (21).

180. *Vernonia cinerea*(L.) Less. (Asteraceae): SAHDEVI. A decoction of the

plant is prescribed to promote perspiration in fevers, and its infusion is used in combination with quinine to relieve malarial fever (16). Sesquiterpene lactones isolated from dichloromethane fraction of aqueous extract from plant showed antimalarial activity (3).

181. *Vitex negundo*L. (Verbenaceae): Samhalu, Nirgundi. The smoke of leaves With*Leucas aspera* is toxic to filarial vector mosquito, *Culex quinquefasciatus* and was found better than the synthetic mosquito-repellent mat containing d-allethrin (3).

182.*V. peduncularis* Wall. (Verbenaceae): THING-KHAWI-LU (Mizo). Bark is crushed and boiled; steam vapour is inhaled by patient; infusion of leaf or root-bark or young stem-bark is useful in malaria and black water fever (21).

183. *Wrightia tinctoria* R. Br. (Apocynaceae): DUDDHI. Decoction of stem-bark is given daily for five days in malarial fever (12).

184. *Xanthium indicum* L. (Asteraceae): AGARA (Ass). Leaf of the plant is given (21).

185.*Zanthoxylum hamiltonianum* Wall. (Rutaceae). Root and bark is given in malarial fever (21).

186. *Zea mays* L. (Poaceae): MAZE, MAKKA. Flowers are used (19).

189.*Zingiber officinale* Rosc. (Zingiberaceae): GINGER, ADRAK. Rhizome is given (15).

187. *Ziziphus mauritiana* (Rhamnaceae): BER. Roots are used (19).

Conclusion

The world Health Organisation estimates that there are between 300-500 million new cases of malaria every year, mostly in Africa, Asia, South pacific islands and South America which causes at least 1 million deaths annually. Control of this disease is complex because of the appearance of drug-resistance strains of *Plasmodium*. There is a vast scope especially to utilize our own heritage and accumulated experiences in folk medicine or traditional system of medicine for the development of new drugs of malaria. Therefore, the more extensive ethno- pharmacognostic studies are warranted with activity guided phytochemical and pharmacological investigation with prime objective of exerting less pressure on nature which could be the alternative source for eradication and management of malaria and will help save the highly valuable/precious plant species from depletion from their natural habitat.

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