

Traditional herbal healing practices for the treatment of Malaria and associated symptoms by *Miju-Mishmi* tribe of Lohit district, Arunachal Pradesh, Northeast India

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Research

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Abstract

Background: *Miju-Mishmi* tribe of Lohit district have been practising traditional herbal medicine for curing various ailments including malaria. Present study investigated the traditionally used antimalarial plants and their mode of preparation by *Miju-Mishmi* tribe to cure malaria and associated symptoms. Also, to explore their biological relevance and phytopharmacological confirmation about the presence of secondary metabolites.

Methods: The study was conducted in three villages of Lohit district of Arunachal Pradesh., viz. Karhe, ZiroBasti and Telluliang village. Semi-structured interviews and Focus Group Discussions (FGD) were conducted with purposively selected interviewees including traditional healers, herb sellers, cured patients, and elderly knowledgeable persons. To understand the popularity of each medicinal plant, systematic analysis of ethnobotanical indices, viz., Fidelity Level, Preference Ranking, Use Value, Informant Consensus Factor and Formulation Score were calculated. Qualitative phytochemical profiling was performed for the plants whose PR % scores ≥ 65 and FL scores $\geq 80\%$.

Results: A of total 79 medicinal plants belonging to 50 families and 71 genera were used in twenty-nine ethnomedicinal formulations. Among these, twenty-four plants were reported to be newly used. Mostly leaves (30.38%) of the herbaceous species (48.10%) were used in different formulations. Maximum formulations were prescribed for internal application (83.54%) with wide utility of extraction (25.81%) followed by decoction (22.58%) mode. The highest fidelity value ($\geq 80\%$) was reported for *Aconitum heterophyllum* followed by *Paris polyphylla*, *Coptis teeta*, *Euphorbia neriifolia*, *Holarrhena pubescens*, *Tinospora cordifolia*, *Andrographis paniculata*. The highest PR value ($\geq 65\%$) was account for *C. teeta*, followed by *T. cordifolia*, *A. nilagirica* and *P. polyphylla* for curing malaria fever. The UV index ranges between 0.07 to 0.87, with highest ranking reported for *C. teeta* (UV=0.87). Species like *A. heterophyllum*, *Andrographis paniculata*, *Artemisia nilagirica*, *C. teeta*, *Holarrhena pubescens*, and *P. polyphylla* are in high market demand. Preliminary qualitative phytochemical profiling of selected plants has confirmed their therapeutic efficacy against malaria.

Conclusion: Indigenous *Miju-Mishmi* people have a great knowledge of antimalarial medicinal plants, which requires a proper documentation. There is an enormous probability of getting many effective antimalarial leads from the reported indigenous plants of *Mishmi* hills for discovery of new drugs.

Background

Malaria, an arthropod-borne disease is caused by single-celled protozoan parasites called *Plasmodium* and is among the major causes of morbidity and mortality in many tropical and subtropical countries of the world. The devastating nature of malaria has plummeted the global public health affecting more than 31 endemic countries worldwide. It has victimized many developing countries (~38 countries) where an estimated 11 million pregnant women and 24 million young children were mostly affected. Maximum mortality cases were reported due to *Plasmodium falciparum*. However, according to recent report of WHO, 2019, *Plasmodium vivax* also can't be ignored as it increasingly causing severe malaria and death (<https://www.who.int/news-room/feature-stories/detail/world-malaria-report-2019>). Approximately ~1.4 billion people living in Southeast Asian countries and of this, around 1.2 billion people are exposed to the highly endemic malaria-prone areas of India [1]. Though the contribution from Southeast Asia countries is only 2.5 million to the global malaria scenario, but India alone contributed 76% of the total cases. In 2017, out of ~0.84 million malaria cases from India, 80% were reported from North Eastern, Eastern, and Central Indian regions [2]. National Vector Borne Disease Control Program (NVBDCP) has reported that both the malaria parasite, i.e. *P. falciparum* and *P. vivax* are transmitted through multiple mosquito vectors causing the epidemic in Arunachal Pradesh (A.P.), Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, and Tripura (www.nvbdc.gov.in). Over the decades, the application of multi-drugs has shown the appearance of successive resistant strains in *Plasmodium* towards modern antimalarial medicines. In this circumstance, the commercial antimalarial drug industry is adversely affected and the next challenge is to develop some new classes of drugs that will be persistent with maximum precision against the novel molecular targets and can confirm the success of malaria control strategies with eradication efforts [3,4,5]. Therefore, the need for an alternative drug from a novel plant has become unavoidable towards discovering an antimalarial lead to eradicate the disease.

The use of indigenous plants and preparation herbal formulation has always been a major healing system in many developing countries, which reflexes the traditional knowledge and cultural practice of a community. An estimated 80% of the rural and schedule tribe areas of developing countries are far away from the modern health care systems [6]. Exploration of herbs and their application for curing various ailments is an integral part of those societies and also plays a crucial role in the discovery of new therapeutic drugs, especially in the field of malaria [7]. Most of the available antimalarial drugs have been derived from the plants through the synthesis and screening process [8].

With the highest land cover in the Northeastern states, Arunachal Pradesh (83,743 km²) is the home for 26 major tribes and 110 sub-tribes of diverse culture and lifestyle. Amongst the multitudes of tribal communities that are found in A.P., the anthropologists have come to a unanimous decision of bestowing a place of prominence to a tribal community of *Mishmi* Hills, i.e. *Mishmi* community. The majority of the *Mishmi* tribes have settled down peacefully in hilly districts, namely, Lohit, Upper Dibang Valley, and Lower Dibang Valley. *Mishmi* community can be broadly divided into three major groups, viz. *Idus* or *Chulikatas Mishmi*, *Digarus* or *Taroan Mishmi* and *Miju Mishmi*. Less availability of health centers, modern facilities, and low-income levels has steered them to solely dependent on natural resources including the use of herbal medicine [9].

The present paper is dealing with ethnomedicinal important plant species used by *Miju-Mishmi* tribe of Lohit district, A.P., to cure malaria and associated symptoms. Earlier studies have reported various plants used by the local communities of Lohit district [10, 11], collection and conservation of medicinal plants [12], antimalarial plants of Northeast India [13]. Till date, no such in-depth quantitative ethnopharmacological and phytochemical studies have been carried out, specifically, on *Miju-Mishmi*. As the entire area is climatically and topographically challenging and situated in high altitude, hence it is also very difficult to access those areas for studies. To accomplish the research gap, a study was undertaken with the aim of (i) documentation of traditionally used herbal plant's name by the local people, healers and herb sellers; different mode of administration; plant parts used for herbal medicine preparation; seasonal availability and market price (from herb sellers); the number of plants used in different formulations; (ii) systematic quantitative analysis of all those; (iii) Preliminary phytochemical screening has also been attempted for the top twelve plants with the highest PR ($\geq 65\%$) and FL ($\geq 80\%$), in order to check the secondary

metabolites present therein. This would be significantly beneficial for the authentication of traditional herbal medicine used by the rural society and also help towards pharmacological research for new anti-malarial drug discoveries.

Methods

Study Area

Arunachal Pradesh is the largest state among all the eight states in Northeast India, covering an area of 83,473 km² and sharing its boundary with Assam and Nagaland in the South, Tibet (China) in the North and North East, Bhutan in the West and Myanmar in the East. Geographically, the area is recognized as Himalayan Biodiversity Hotspot by IUCN [14] and exceptionally rich in ethnic culture and biological diversity [15]. The Mishmi Hills (95°49'–95°59' N & 28°06'–28°23'E) is located in the eastern region of A.P. with altitude varies from 400–3568 m. The major part of the *Mishmi* Hills is in the Dibang Valley, followed by Anjaw and Lohit districts.

Lohit district is covering about ~2,402 km² area with district headquarter located at Tezu. The vegetation is characterized by tropical evergreen forests (up to 900m), subtropical and temperate forests (900–1800 m), temperate broadleaf forest (1800–2800 m), and temperate conifer forest (2800–3500 m) [16]. The present study was conducted in three *Miju-Mishmi* dominated villages, viz. Karhe and Ziro Basti village in Wakro circle and Telluliang village in Tezu circle of Lohit district (Fig. 1). Karhe is a small village in Wakro Circle of Lohit district, with a total of 35 families residing. Ziro Basti is located ~3-4 Km from Karhe, inhabited by ~21 families. According to the 2011 census, the total population of Telluliang is 856 peoples and about 190 houses in Telluliang village. Tezu is the nearest town to Telluliang which is approximately 3km away.

Questionnaire-based ethnobotanical data collection

Data collection related to the ethnomedicinal practices was conducted during April, 2017 till July, 2018 from selected participants of the villages. Prior Information Consent (PIC) was obtained from all participants for ethical documentation and publication, explaining the aim and objectives of this study. A standard semi-structured questionnaire was prepared prior to conducting individual interviews including both the open and close-ended questions [17]. The questionnaire was tested in a pilot survey and designed in the English language for data collection. However, interpretation during the interview was conducted in *Miju-Mishmi* language with the help of a local guide and after cross-checking the name of the plants, documentation was done in English language.

The purposively selected respondents included traditional healers, cured patients, herb sellers and elderly knowledgeable persons from all three villages, viz. Karhe, Ziro Basti and Telluliang village. Five persons were selected from each village, of which seven were traditional healers, two were herb sellers, three were cured patients and three were elderly knowledgeable persons. Among the total fifteen, thirteen were male and two were female members. Age category among the respondents' ranges between 55-97, irrespective of gender. Face-to-face interviews with the help of questionnaire was carried out at an individual level, gathering information on local names of the taxa, disease cured, specific part used for formulations, mode of preparation and administration, frequency of use and dosage, seasonal availability and market price of high scoring plants. Furthermore, Focus Group Discussion (FGD) was carried out in a very informal way for the cross verification of data and to gather further more information on the ethnomedicinal plants available in their locality [18].

Plant collection, identification and herbarium preparation

Field trips were conducted for identification and collection of medicinal plants from wild, cultivated lands with the help of local healers, herb sellers, and elderly knowledgeable persons. All the voucher specimens were properly tagged, sun-dried, prepared herbarium, and deposited in the Botany Department of Arunachal University of Studies, A.P., India. Rare and endangered species were not collected from the field. For phytochemical screening of those, dry samples were collected from traditional healers. Samples were authenticated according to the standard literature [19] and looking at the pictures, clicked during the field survey in their original habitat. Scientific names and recent accepted names' of the taxa were followed according to the plant list (<http://www.theplantlist.org>; <http://www.catalogueoflife.org>).

Ethnobotanical indices for quantitative data analysis

In order to achieve the information on popularity and potentiality of each local medicinal plant, quantitative analysis was further accomplished with ethnobotanical indices, viz., Fidelity Level (FL), Preference Ranking (PR), Use Value (UV), Informant Consensus Factor (ICF) and Formulation Score (FS). Data analysis was done by transforming the raw data into expressive information using IBM SPSS 20.0 software.

The potentiality of each local medicinal plant to cure a particular disease can be calculated by fidelity level (FL) based on the proportion of key informants' most preferred species against a given ailment category.

$$FL = \frac{Ip}{Iu} \times 100$$

Where, Ip is the number of informants who independently claimed the use of a particular species for curing the same ailment and Iu the total number of informants who mentioned the plant for any major ailment [20]. Plants scoring, $\geq 80\%$ in FL were selected for preliminary chemical profiling.

To find out the homogeneity of the information obtained from respondents on the reported cures for each group of diseases, the Informant Consensus Factor test was carried out. ICF values range between 0 and 1.

$$ICF = \frac{Nur - Nt}{Nur - 1}$$

Whereas, Nur = Use reports' number of each disease category, Nt = Total number of species in each category [21].

Use value estimates the relative importance of each medicinal plant based on its relative use among informants and adapted by others [22]. UV was calculated using the following formula:

$$UV = (\sum U_i)/N,$$

Where, U_i indicates the number of uses cited by each respondent for a given species and N is the total number of respondents.

For preference ranking technique was carried out with the respondents from each village to identify the most preferred species for a particular ailment [17.] Respondents were asked to present the values (5=best, 4 = very good, 3 = good, 2 = less used, 1 = least used, 0=do not know) to each plant species. The average value calculated by summing up all scores for a plant and divided by the total number of respondents and converted to percentage. Plants scoring, $\geq 65\%$ in PR were further selected for qualitative chemical profiling.

Since most of the dosages were given in combination form of two or more plants, therefore, scores were given to each plant variety in formulation. Formulations including two plants were considered as diherbal formulations (DFs) and more than two were polyherbal formulations (PFs). Formulation scores for DFs, 0.5, and PFs 0.25 is given [23]. Number of times a plant was mentioned in the different formulations, the score adds up.

Selected plant material for phytochemical screening

The uninfected plant parts of *A. paniculata* (whole plant), *A. nilagirica* (leaves), *C. asiatica* (leaves), *D. indica* (fruit), *E. nerifolia* (leaves), *H. pubescens* (bark), *J.adhatoda* (leaves), *P. foetida* (leaves), *T. cordifolia* (leaves) were collected for phytochemical screening during their flowering season. Samples were thoroughly washed with clean water and then with distilled water, chopped into small pieces, shade-dried and ground into a fine powder using Philips HL 7756/00 mixer grinder. For plant extracts preparation, 50 gm of fine ground powdered of each material was taken into a biker and added with 100 ml of methanol. The extracts were filtered using Whatman no. 1 filter paper (WHA No. 28413902, US). The extracts were concentrated to one-fourth of the total volume by keeping in a water bath set at 55°C till all the solvent got evaporated and later on, kept it for cooling. The remaining crude extract was kept in a refrigerator at 4°C for their future use in phytochemical analysis. Extractions obtained from different plant parts were subjected to various standard procedures [24, 25] to identify the important secondary metabolites, viz. alkaloids, flavonoids, terpenoids, saponins, tannin, carbohydrates, glycosides, proteins, phenolic compounds.

Results And Discussion

Morphological plant parts used, mode of drug preparation and utilization

The present study revealed the application of a total of 79 different medicinal plants used in twenty-nine ethnomedicinal formulations (3 DFs, 26 PFs) for curing malaria fever and the other nine associated symptoms (Table 1). Among these, twenty-four plants were reported to be newly used in curing malaria fever and associated symptoms. A combination of plant parts for polyherbal remedy (89.66%) was found to be more favored and prescribed by traditional healers, than to the diherbal formulation (10.34%). It is believed that a mixture of more than two plants increases effectiveness of a formulation while phytochemicals of different plant parts react with each other leading to cure the targeted areas [24] Although, the active compounds are present in the plants, prayers and ritual recitation are the most integral parts of those traditionally prepared formulations. And therefore, there was a prayer by traditional healers before and after they handed over the dosages to their patients. Verbally these prayers/ritual recites have been transferring from one generation to the next generation. Ten plant species were gathered from the cultivated land and rest 69 species were collected from the wild habitat. Indigenous *Miju-Mishmi* people mostly preferred wild plants as they believe that those possess more effective healing power towards a disease. The tolerance capacity towards different environmental stresses makes those plants better survivor and coerced to produce good quality secondary bioactive compounds having great medicinal value for mankind [25].

Table 1: Traditionally used antimalarial plants in diherbal formulations (DFs) and polyherbal formulations (PFs) along with different methods of preparation, modes of administrations and their FL (%), PR (%), FS and UV values.

Scientific name/Voucher No/ Family name/Mishmi Name	Life forms/Plant parts	Disease cured/ Mode of preparation/ Mode of administration	FL (%)	PR (%)	FS
<i>Achyranthes aspera</i> L./ (SI/L/001)/ Amaranthaceae/ <i>Appamargo+ Aconitum</i>	Herb/ Whole plant +Herb/ Tuberous	Fever (PFs)/ Decoction	<i>A. aspera</i> (69.23), <i>A. heterophyllum</i> (93.33),	<i>A. aspera</i> (25.33), <i>A. heterophyllum</i> (49.33),	<i>A. aspera</i> (0
<i>heterophyllum</i> Wall./ (SI/L/002)/ Ranunculaceae/ <i>Bonga-Karpho+ Clerodendrum</i>	root +Shrub/ Tender leaves	~ 100 gm of fresh <i>A. aspera</i> ground with~50	<i>C. infortunatum</i> (54.67),	<i>C. infortunatum</i> (71.43),	<i>infortunatu</i> <i>F. racemosa</i>
<i>infortunatum</i> L./ (SI/L/027)/ Verbenaceae/ <i>Khangjela-shing+ Ficus racemosa</i> L./ (SI/L/045)/ Moraceae/ <i>Phangrok</i>	+Tree/ Root	gm of <i>A. heterophyllum</i> root, ~25 gm of <i>C. infortunatum</i> and ~25 gm of <i>F. racemosa</i> root and boil in 500 ml of water and concentrate to 200 ml. ~10 ml is given daily once for 13-14 days	<i>F. racemosa</i> (52)	<i>F. racemosa</i> (40)	
<i>Acorus calamus</i> L./ (SI/L/003)/ <i>Acoraceae/ Vocha+ Bombax</i>	Herb/ Stem+ Tree/	Diarrhoea (PFs)/ Decoction	<i>A. calamus</i> (69.23), <i>B. ceiba</i> (70),	<i>A. calamus</i> (32), <i>B. ceiba</i> (42),	<i>A. calamus</i> (0
<i>ceiba</i> L./ (SI/L/018)/ Malvaceae / <i>Makhao+ Psidium</i>	Bark+				<i>ceiba</i> (0.25)
<i>guajava</i> Linn./ (SI/L/071)/ Myrtaceae/ <i>Halaha+ Punica</i>	Tree/Leaves+	An equal amount of each	<i>P. guajava</i> (44.44), <i>P. granatum</i> (75)	<i>P. guajava</i> (54.67), <i>P. granatum</i> (38.67)	<i>guajava</i> (0.2
<i>granatum</i> L./ (SI/L/072)/ <i>Lythraceae /Dalemsing</i>	Shrub/ Unripe fruit	ingredient is ground and boiled in water in a 1:4 ratio. Make the mixture of this concentration to 1 and given once during bedtime for 1 months			<i>granatum</i> (0
<i>Adiantum capillus-veneris</i> L./ (SI/L/004)/ <i>Pteridaceae/ Lashung+Ageratum conyzoides</i> (SI/L/005)/ <i>Asteraceae/ Enepu+ Drymaria cordata</i> (L.) Willd. ex Schult./ (SI/L/036)/ Caryophyllaceae/ <i>Kadokairon+ Ocimum tenuiflorum</i> L./ (SI/L/058)/ Lamiaceae/ <i>Tulashi+ Piper longum</i> L./ (SI/L/068)/ <i>Piperaceae/ Ahoma+ Piper nigrum</i> DC./ (SI/L/069)/ Piperaceae/ <i>Marcha+ Zingiber officinale</i> Roscoe/ (SI/L/079) /Zingiberaceae/ <i>Deing</i>	Fern/ Whole plant+ Herb/ Flower + Herb/ Whole plant+ Herb/ Leaves+ Climber/ Fruit+ Climber/ Seed+ Herb/ Rhizome	Cough & cold (PFs)/ Extraction ~50 gm of each ingredients ground with 100 ml of honey and filtered juice is given with honey twice a day till it cured	<i>A. capillus-veneris</i> (66.67), <i>A. conyzoides</i> (55.56), <i>D. cordata</i> (42.86), <i>O. tenuiflorum</i> (62.5), <i>P. longum</i> (78.57), <i>P. nigrum</i> (75), <i>Z. officinale</i> (75)	<i>A. capillus-veneris</i> (cold-33.33, cough-49.33), <i>A. conyzoides</i> (cold-53.33, cough-36), <i>D. cordata</i> (cold-37.33, cough-21.33), <i>O. tenuiflorum</i> (cold-21.33, cough-46.67), <i>P. longum</i> (cough-50.67), <i>P. nigrum</i> (cold-54.67, cough-40), <i>Z. officinale</i> (cough-36)	<i>A. capillus-veneris</i> (0.2 <i>conyzoides</i> (0.2 <i>cordata</i> (0.2 <i>tenuiflorum</i> <i>longum</i> (0.5 <i>nigrum</i> (0.7 <i>officinale</i> (0
<i>Ageratum conyzoides</i> L./ (SI/L/005)/ <i>Asteraceae/ Enepu+ Alstonia scholaris</i> (L.) R. Br./ (SI/L/008) /Apocynaceae / <i>Thamrita+ Chromolaena odorata</i> (L.) R. King & H. Rob./ (SI/L/025) <i>Asteraceae/ Malinga-jumpak</i>	Herb/leaves+ Tree/ Bark+ Shrub/ Leaves	Fever (PFs)/ Pill ~ 200 gm of <i>A. conyzoides</i> and <i>C. odorata</i> leaves and ~100 gm of <i>A. scholaris</i> bark ground together and small pills were prepared by sun-drying method. One	<i>A. conyzoides</i> (55.56), <i>C. odorata</i> (66.67), <i>A. scholaris</i> (38.46)	<i>A. conyzoides</i> (50.67), <i>C. odorata</i> (21.33), <i>A. scholaris</i> (44)	<i>A. conyzoides</i> (0.5 <i>odorata</i> (0.5 <i>scholaris</i> (0

pill given twice a day with lukewarm water and one spoon honey.

<i>Ajuga macrosperma</i> Wall.ex	Herb/ Root+ Herb/	Liver strengthening	<i>A. macrosperma</i> (70),	<i>A. macrosperma</i> (60),	<i>A. macrosperma</i> (60),
Benth./ (SI/L/006)/ Lamiaceae/ <i>Athing-phang+ Phyllanthus</i>	Root+ Herb/	(PFs)/ Powder	<i>P. amarus</i> (75), <i>P.</i>	<i>P. amarus</i> (38.67), <i>P.</i>	<i>P. amarus</i> (0.5)
<i>amarus</i> Schumach & Thonn. / (SI/L/065)	Rhizome (dry)		<i>kurroa</i> (75)	<i>kurroa</i> (57.33)	<i>kurroa</i> (0.5)
/Phyllanthaceae/ <i>Bhumiamlai+ Picrorhiza kurroa</i>		~350 gm raw root of <i>A.</i>			
Royle/ (SI/L/067)/ Plantaginaceae/ <i>Honglen</i>		<i>macrosperma</i> and <i>P.</i>			
		<i>amarus</i> and ~150 gm of			
		dry rhizome of <i>P. kurroa</i>			
		ground together forming			
		dry powder. Two spoons			
		twice daily after food given			
		with 50 gm of jiggery for			
		2-3 months to			
		recover/strengthen the			
		liver.			
<i>Allium sativum</i> L./ (SI/L/007)/ Amaryllidaceae/ <i>Puluo+</i>	Herb/ Cloves+	Cold (PFs)/ Oil	<i>A. sativum</i> (64.29), <i>A.</i>	<i>A. sativum</i> (54.67), <i>A.</i>	<i>A. sativum</i> (54.67), <i>A.</i>
<i>Amomum aromaticum</i> Roxb./ (SI/L/009) /Zingiberace	Herb/ Seed+		<i>aromaticum</i> (70), <i>D.</i>	<i>aromaticum</i> (22.67), <i>D.</i>	<i>aromaticum</i> (22.67), <i>D.</i>
ae/ <i>Sthula ella+ Dioscorea pentaphylla</i> L./ (SI/L/035)	Climber/ Rhizome	5-10 cloves of <i>A. sativum</i> ,	<i>pentaphylla</i> (75)	<i>pentaphylla</i> (38.67)	<i>pentaphylla</i> (38.67)
/Dioscoreaceae/ <i>Ni-Mawan</i>		4-5 <i>A. aromaticum</i> and 2-3			
		inch of <i>D.</i>			
		<i>pentaphylla</i> ground and			
		warm in 50 ml of mastered			
		oil. Apply this oil on the			
		chest, neck and forehead			
		during the night			
<i>Allium sativum</i> L./ (SI/L/007)/ Amaryllidaceae/ <i>Puluo+</i>	Herb/ Cloves	High Fever	<i>A. sativum</i> (64.29), <i>A.</i>	<i>A. sativum</i> (36), <i>A.</i>	<i>A. sativum</i> (36), <i>A.</i>
<i>Andrographis paniculata</i> (Burm. fil.) Nees/ (SI/L/010)/	+Herb/ Whole plant	(PFs)/ Decoction	<i>paniculata</i> (83.33), <i>A.</i>	<i>paniculata</i> (62.67), <i>A.</i>	<i>paniculata</i> (62.67), <i>A.</i>
<i>Acanthaceae/ Hnakapuii+ Artemisia vulgaris</i> L./ (SI/L/013)	+Herb/ Leaves+		<i>vulgaris</i> (57.14), <i>D.</i>	<i>vulgaris</i> (57.33), <i>D.</i>	<i>vulgaris</i> (57.33), <i>D.</i>
/Asteraceae/ <i>Damank+ Dactylorhiza hatagirea</i> (D.Don)	Orchid/ Rhizome	10 cloves of <i>A. sativum</i> ,	<i>hatagirea</i> (71.43)	<i>hatagirea</i> (30.67)	<i>hatagirea</i> (30.67)
Soó/ (SI/L/031)/ <i>Orchidaceae/ Salep, Wanpolagpa</i>		~250 gm of <i>A. paniculata</i> ,			
		~100 gm of dry leaves of			
		<i>A. vulgaris</i> and ~ 100 gm			
		of <i>D. hatagirea</i> rhizome			
		ground together and boil			
		in 1L of water.			
		Concentrated to ½ and			
		given two teaspoon thrice			
		daily for 20-30 days.			
<i>Allium sativum</i> L./ (SI/L/007)/ Amaryllidaceae/ <i>Puluo+</i>	Herb/ Cloves+	Headache (external use)	<i>A. sativum</i> (64.29), <i>E.</i>	<i>A. sativum</i> (64), <i>E.</i>	<i>A. sativum</i> (64), <i>E.</i>
<i>Elsholtzia blanda</i> Benth/ (SI/L/037)/ Lamiaceae/ <i>Popit-</i>	Herb/ Leaves+	(PFs)/ Paste	<i>blanda</i> (80), <i>L.</i>	<i>blanda</i> (29.33), <i>L.</i>	<i>blanda</i> (29.33), <i>L.</i>
<i>namdung+ Leucas aspera</i> (Willd.) Link./ (SI/L/053)/	Herb/ Leaves+		<i>aspera</i> (72.73), <i>M.</i>	<i>aspera</i> (49.33), <i>M.</i>	<i>aspera</i> (49.33), <i>M.</i>
Lamiaceae/ <i>Droni+ Musa balbisiana</i> Colla/ (SI/L/056)	Shrub/ Root+	5 cloves of <i>A. sativum</i> , 5-6	<i>balbisiana</i> (60)	<i>balbisiana</i> (41.33)	<i>balbisiana</i> (41.33)
/Musaceae/ <i>Siambyong</i>		leaves of <i>E. blanda</i> and <i>L.</i>			
		<i>aspera</i> each and 100 gm			
		fresh roots of <i>M.</i>			
		<i>balbisiana</i> ground together			

and paste is applied on the forehead.

<i>Andrographis paniculata</i> (Burm. fil.) Nees/(SI/L/010)	Herb/Whole plant+	High fever (PFs)/ Paste	<i>A. paniculata</i> (83.33),	<i>A. paniculata</i> (62.67),	<i>A. paniculata</i> (62.67),
/Acanthaceae/ Hnakapuii+ <i>Coptis teeta</i> Wall./(SI/L/029)/	Herb/ Rhizome+		<i>C. teeta</i> (90.91), <i>P.</i>	<i>C. teeta</i> (92), <i>P.</i>	<i>teeta</i> (1.5),
Ranunculaceae/ Pawah, Ayaro, Mishmi <i>teeta</i> + <i>Panax</i>	Herb/ Root (dry)+	~100 gm of fresh <i>A.</i>	<i>pseudoginseng</i> (55.56),	<i>pseudoginseng</i> (48), <i>T.</i>	<i>pseudoginseng</i> (48),
<i>pseudoginseng</i> Wall./(SI/L/062)	Climber/ Leaves	<i>paniculata</i> plant and	<i>T. cordifolia</i> (85.71)	<i>cordifolia</i> (78.67)	<i>T. cordifolia</i>
/Araliaceae/Ginseng+ <i>Tinospora cordifolia</i> (Willd.)		rhizome of <i>C. teeta</i> each,			
Miers/(SI/L/ 078)/Menispermaceae/ <i>Swein kije</i>		~50 gm root of <i>P.</i>			
		<i>pseudoginseng</i> and fresh			
		leaves of <i>T. cordifolia</i>			
		ground with fresh			
		<i>ghee</i> (clarified butter) and			
		one teaspoon of this paste			
		is given once a day for 45			
		days.			
<i>Argyrea nervosa</i> (Burm. fil.) Bojer (SI/L/011)/	Climber/ Seed+	Body pain (external use)	<i>A. nervosa</i> (75), <i>C.</i>	<i>A. nervosa</i> (45.33), <i>C.</i>	<i>A. nervosa</i> (45.33),
Convolvulaceae/ <i>Hemlata</i> + <i>Croton tiglium</i> L./(SI/L/030)/	Shrub/ Seed, root+	(PFs)/ Oil	<i>tiglium</i> (77.78), <i>D.</i>	<i>tiglium</i> (42.67), <i>D.</i>	<i>tiglium</i> (0.2)
Euphorbiaceae/ Konibikh+ <i>Dioscorea pentaphylla</i> L./	Climber/ Rhizome		<i>pentaphylla</i> (75), <i>E.</i>	<i>pentaphylla</i> (54.67), <i>E.</i>	<i>pentaphylla</i>
(SI/L/035) /Dioscoreaceae/Ni-Mawan+ <i>Entada</i>	+ Climber/ Stem+	Equal amount of all	<i>phaseoloides</i> (80), <i>E.</i>	<i>phaseoloides</i> (30.67),	<i>phaseoloides</i> (30.67),
<i>phaseoloides</i> (L.)Merr./ (SI/L/039)/ Fabaceae/ <i>Ghillagos</i> + <i>Euphorbia neriifolia</i> L./(SI/L/042)/	Shrub/ Leaves	ingredients ground	<i>neriifolia</i> (90)	<i>E. neriifolia</i> (66.67)	<i>neriifolia</i> (0.66)
Euphorbiaceae/ Changrawng		together with mastered oil			
		and massage on the body,			
		whenever required			
<i>Artemisia nilagirica</i> (C.B. Cl.)	Herb/Leaves+	High fever	<i>A. nilagirica</i> (62.5), <i>C.</i>	<i>A. nilagirica</i> (77.33), <i>C.</i>	<i>A. nilagirica</i> (77.33),
Pamp./(SI/L/012)/Asteraceae/ Illumu/Shaa+ <i>Coptis</i>	Herb/ Rhizome+	(PFs)/ Decoction	<i>teeta</i> (90.91), <i>B.</i>	<i>teeta</i> (92), <i>B.</i>	<i>teeta</i> (1.5),
<i>teeta</i> Wall./(SI/L/029)/ Ranunculaceae/ Pawah, Ayaro,	Shrub/ Root (dry)+		<i>aristata</i> (57.14), <i>B.</i>	<i>aristata</i> (60), <i>B.</i>	<i>aristata</i> (0.2)
Mishmi <i>teeta</i> + <i>Berberis aristata</i> DC./(SI /L/015)/	Herb/ Whole	~250 gm leaves of <i>A.</i>	<i>pilosa</i> (66.67), <i>F.</i>	<i>pilosa</i> (44), <i>F.</i>	<i>pilosa</i> (0.5),
Berberidaceae/ Tipi-tire+ <i>Bidens pilosa</i> L./ (SI/L/017)/	plant+ Tree/ Root+	<i>nilagirica</i> , ~150 gm	<i>racemosa</i> (40), <i>P.</i>	<i>racemosa</i> (52), <i>P.</i>	<i>racemosa</i> (0.52)
Asteraceae/ Phutium+ <i>Ficus racemosa</i> L./(SI/L/045)/	Shrub/ Root+	rhizome and root of <i>C.</i>	<i>longum</i> (78.57)	<i>longum</i> (49.33)	<i>longum</i> (0.5)
Moraceae/ Phangrok+ <i>Flemingia strobilifera</i> (L.) W.T.	Climber/ Fruit	<i>teeta</i> and <i>B. aristata</i> each,			
Aiton/(SI/L/046)/ Fabaceae /Liang-sukh+ <i>Piper</i>		~50 gm of <i>B. pilosa</i> plant			
<i>longum</i> L./(SI/L/068)/ Piperaceae/ Ahoma		and root of <i>F. racemosa</i>			
		each and 10-15 seeds of <i>P.</i>			
		<i>longum</i> ground together			
		and boiled in 1 L water till			
		concentrated to ½.			
		Given two spoons of this			
		juice twice daily after			
		breakfast for one month			
<i>Artemisia vulgaris</i> L./(SI/L/013)/ Asteraceae/ Damank+	Herb/ Leaves+	High fever (PFs)/ Pill	<i>A. vulgaris</i> (57.14), <i>C.</i>	<i>A. vulgaris</i> (57.33), <i>C.</i>	<i>A. vulgaris</i> (57.33),
<i>Chromolaena odorata</i> (L.) R. King & H.	Shrub/ Leaves+		<i>odorata</i> (66.67), <i>C.</i>	<i>odorata</i> (21.33), <i>C.</i>	<i>odorata</i> (0.5)
Rob./(SI/L/025)/Asteraceae/ Malinga-jumpak+ <i>Coptis</i>	Herb/ Rhizome+	Equal amount of all	<i>teeta</i> (90.91),	<i>teeta</i> (92),	<i>teeta</i> (1.5),
<i>teeta</i> Wall./(SI/L/029)/ Ranunculaceae/ Pawah, Ayaro,	Tree/ Bark (Dry)	ingredients ground	<i>P. javanica</i> (42.86)	<i>P. javanica</i> (50.67)	<i>P. javanica</i> (50.67)
Mishmi <i>teeta</i> + <i>Picrasma javanica</i> Bl./(SI/L/066)/		together and small pea-			
Simaroubaceae/Nisso		sized pills were prepared			
		by sun drying. Two pills			
		are given after breakfast			
		with honey for 20-30 days			

<i>Balakata baccata</i> (Roxb.) Esser/ (SI/L/014)/ Euphorbiaceae / <i>Yaoulu</i> + <i>Coccinia grandis</i> (L.) Voigt/ (SI/L/028)/ Cucurbitaceae / <i>Kundul</i> + <i>Elsholtzia blanda</i> Benth/(SI/L/037)/ Lamiaceae/ <i>Popit-namdung</i> + <i>Rauvolfia</i> <i>serpentina</i> (L.) Benth. ex Kurz/(SI/L/073)/ Apocynaceae / <i>Bhungmarajo</i>	Tree/ Bark+ Climber/ Fruit+ Herb/ Leaves+ Herb/ Root	Nausea (PFs)/ Extraction ~100 gm bark of <i>B.</i> <i>baccata</i> , 250 gm fruit of <i>C.</i> <i>grandis</i> , 5 leaves of <i>E.</i> <i>blanda</i> , ~50 gm root of <i>R.</i> <i>serpentina</i> ground together and fresh juice is given during nausea	<i>B. baccata</i> (66.67), <i>C.</i> <i>grandis</i> (57.14), <i>E.</i> <i>blanda</i> (80), <i>R.</i> <i>serpentina</i> (60)	<i>B. baccata</i> (24), <i>C.</i> <i>grandis</i> (41.33), <i>E.</i> <i>blanda</i> (36), <i>R.</i> <i>serpentina</i> (41.33)	<i>B. baccata</i> (<i>grandis</i> (0.2 <i>blanda</i> (0.5) <i>serpentina</i> (
<i>Berberis aristata</i> DC./(SI/L/015)/ Berberidaceae/ <i>Tipi-tire</i> + <i>Calamus erectus</i> Roxb./(SI/L/020)/Arecaceae / <i>Aruto</i> + <i>Calotropis gigantea</i> (L.) W. T. Aiton/(SI/L/021) /Apocynaceae/ <i>Tupawknung</i> + <i>Centella asiatica</i> (L.) Urb./(SI/L/024)/ Apiaceae / <i>Mawanro</i>	Shrub/ Root (dry)+ Palm/ Root + Shrub/Root+ Herb/ Leaves	Diarrhoea (PFs)/ Decoction ~ 250 gm dry root of <i>B.</i> <i>aristata</i> , ~300 gm fresh root of <i>C. erectus</i> and <i>C.</i> <i>gigantea</i> each, ~150 gm of <i>C. asiatica</i> ground together and boiled in 1L water till concentrated to ½. Filter the juice and given one teaspoon in empty stomach till the disease cured	<i>B. aristata</i> (57.14), <i>C.</i> <i>erectus</i> (75), <i>C.</i> <i>gigantea</i> (60), <i>C.</i> <i>asiatica</i> (80)	<i>B. aristata</i> (42.67), <i>C.</i> <i>erectus</i> (48), <i>C.</i> <i>gigantea</i> (44), <i>C.</i> <i>asiatica</i> (73.33)	<i>B. aristata</i> (<i>erectus</i> (0.2 <i>gigantea</i> (0 <i>asiatica</i> (0.2
<i>Bergenia ciliata</i> (Haw.) Sternb./(SI/L/016)/ Saxifragaceae / <i>Bra-</i> <i>mentock</i> + <i>Euphorbia neriifolia</i> L./(SI/L/042)/ Euphorbiaceae / <i>Changrawng</i> + <i>Fagopyrum</i> <i>esculentum</i> Moench/(SI/L/044) /Polygonaceae/ <i>Chhika</i> + <i>Justicia adhatoda</i> L./(SI/L/050)/ Acanthaceae / <i>Ngamok-phare</i>	Herb/ Root+ Shrub/ Leaves+ Herb/ Grain+ Shrub/ Leaves	Cold and Cough (PFs)/ Extraction ~ 100 gm root and leaves of <i>B. ciliata</i> and <i>E.</i> <i>neriifolia</i> each, one spoon of <i>F.</i> <i>esculentum</i> , 10-20 leaves of <i>J. adhatoda</i> (heated in fire) ground together and filtered extraction given twice a day for 15-20 days	<i>B. ciliate</i> (50), <i>E.</i> <i>neriifolia</i> (90) , <i>F.</i> <i>esculentum</i> m (63.64), <i>J.</i> <i>adhatoda</i> (42.86)	<i>B. ciliate</i> (cold- 29.33, cough-44), <i>E.</i> <i>neriifolia</i> (cold-65.33, cough-64) , <i>F.</i> <i>esculentum</i> m (cough- 49.33), <i>J.</i> <i>adhatoda</i> (cough-70.67)	<i>B. ciliate</i> (0 <i>neriifolia</i> (0 <i>esculentum</i> m <i>adhatoda</i> (0
<i>Bidens pilosa</i> L./(SI/L/017)/ Asteraceae / <i>Phutium</i> + <i>Buddleja asiatica</i> Lour./(SI/L/019)/ Scrophulariaceae/ <i>Feb-</i> <i>shang</i> + <i>Cissampelos pareira</i> L. /(SI/L/026)/ Menispermaceae / <i>Ambasthu</i> + <i>Debregeasia</i> <i>longifolia</i> (Burm. fil.) Wedd. /(SI/L/032)/ Urticaceae / <i>Jirpollee</i> + <i>Dillenia indica</i> L. /(SI/L/033)/ Dilleniaceae / <i>Jaopa</i> + <i>Embelia ribes</i> Burm. Fil. /(SI/L/038) /Primulaceae / <i>Biakol-lata</i>	Herb/ Whole plant+ Shrub/ Root + Climber/ Root+ Shrub/ Tender leaves+ Tree/ leaves+ Shrub/ Fruit	Fever (PFs)/ Pill ~250 gm of <i>B. pilosa</i> , ~50 gm root of <i>B. asiatica</i> and <i>C. pareira</i> each, ~100 gm tender leaves of <i>D.</i> <i>longifolia</i> , <i>D. indica</i> and ~200 gm fruit of <i>E. ribes</i> ground together and small sundry pills were prepared. Given two pills with one spoon of honey in empty stomach till the disease is cured.	<i>B. pilosa</i> (66.67), <i>B.</i> <i>asiatica</i> (70), <i>C.</i> <i>pareira</i> (75), <i>D.</i> <i>longifolia</i> (77.78), <i>D.</i> <i>indica</i> (83.33), <i>E.</i> <i>ribes</i> (57.14)	<i>B. pilosa</i> (44), <i>B.</i> <i>asiatica</i> (60), <i>C.</i> <i>pareira</i> (29.33), <i>D.</i> <i>longifolia</i> (29.33), <i>D.</i> <i>indica</i> (21.33), <i>E.</i> <i>ribes</i> (50.67)	<i>B. pilosa</i> (0 <i>asiatica</i> (0.5 <i>pareira</i> (0.5 <i>longifolia</i> (0 <i>indica</i> (0.5) <i>ribes</i> (0.25)
<i>Dillenia indica</i> L./ (SI/L/033)/	Tree/Fruit+	Loss of appetite	<i>D. indica</i> (83.33), <i>M.</i>	<i>D. indica</i> (72), <i>M.</i>	<i>D. indica</i> (0

Dilleniaceae/ <i>Jaopa</i> + <i>Marsilea minuta</i> L./ (SI/L/055)/	Aquatic herb /	(PFs)/ Curry	<i>minuta</i> (50), <i>P.</i>	<i>minuta</i> (58.67), <i>P.</i>	<i>minuta</i> (0.2)
Marsileaceae/ <i>Kanjai</i> + <i>Piper nigrum</i> DC./ (SI/L/069)/	Leaves+ Climber/		<i>nigrum</i> (75), <i>Z.</i>	<i>nigrum</i> (60), <i>Z.</i>	<i>nigrum</i> (0.7)
Piperaceae/ <i>Marcha</i> + <i>Zingiber officinale</i> Roscoe/	Seed+ Herb/	Raw fruit of <i>D. indica</i> ,	<i>officinale</i> (75)	<i>officinale</i> (64)	<i>officinale</i> (0
(SI/L/079) /Zingiberaceae/ <i>Deing</i>	Rhizome	leaves of <i>M. minuta</i> , 5-10 seed of <i>P. nigrum</i> and small piece of <i>Z.</i> <i>officinale</i> ground together and prepared curry and given to the patient			
<i>Dioscorea floribunda</i> M. Martens & Galeotti/(SI/L/034)	Climber/ Tuber+	Fever (external use)	<i>D. floribunda</i> (72.73),	<i>D. floribunda</i> (29.33),	<i>D. floribunda</i> (0.2)
/Dioscoreaceae/ <i>Mawan</i> + <i>Hypodematum crenatum</i> (Forsk.)	Fern/ Leaves+	(PFs)/ Paste	<i>H. crenatum</i> (77.78), <i>K.</i>	<i>H. crenatum</i> (61.33), <i>K.</i>	<i>crenatum</i> (0.2)
Kuhn/(SI/L/049)/ Hypodematiaceae/ <i>Bhutkesar</i> + <i>Kalanchoe pinnata</i> (Lam.) Pers./ (SI/L/051)/Crassulaceae/ <i>Hurroreshia</i> + <i>Ligularia</i>	Herb/ Leaves+		<i>pinnata</i> (62.50), <i>L.</i>	<i>pinnata</i> (40), <i>L.</i>	<i>pinnata</i> (0.2)
<i>amplexicaulis</i> (Wall.) DC./ (SI/L/054)/Asteraceae/ <i>Rihu</i>	Herb/ Stem (dry)	Small piece of <i>D.</i> <i>floribunda</i> ground with fresh leaves of <i>H. crenatum</i> and <i>K. pinnata</i> and 2-3 inch stem of dry <i>L.</i> <i>amplexicaulis</i> . Prepared paste applied with a little amount of mustard oil and applied on the forehead during fever.	<i>amplexicaulis</i> (55.56)	<i>amplexicaulis</i> (62.67)	<i>amplexicaulis</i> (0.2)
<i>Euphorbia hirta</i> L./ (SI/L/041)/	Herb/ Whole	Fever (PFs)/ Extraction	<i>E. hirta</i> (72.73), <i>L.</i>	<i>E. hirta</i> (64), <i>L.</i>	<i>E. hirta</i> (0.2)
Euphorbiaceae/ <i>Dudhboon</i> + <i>Lantana</i>	plant+ Herb/		<i>camara</i> (71.43), <i>R.</i>	<i>camara</i> (46.67), <i>R.</i>	<i>camara</i> (0.2)
<i>camara</i> L./ (SI/L/052)/ Verbenaceae/ <i>Luanha</i> + <i>Ricinus</i>	Leaves+ Shrub/	~100 gm of <i>E. hirta</i> , 10-15	<i>communis</i> (77.78), <i>S.</i>	<i>communis</i> (36), <i>S.</i>	<i>communis</i> (0.2)
<i>communis</i> L./ (SI/L/074)/	Root+ Shrub/ Fruit	leaves of <i>L. camara</i> , ~50	<i>nigrum</i> (72.73)	<i>nigrum</i> (44)	<i>nigrum</i> (0.2)
Euphorbiaceae/ <i>Changkhro</i> + <i>Solanum nigrum</i> Linn. / (SI/L/076)/ Solanaceae/ <i>Gangko</i> , <i>Kakamachii</i>		gm of fresh <i>R.</i> <i>communis</i> and ~100 gm of fresh fruit of <i>S. nigrum</i> ground together and one spoon of extract given twice daily after meal.			
<i>Eryngium foetidum</i> L. / (SI/L/040)/Apiaceae/ <i>Hariyo</i> + <i>Oxalis corniculata</i> L. / (SI/L/060)/ Oxalidaceae/ <i>Kanjai</i>	Herb/ Leaves+	Vomiting (PFs)/ Pill	<i>E. foetidum</i> (87.5), <i>O.</i>	<i>E. foetidum</i> (18.67), <i>O.</i>	<i>E. foetidum</i> (0.2)
(small)+ <i>Plantago asiatica</i> (Wallich) Z. Y.	Herb/ Whole		<i>corniculata</i> (69.23),	<i>corniculata</i> (48),	<i>corniculata</i> (0.2)
Li/ (SI/L/070)/Plantaginaceae/ <i>Donihana-khang</i> + <i>Punica</i>	plant+ Herb/	An equal quantity of all the	<i>P. asiatica</i> (70), <i>P.</i>	<i>P. asiatica</i> (34.67), <i>P.</i>	<i>P. asiatica</i> (0.2)
<i>granatum</i> L./ (SI/L/072)/ Lythraceae/ <i>Dalemsing</i> + <i>Zingiber</i>	Leaves+ Shrub/	ingredients ground	<i>granatum</i> (44.44), <i>Z.</i>	<i>granatum</i> (53.33), <i>Z.</i>	<i>granatum</i> (0.2)
<i>officinale</i> Roscoe/ (SI/L/079)/Zingiberaceae/ <i>Deing</i>	Unripe fruit+	together with black salt	<i>officinale</i> (75)	<i>officinale</i> (62.67)	<i>officinale</i> (0.2)
	Herb/ Rhizome	and pea-sized pills were prepared. After air dry, they were stored in glass bottles and given whenever necessary.			
<i>Nardostachys jatamansi</i> (D. Don) DC./ (SI/L/057)	Herb/ Rhizome	Nausea (PFs)/ Extraction	<i>N. jatamansi</i> (72.73), <i>P.</i>	<i>N. jatamansi</i> (72.73), <i>P.</i>	<i>N. jatamansi</i> (0.2)
/Caprifoliaceae/ <i>Pangposh</i> + <i>Plantago asiatica</i> (Wallich) Z.	(dry)+ Herb/		<i>asiatica</i> (70), <i>T.</i>	<i>asiatica</i> (70), <i>T.</i>	<i>asiatica</i> (0.5)
Y. Li/ (SI/L/070)/ Plantaginaceae/ <i>Donihana-khang</i> + <i>Tinospora cordifolia</i> (Willd.)	Leaves+ Climber/	~100 gm dry rhizome of <i>N.</i>	<i>cordifolia</i> (85.71)	<i>cordifolia</i> (85.71)	<i>cordifolia</i> (0.2)
Miers/(SI/L/078) /Menispermaceae/ <i>Swein kije</i>	Bark	<i>jatamansi</i> , 5-10 fresh leaves of <i>P. asiatica</i> , ~50 gm of <i>T. cordifolia</i> bark			

ground with one cup of
water and the filtered
extract is given freshly
during nausea

<i>Perilla frutescens</i> (L.) Britton /(SI/L/064)/ Lamiaceae / <i>Namdung+ Euphorbia</i> <i>royleana</i> Boiss. /(SI/L/043)/ Euphorbiaceae / <i>Changrong+ Scoparia dulcis</i> L./ (SI/L/075)/ Plantaginaceae / <i>Roukrit</i>	Herb/ Leaves+ Shrub/ Stem+ Herb/ Leaves	Cold (PFs) (external use)/ Paste Both the leaves of <i>P.</i> <i>frutescens</i> and stem of <i>E.</i> <i>royleana</i> in equal amount preheated in oven and ground with 3-4 leaves of <i>S. dulcis</i> leaves and paste is applied on the chest and feet.	<i>P. frutescens</i> (42.86), <i>E. royleana</i> (62.5), <i>S.</i> <i>dulcis</i> (72.73)	<i>P. frutescens</i> (29.33), <i>E. royleana</i> (48), <i>S.</i> <i>dulcis</i> (36)	<i>P. frutescens</i> <i>royleana</i> (0. <i>dulcis</i> (0.25
<i>Cissampelos pareira</i> L./ (SI/L/026) / Menispermaceae / <i>Ambasthu+ Coptis teeta</i> Wall./(SI/L/029)/ Ranunculaceae / <i>Pawah, Ayaro, Mishmi</i> <i>teeta+ Dactylorhiza hatagirea</i> (D.Don) Soó/(SI/L/031)/ Orchidaceae / <i>Salep, Wanpolagpa+ Fagopyrum esculentum</i> Moench/ (SI/L/044)/ Polygonaceae / <i>Chhika+ Garcinia</i> <i>pedunculata</i> Roxb./ (SI/L/047)/ Clusiaceae / <i>Tabing-asing+ Holarrhena pubescens</i> (Buch.-Ham.) Wall. ex G. Don/(SI/L/048)/ Apocynaceae / <i>Dudhkuri</i>	Climber/ Root+ Herb/ Rhizome+ Orchid/ Rhizome + Herb/ Grain+ Tree/fruit+ Tree/ Bark (Dry)	Diarrhoea (PFs)/ Decoction ~100 gm fresh root and rhizome of <i>C. pareira</i> and <i>C. teeta</i> , 20 gm rhizome of <i>D. hatagirea</i> , starch of <i>F.</i> <i>esculentum</i> , ~50 gm dry fruit of <i>G. pedunculata</i> and dry bark of <i>H.</i> <i>pubescens</i> each ground together and boiled in 1L water and concentrated to 1/4. Two spoon of this decoction juice given twice daily after food till it cured	<i>C. pareira</i> (75), <i>C. teeta</i> (90.91), <i>D. hatagirea</i> (71.43), <i>F. esculentum</i> (63.64), G. <i>pedunculata</i> (66.67), <i>H.</i> <i>pubescens</i> (88.89)	<i>C. pareira</i> (62.67), <i>C. teeta</i> (68), <i>D. hatagirea</i> (50.67), <i>F. esculentum</i> (57.33), G. <i>pedunculata</i> (42.67), <i>H.</i> <i>pubescens</i> (41.33)	<i>C. pareira</i> (6 <i>C. teeta</i> (1.5 <i>D. hatagire</i> <i>esculentum</i> <i>pedunculata</i> <i>pubescens</i> (
<i>Oxalis corniculata</i> L./(SI/L/060)/ Oxalidaceae / <i>Kanjai</i> (small)+ <i>Paederia foetida</i> L./(SI/L/061)/ Rubiaceae / <i>Yepe-</i> <i>tere+ Paris polyphylla</i> Sm./(SI/L/063)/ Melanthiaceae / <i>Dipogoiak+ Piper nigrum</i> DC./(SI/L/069)/ Piperaceae / <i>Marcha+ Zingiber officinale</i> Roscoe/ (SI/L/079) / Zingiberaceae / <i>Deing</i>	Herb/ Whole plant+ Climber/ Leaves+ Herb/ Rhizome+ Climber/ Seed+ Herb/ Rhizome	Diarrhoea (PFs)/ Extraction ~250 gm of <i>O. corniculata</i> ground with ~100 gm leaves and rhizome of <i>P.</i> <i>foetida</i> and <i>P.</i> <i>polyphylla</i> , ~25 gm seed of <i>P. nigrum</i> , 4-5 inch sized <i>Z. officinale</i> . The extract is filtered and given in empty stomach with curd/yogurt for 20 days	<i>O. corniculata</i> (69.23), <i>P. foetida</i> (71.43), <i>P.</i> <i>polyphylla</i> (91.67), <i>P.</i> <i>nigrum</i> (75), <i>Z.</i> <i>officinale</i> (75)	<i>O. corniculata</i> (56), <i>P.</i> <i>foetida</i> (77.33), <i>P.</i> <i>polyphylla</i> (69.33), <i>P.</i> <i>nigrum</i> (54.67), <i>Z.</i> <i>officinale</i> (64)	<i>O. corniculata</i> <i>foetida</i> (0.25 <i>polyphylla</i> (<i>nigrum</i> (0.7 <i>officinale</i> (0
<i>Oroxylum indicum</i> (L.) Kurz/ (SI/L/059)/ Bignoniaceae / <i>chayoonaka+ Swertia</i> <i>chirata</i> (Roxb.) Karst./ (SI/L/077)/ Gentianaceae / <i>Puwtik-</i>	Tree/ Bark +Herb/ Whole plant+ Herb/ Rhizome (dry)	Shaking chill with fever (PFs)/ Pill	<i>O. indicum</i> (66.67), <i>P.</i> <i>kurroa</i> (75), <i>S. chirata</i> (76.92)	<i>O. indicum</i> (40), <i>P.</i> <i>kurroa</i> (62.67), <i>S. chirata</i> (60)	<i>O. indicum</i> <i>kurroa</i> (0.5) <i>S. chirata</i> (0

<i>titta+ Picrorhiza kurroa</i> Royle/ (SI/L/067)/ Plantaginaceae/ <i>Honglen</i>		~100 gm fresh bark of <i>O. indicum</i> from the southern part of the tree, ~50 gm of fresh <i>S. chirata</i> and ~50 gm of dry rhizome of <i>P. kurroa</i> ground together and pea sized pills were prepared and allow to sundry. Two pills thrice a day after food is given 2-3 months			
<i>Artemisia nilagirica</i> (C.B. Cl.) Pamp./ (SI/L/012)/ <i>Asteraceae/ Illumu/Shaa+ Holarrhena pubescens</i> (Buch.-Ham.) Wall. ex G. Don/(SI/L/048)/ Apocynaceae <i>/Dudhkuri+ Paris polyphylla</i> Sm./ (SI/L/063)/ Melanthiaceae/ <i>Dipogoia</i> k	Herb/Leaves + Tree/ Bark (Dry)+ Herb/ Rhizome	High fever (PFs)/ Decoction ~250 gm leaves of <i>A. nilagirica</i> , ~100 gm dry bark of <i>H. pubescens</i> , ~200 gm rhizome of <i>P. polyphylla</i> ground together and boiled in 1L water till concentrated to 1/4. Two spoon twice daily after food given to the patient for one month	<i>A. nilagirica</i> (62.5), <i>H. pubescens</i> (88.89), <i>P. polyphylla</i> (91.67)	<i>A. nilagirica</i> (77.33), <i>H. pubescens</i> (49.33), <i>P. polyphylla</i> (76)	<i>A. nilagirica</i> (77.33), <i>H. pubescens</i> (49.33), <i>P. polyphylla</i> (76)
<i>Artemisia vulgaris</i> L./ (SI/L/013)/ <i>Asteraceae/ Damank+ Coptis teeta</i> Wall./ (SI/L/029)/ <i>Ranunculaceae/ Pawah, Ayaro, Mishmi teeta</i>	Herb/ Leaves+ Herb/ Rhizome	Shaking chill with fever (DFs)/ Powder Both in equal quantity ground together in powder form and given with honey to the patient thrice daily for one month	<i>A. vulgaris</i> (57.14), <i>C. teeta</i> (90.91)	<i>A. vulgaris</i> (57.33), <i>C. teeta</i> (92)	<i>A. vulgaris</i> (57.33), <i>C. teeta</i> (92)
<i>Carica papaya</i> L./ (SI/L/022)/ <i>Caricaceae/ Phumtoh+ Carum carvi</i> L./ (SI/L/023)/ <i>Apiaceae /Tuoma</i>	Shrub/ Fruit+ Herb/Seed	Loss of appetite (DFs)/ Curry Raw fruit of <i>C. papaya</i> used to prepare boil curry with <i>C. carvi</i> and given to the patient	<i>C. papaya</i> (57.14), <i>C. carvi</i> (62.5)	<i>C. papaya</i> (56), <i>C. carvi</i> (38.67)	<i>C. papaya</i> (56), <i>C. carvi</i> (38.67)
<i>Argyreia nervosa</i> (Burm. fil.) Bojer (SI/L/011)/ Convolvulaceae/ <i>Hemlata+ Euphorbia royleana</i> Boiss. <i>/ (SI/L/043)/Euphorbiaceae/ Changrong</i>	Climber/Root+ Shrub/ Stem	Anaemia (DFs)/ Paste Equal quantity of <i>A. nervosa</i> root and <i>E. royleana</i> stem were ground and one spoon of this	<i>A. nervosa</i> (75), <i>E. royleana</i> (62.5)	<i>A. nervosa</i> (37.33), <i>E. royleana</i> (16)	<i>A. nervosa</i> (37.33), <i>E. royleana</i> (16)

The highest number of medicinal formulations were reported in Karhe village (12), followed by Telluliang (10) and Zero Basti (7). Most of the herbaceous species (48.10%) were widely used in different formulations followed by shrubs (21.52%), trees and climber (12.66% each) and ~5 % contributed by palm, orchid and ferns. The highest number of medicinal formulations were reported in Karhe village (12), followed by Telluliang (10) and Zero Basti (7). Most of the herbaceous species (38 plants) (48.10%) were widely used in different formulations followed by shrubs (17 plants) (21.52%), trees and climber (10 plants each) (12.66%) and ~5 % contributed by palm, orchid and ferns. Higher usages of herbs, indicate their maximum availability in the study area compare to other growth forms and also might be due to their maximum efficacy against the diseases [20] and easy collection process. Similar reports also found from the other parts of the world [23, 26]. Leaves (24) (30.38 %) were the most commonly used plant parts in herbal formulations followed by seventeen plants (21.52%) for their root, eight plants (10.13%) for the whole plant, rhizome and fruit, seven plants (8.86%) for bark. As leaves are the main photosynthetic organ in plants, hence they are phytochemically rich in many active compounds. Adding more to this, the collection process is convenient than the others, which makes it a key ingredient in many formulations [23]. The reported lifeforms and application of plant parts used for the herbal formulation are shown in Fig. 2.

Reported species were belonging to 50 families and 71 genera. The most predominant plant families were Asteraceae and Euphorbiaceae (6) family, followed by Lamiaceae (5), Apocynaceae (4), Apiaceae and Plantaginaceae (3), Ranunculaceae, Zingiberaceae, Acanthaceae, Menispermaceae, Verbenaceae, Dioscoreaceae, Fabaceae and Piperaceae (2) (Fig. 3). The remaining families contributing ≤ 1 species in preparation of herbal formulation. Dominance of Asteraceae and Euphorbiaceae families might be due to the wide range of distribution of plant species in Northeast India [27]. The Asteraceae family is of great importance as it includes a huge range of medicinal plants used in curing ailments like inflammatory diseases, malaria, and tuberculosis [28]. Knowledge and preference of using these plant families against malarial have been passing from one generation to the next generation. Also, it was observed that herbal practitioners were very much aware of the plant families, having specific groups of phytochemicals in plant parts possessing antimalarial properties.

The majority of the formulations were prescribed for internal application (83.54%) and less favored for external use (16.46%). However, in both the cases, wild plants (87.34%) accounts for a higher application rate compare to the cultivated one (12.66%) (Fig. 4).

Extraction (8 formulation) (25.81%), decoction (7 formulation) (22.58%), paste and pills (5 formulation for each) (16.13 %) were some of the ancient preparation methods, signifying the fact that application of heat in herbal formulations stimulates the maximum ability of active compounds by accelerating biological reactions [29]. Plant ingredients were also applied as oil (6.9%) for massaging body and forehead, which is again a prominent part of herbal therapy, enhancing the blood circulation, reducing pain and boosting immune system. In many formulations, it was observed that some additive/items viz. honey, jaggery, curd, milk, oil were added to enhance the efficacy of the medicine along with maintaining a complementary taste/aroma. Among twenty nine herbal formulations, twelve formulations were specifically for curing malaria fever including 38 species for both oral and external application. In many formulations, application of a particular species was reported to cure more than one ailment. For example, *Berberis aristata*, *Coptis teeta*, *Paris polyphylla*, *Holarrhena pubescens* were used extensively in various formulations of both malaria fever and diarrhoea. From all the three villages, nineteen plants were reported for curing diarrhoea, thirteen for cold, eleven for cough, seven for nausea, six for loss of appetite, five for body pain and vomiting each and four for headache. As a post malarial treatment, patients were given oral herbal medicine for liver strengthening and anaemia, which helped to recover the patients faster. Mode of administration of herbal formulations against different ailments is shown in Fig. 5.

Quantitative analysis of FL, PR, UV, ICF and FS

The highest fidelity value ($\geq 80\%$) was reported for *Aconitum heterophyllum* (93.33%) followed by *Paris polyphylla* (91.67%), *Coptis teeta* (90.91%), *Euphorbia neriifolia* (90%), *Holarrhena pubescens* (88.89%), *Tinospora cordifolia* (85.71%), *Dillenia indica* and *Andrographis paniculata* (83.33%), *Centella asiatica* (80%) (Table 1). IUCN Red list categorized endangered *A. heterophyllum* is a terrestrial herb endemic to the foothills of Himalayas [13]. Tuberous roots of *A. heterophyllum* have been traditionally used in Ayurveda and a verified vital constituent in many Chinese and Japanese traditional medicines [30]. The species has been reported to contain antifungal, antiviral, anti-inflammatory and immune-stimulant properties, which helps to cure diarrhea, dysentery, cough, dyspepsia, and chronic enteritis and used in many parts of Bhutan, China and India [31]. PR indicates the respondent's satisfaction towards a species for its effectiveness against a disease which reveals in their scoring between 5 and 1. The output of PR showed, the highest value received by *C. teeta* (PR=92%), followed by *T. cordifolia* (PR=78.67%), *A. nilagirica* (PR=77.33%), and *P. polyphylla* (PR=76%) for curing malaria fever. Species like *P. foetida* (PR=77.33%), *C. asiatica* (PR=73.33%), *P. polyphylla* (PR=69.33%), *C. teeta* (PR=68%) were among the highly scored PR plants to cure diarrhoea. Plants scoring $\geq 65\%$ against different ailments in PR ranking tabulated in Table 2. It has been observed that highly ranked PR and FL species, selected for the curing the malaria were mostly bitter, viz., roots of *A. heterophyllum*, rhizome of *C. teeta* and *P. polyphylla*, leaves of *T. cordifolia*, *A. paniculata*, and *A. nilagirica*. In local belief, bitterness acts like an antidote, which helps to kill the germs in the blood stream and cure malaria from its root cause. The similar concept of herbal drug use seems to be followed by many tribal societies throughout the globe [32].

Table 2: Preference ranking of ethnomedicinal plants scoring $\geq 65\%$ against different ailments.

Ethnomedicinal plants	Village-1					Village-2					Village-3					Total score	%
	Karhe					Zero basti					Telluliang						
	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E		
Malaria fever																	
Artemisia nilagirica	5	3	4	5	4	3	4	4	3	5	5	3	1	4	5	58	77.33
Coptis teeta	5	4	5	5	4	5	5	4	5	5	5	3	5	4	5	69	92.00
Paris polyphylla	3	2	5	3	2	5	4	5	4	4	3	5	4	5	3	57	76.00
Tinospora cordifolia	3	4	4	3	4	5	3	5	5	4	3	5	4	4	3	59	78.67
Diarrhoea																	
Centella asiatica	4	2	5	3	2	5	5	2	5	2	3	4	4	5	4	55	73.33
Coptis teeta	3	5	5	3	5	4	2	4	3	3	4	2	3	0	5	51	68.00
Paederia foetida	5	5	3	5	2	3	5	5	4	3	3	3	4	4	4	58	77.33
Paris polyphylla	5	4	3	5	5	3	4	4	4	4	3	1	2	2	3	52	69.33
Cold																	
Euphorbia neriifolia	3	3	4	4	5	0	2	4	4	3	2	5	2	4	4	49	65.33
Nausea																	
Tinospora cordifolia	4	5	4	3	5	4	0	4	3	3	4	4	3	0	5	51	68.00
Loss of appetite																	
Dillenia indica	4	3	5	4	4	3	5	5	5	2	3	1	4	3	3	54	72.00
Body pain																	
Euphorbia neriifolia	4	5	3	4	3	4	5	2	3	2	0	5	3	4	3	50	66.67

Endemic *C. teeta* (locally popular as *Mishmi teeta*) is one of the most significantly used traditional herbs among the *Mishmi* community of A.P. As a representative of the total population, India (A.P.) harbor about 90% of this species and the remaining population is confined to China (Yunnan). The wide utility of this species in traditional Chinese medicine and in other South Asian countries, has created a high market demand of this species, which leads to unregulated collection [33]. As a consequence, the population has declined over 60%, leading *C. teeta* in the IUCN Red List category as endangered species (A2cd ver 3.1) and included in Category II of CITES [34]. Similarly, *P. polyphylla* is another most demanding and widely used traditional herbal medicine in Bhutan, India, China, Nepal, Thailand and Vietnam. Though the species has not been enlisted in global IUCN Red List, but the inclusion of species in CITES Appendix II (Art. IV 2.a) indicates the overharvesting and decline of its population in China, India, and Nepal due to commercial trade [35]. Use of *A. nilagirica* has previously reported from A.P. by *Galo* tribe and *Monpa* tribe [36] *Adi* and *Nishy* tribe [37] and Hill *Miri* tribe [9]. Present study adding new reports on its utilization for curing malaria and associated symptoms. *Euphorbia neriifolia* has identified as the highest PR species for curing cold (65.33%) and body pain (66.67%) during malaria. Previous reports also reveal the wide utility of *E. neriifolia* against cold and cough [38]. *Miju-Mishmi* people have also learned to apply the herbs to massage the body, including species viz., *E. neriifolia*, *A. nervosa*, *C. tigilium*, *D. pentaphylla*, *E. phaseoloides*. It is believed that, along with the oral administration, body massaging with certain herbs helps to reduce the body temperature, releasing sweats and relaxing the body muscles [39]. The UV index of the reported medicinal species ranges between 0.07 to 0.87. The highest UV was reported for *C. teeta*, (UV=0.87) followed by *P. polyphylla*, *P. nigrum*, *Z. officinale* (UV=0.80, for each species), *T. cordifolia*, *P. longum*, *O. indicum* (UV=0.73, for each species), *A. paniculata*, *M. minuta*, *O. corniculata* (UV=0.67, for each species). These outcomes demonstrate the local availability of above mentioned species and their profound cognizance of indigenous peoples, which makes extensive use of those species in different herbal formulations. The native species of *Mishmi* Hills, i.e. *Mishmi teeta* or *C. teeta* used to cure eye diseases, jaundice, skin problem, stomach disorder, constipation, urine disorders, typhoid and tuberculosis [33]. From very ancient time, spices king *P. nigrum* or black piper and *Z. officinale*, has been extensively used in Ayurveda, Siddha, Unani medicine to cure cold, cough, asthma, nausea, vomiting, loss of appetite, constipation, indigestion [40, 41]. Similarly, *A. paniculata*, *M. minuta*, *O. corniculata* and *T. cordifolia* has wide utility as vermifugal, analgesic, antibacterial, heart diseases, leprosy, arthritis, antiviral, hepatoprotective, diabetes, and hepatitis [26, 42].

To determine the ICF, the reported ailments were classified into eleven categories, viz., malaria fever, diarrhea, cold, cough, nausea, loss of appetite, vomiting, body pain, headache, liver strengthening and anaemia, based on their use reports (Table 3). The ICF value ranged between 0.33 to 0.59. Informants cited a total of 38 plant species use-reports, solely for curing malaria fever (ICF=0.59), followed by 19 use-reports for diarrhoea problems (ICF=0.47), 13 and 11 use-reports for cold (ICF=0.43) and cough (ICF=0.44) respectively. Least ICF value was recorded for nausea (ICF=0.33). Species were also ranked according to their formulation scoring (FS), i.e. the number of times a particular species used in various formulations for curing different ailments. Highest FS score achieved by the *C. teeta* (FS=1.5) followed by *Artemisia vulgaris* (FS=1.0), *Allium sativum*, *Argyrea nervosa*, *Euphorbia royleana*, *Zingiber officinale* (FS=0.75 for each species). *C. teeta* has been reported to use by different local communities of Northeast India for curing malaria, diarrhea [33]. Species like *Allium sativum*, *Argyrea nervosa*, *Euphorbia royleana*, *Zingiber officinale* were very common in the study area and local people have learned to utilize those in di and poly-herbal formulations, contributing more efficacies towards curing a particular disease. Therefore, it is necessary to identify the plant species and their plant parts along with their phytochemical screening, which would be helpful for cross-verification of traditional knowledge of local *Miju-Mishmi* people against malaria.

Table 3: Informant Consensus Factor (ICF) of plant species reported against malaria and associated symptoms.

Disease Categories	Nt	Nur	Nur-Nt	Nur-1	Fic
Malaria fever	38	91	53	90	0.59
Diarrhoea	19	35	16	34	0.47
Cold	13	22	9	21	0.43
Cough	11	19	8	18	0.44
Nausea	7	10	3	9	0.33
Loss of appetite	6	11	5	10	0.50
Vomiting	5	10	5	9	0.56
Body pain	5	8	3	7	0.43
Headache	4	7	3	6	0.50
Anaemia	2	3	1	2	0.50
Liver strengthening	3	4	1	3	0.33

Seasonal availability and market price of the highest scoring (PR and FL) plants were recorded (Fig. 6). Local market price for different herbs varies according to their seasonal availability, their forms (raw/fresh or dry form), demand in the market depending on their status (common or rare). The herb sellers stated that seasonal and highly demanding species are generally stored in dry form whenever available and bought to the market during offseason to get good returns. Species like *A. heterophyllum*, *P. polyphylla* and *C. teeta* are gathered from the jungle, which is very difficult to collect from those hilly terrains. All three species are exported to regional, national and international markets with high prices because of their high medicinal efficacy and wide utility in traditional medicine of Japan, China, Vietnam, Laos, and Vietnam. Although, all these three species are declared as endangered by IUCN, but because of high market demand, the species have been illegally harvested from the forest and sold to the market since long [43]. However, now some traditional healers and herb sellers have started growing these species in their lands and making them available both in fresh and dry form. The mainstream players in this chain included herb sellers mostly local harvesters, brokers, and formal vendors. Local herb sellers claimed that brokers are the highest benefiter as they buy the herbs from the local market with minimal price and exported to other countries at a high international market price. Therefore, now-a-days, local herb sellers also raised their prices in the local market ranges 1500-3000 INR per kg for the above three species. They have also mentioned that the current price of *A. nilagirica* (1500-3500 INR/kg), *A. paniculata* (1000-2500 INR/kg), *H. pubescens* has also increased (1700-3000 INR/kg) in the local market, as they are widely used in many traditional and Ayurvedic medicine within India and abroad. Some locally available plant parts, viz. the fruit of *D. indica*, leaves of *P. foetida*, tender twig of *T. cordifolia*, and leaves of *C. asiatica* were usually sold in the fresh form at the vegetable market in their respective seasons. Besides their medicinal uses, *Miju-Mishmi* people mostly prepared curry from those plant parts and also available in local markets only at a very affordable price.

Preliminary phytochemical screening of extracts

Phytochemical screenings of selected plants' parts were found to contain carbohydrates, alkaloids, flavonoids, terpenoids, tannin, saponins, proteins, phenolic compounds and glycosides, having valuable therapeutic index (Table 4).

Table 4: Preliminary qualitative phytochemical screening of selected ethnomedicinal plants (Plants scoring $\geq 65\%$ in PR and $\geq 80\%$ in FL)

Phyto-constituents	Test Name	Extraction procedure	<i>heterophyllum</i> (Root)	<i>A. paniculata</i> (Leaves)	<i>A. nilagirica</i> (Leaves)	<i>C. asiatica</i> (Leaves)	<i>C. teeta</i> (Rhizome)	<i>D. Indica</i> (Fruit)	<i>E. neriifolia</i> (Leaves)	<i>H. pubescens</i> (Bark)	<i>J. adhatoda</i> (Leaves)	<i>P. foetida</i> (Leaves)	<i>P. po.</i> (Rl)
Alkaloids	Wagner's test	2-3ml extract+ 1 ml of dil. HCl+ Wagner's reagent (I ₃ K +KI)	+	+	+	-	+	+	+	+	+	+	
Flavonoid	Cyanidin Test	2 ml extract + 2 -3 drops conc. HCl+2 pcs Magnesium ribbon	-	+	+	-	+	+	+	+	-	+	
Terpenoid	Salkowski test	2ml extract + 2ml CHCl ₃ + 2-3 drops conc. H ₂ SO ₄	+	-	+	+	-	+	+	+	+	+	
Saponin	Foam test	5ml extract + 5ml H ₂ O + heat	+	+	+	+	-	-	+	+	+	-	
Tannin	Ferric chloride test	2 ml extract + 20ml H ₂ O (hot) + 2-3 drops FeCl ₃ (5%)	+	-	+	-	-	+	+	+	+	+	
Carbohydrates	Molisch's test	2ml extract + 2-3 drops alcoholic α-naphthol (1%) +2ml H ₂ SO ₄ (conc.)	+	+	-	+	-	+	+	+	+	+	
Glycosides	Keller-Kiliani test	2 ml extract +one drop 5% FeCl ₃ + 1 ml conc. H ₂ SO ₄ .	-	-	-	+	+	-	+	-	+	-	
Protein	Xanthoproteic test	2 ml extract+	+	+	+	+	-	-	+	+	-	+	

		2ml of										
		conc.										
		HNO ₃ +1										
		ml 6M										
		NaOH										
Phenols	Folin-	2 ml of	-	+	+	+	-	+	-	+	+	+
	Ciocalteu test	extract+ 2-										
		3 drops of										
	Folin-											
	Ciocalteu											
	reagent+2-											
		3 drops of										
		Na ₂ CO ₃										

Keys: (+) presence, (-) absence

Previous studies have shown that plant-based alkaloid groups exhibit diverse biological activities, as they form structurally diversified compounds of nitrogen atom in the heterocyclic ring, which are derived from the amino acids [25]. A known alkaloid, coptisine belonging to the protoberberine class was derived from *Coptidis* rhizome, a herb frequently used in many traditional formulas for anti-malaria properties. Beside alkaloids, genus coptis has also reported to contain flavonoids, glycosides of various types, which are having anti-tumour, anti-microbial, anti-inflammatory, antioxidant, nematocide, anti-coronary, anti-diarrheal, antiandrogenic properties [44,33]. Phytochemical investigation of an alkaloidal extract of *H. pubescens* roots has shown the isolation of a new pregnene-type alkaloid, mokluangin, along with nine other steroidal alkaloids [45]. Flavonoids are one of the important groups of plant secondary metabolites, which received considerable attention because of their antiviral, antiplasmodial, and antibacterial activity. Species like *A. paniculata* (whole plant), *A. nilagirica* (leaves), *C. teeta* (rhizome), *D. indica* (fruit), *E. nerifolia* (leaves), *H. pubescens* (bark), *P. foetida* (leaves), *P. polyphylla* (rhizome), *T. cordifolia* (leaves) were found to have flavonoids in the present study. Previous reviews have also elucidates the potential antiplasmodial role of flavonoids. The efficiency of some monoterpenes and sesquiterpenes on *Plasmodium falciparum* and *Plasmodium berghei* as potential antimalarial drugs has also been reported [46] The plant extracts containing saponin have been documented as a stimulating agent and a tonic in Chinese and Japanese herbal medicine [47]. Among secondary metabolites, phenolic compounds have shown diverse chemical structures ranging from simple to more complex polymerized compounds and therefore, showing different activities like anti-allergic, antioxidant, anti-carcinogenic, anti-inflammatory, cardioprotective, anti-arthritis [48]. Previous studies demonstrate that the phenolic compound found in *A. nilagirica* has substantial anti-cancerous and antioxidative activity [49]. Also, these phenolic compounds show antioxidative and antibacterial properties, when extracted from various parts of *A. paniculata* [50], *C. asiatica* [51], *J. adhatoda* [52], *P. foetida* [53], *P. polyphylla* [35]. *H. pubescens* along with antidiabetic activity [54]. In *T. cordifolia*, pharmacological activities of phenolic compounds have shown antifungal, anticancer, antioxidant, and antimicrobial properties [55]. It is considered that because of the presence of these essential secondary metabolites, most of the plants are widely used in the Indian system of medicine (ISM) since long and hence also popularity reflex among the ethnic tribe of different corners of India.

As this was a human information based and survey oriented study, therefore, there were certain problems encountered during field work. Because of the hilly terrain and humid sub-tropical climate, conducting field study for sample collection during the monsoon season was difficult. The local participants including guides were also unwilling to visit the field during this period. Some respondents were over approaching during the interview, while some others were more reluctant. Initially, herb sellers and traditional healer were not interestest to disclose their herbal formulation. Some of them did not participated, even after describing the objectives of the study.

Conclusions

Indigenous *Miju-Mishmi* people of Arunachal Pradesh have been following the culture of ethnomedicinal practice for the treatment of malaria and are transmitted from one generation to the next by verbal instructions. The knowledge of medicinal plant collection, processing and preparation of herbal formulations has been confined to old age people only. At this point, a thoughtful documentation and preservation of this incredible treasure of traditional knowledge is very crucial for future generations and scientific importance as well. The present investigation reveals the use of a total of seventy-nine medicinal plants, of which twenty-four plants were reported to be newly used to cure malaria. The wide utility of some endemic and threatened species has also been reported, viz. *Paris polyphylla*, *Coptis teeta*, *Aconitum heterophyllum*. Despite their ecologically sensitive status, the high efficacy of these plants brings them high market demand and hence local traders knowingly or unknowingly collecting those species in an unscientific way. In this situation, the implementation of regeneration techniques and sustainable harvesting is required to conserve and protect these important species. Also, there is an enormous probability of getting many active constituents responsible against malaria from these indigenous plants found in *Mishmi* Hills. Preliminary qualitative phytochemical profiling of selected plants has already confirmed their therapeutic efficacy against malaria and other associated symptoms. Compound showing significant activity should be screened for antiplasmodial activity by *in vitro* and *in vivo* standard tests to justify the scientific validation of tribal claims. Finally, the information established in the present work would convince the pharmaceutical and herbal drug industries for the exploration of highly effective antimalarial leads that will be persistent with maximum precision for synergistic effect against *Plasmodium* species.

Declarations

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Authors' contributions

ST involved in project designing, field data collection with the help of local people, data analysis and preparing final draft of the manuscript. The author read and approved the final manuscript.

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Availability of data and materials

All data have been already included in this manuscript. The voucher specimens of this study are stored in Arunachal University of Studies, Namsai, A.P., India.

Ethics approval and consent to participate

The present study is purely based on the traditional knowledge of medicinal plants use. Therefore, prior informed consent was taken from informants/participants regarding data collection and publication.

Consent for publication

Not applicable.

Competing interests

The author declare that there is no conflict of interest.

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Figures

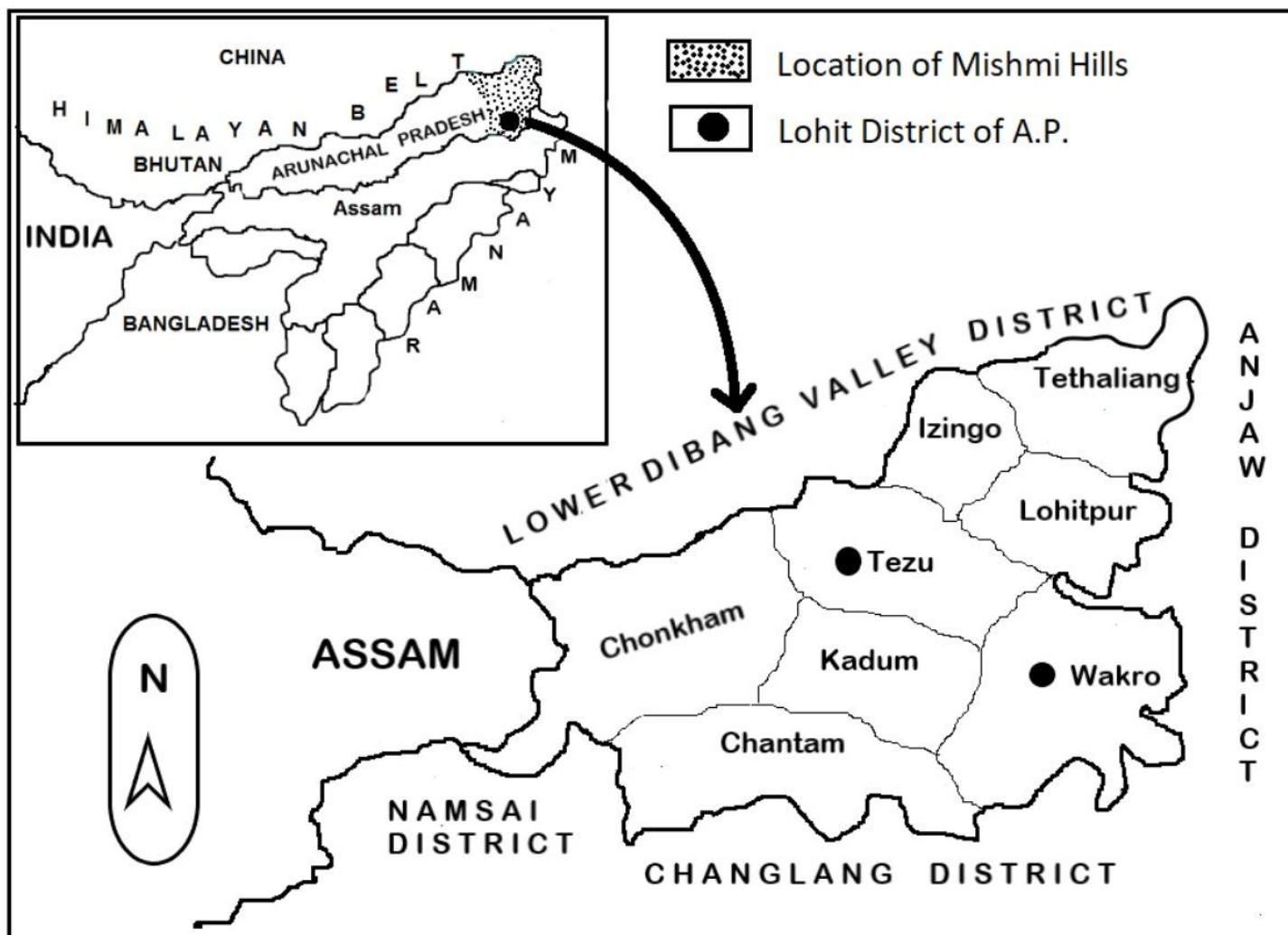


Figure 1

Map of Lohit district showing Tezu and Wakro circle of A.P. (Maps are not to scale). Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

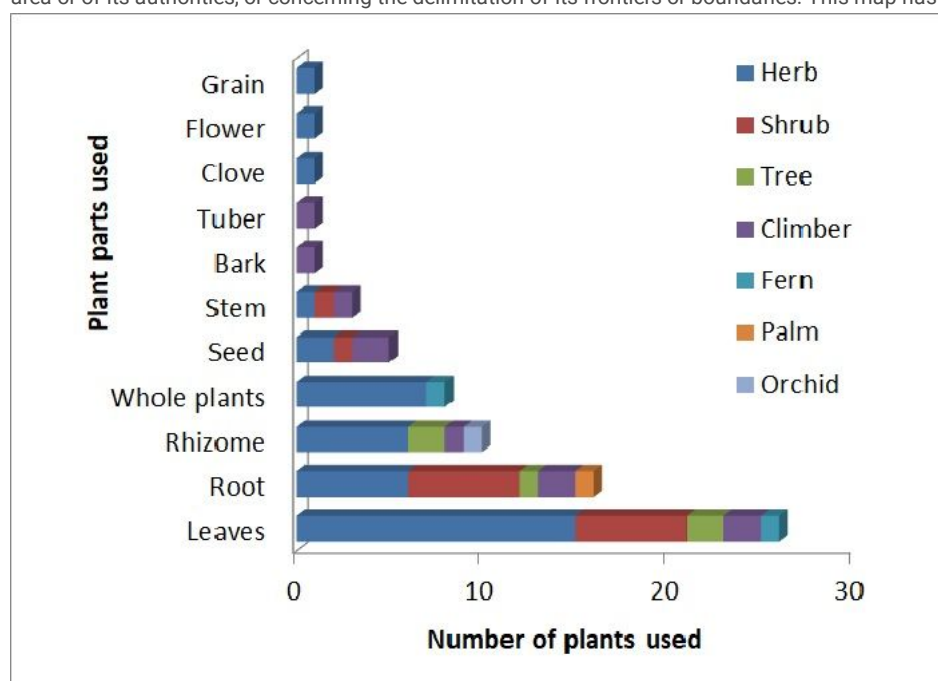


Figure 2

Lifeforms and plant parts used for herbal formulation preparation

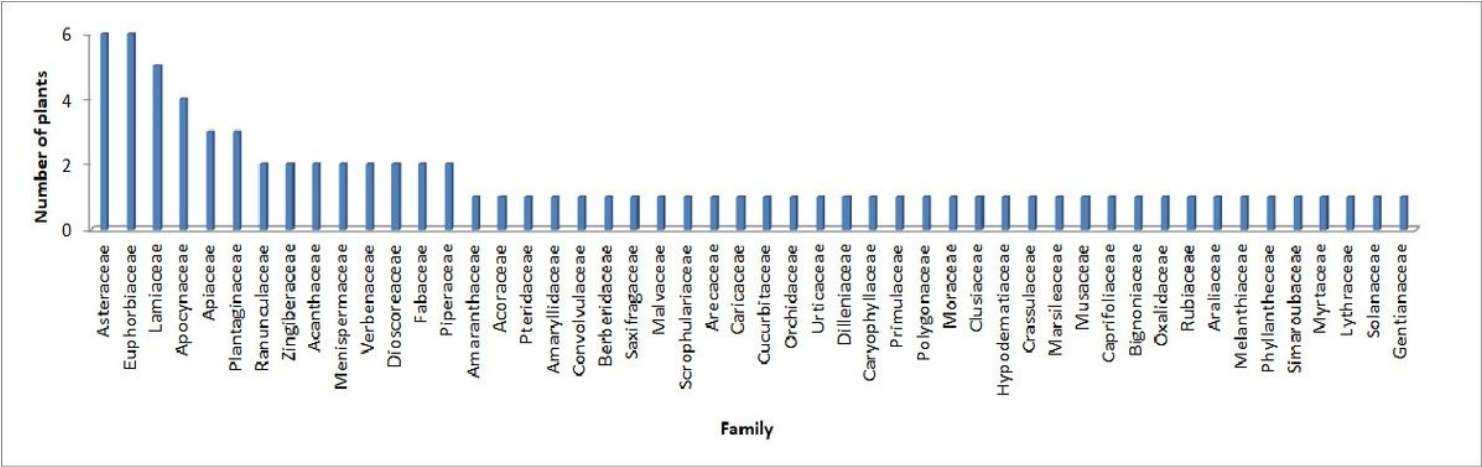


Figure 3

Number of plants belonging to different families

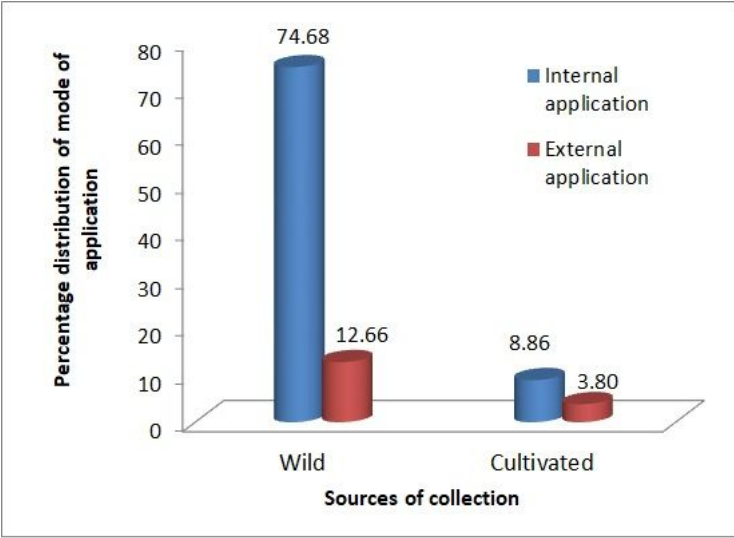


Figure 4

Percentage distribution of various mode of application of medicinal plants collected from different sources

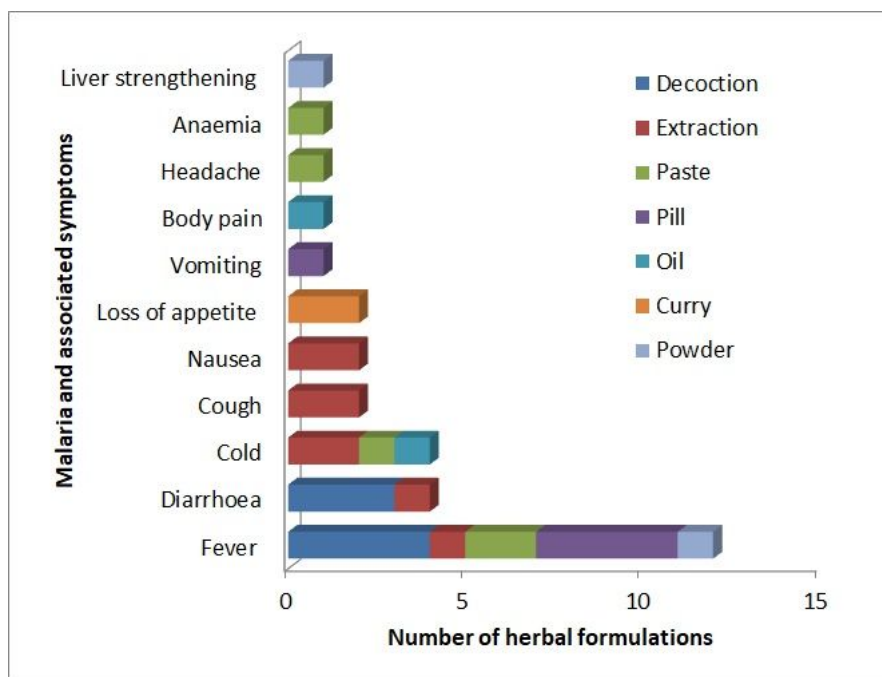


Figure 5

Number of formulations preparation mode used against malaria and associated symptoms

Selected ethnomedicinal plants (Market price/kg (Min-Max)/available months)	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec
<i>Aconitum heterophyllum</i> (Root) (1500-3000)			★	★	★	★	★	★	★	★	★	
<i>Paris polyphylla</i> (Rhizome) (1500-3000)	★	★	★	★	★	★	★	★	★			
<i>Coptis teeta</i> (Rhizome) (2000-3000)			★	★	★	★	★	★				
<i>Artemisia nilagirica</i> (Leave) (1500-3500)			★	★	★	★	★	★	★	★	★	
<i>Andrographis paniculata</i> (Leave) (1000-2500)		★	★	★	★	★	★	★	★			
<i>Dillenia indica</i> (Fruit) (100-200)	★	★	★	★	★							
<i>Euphorbia neriifolia</i> (Leave) (100-200)	★	★	★	★	★	★	★	★	★			
<i>Holarrhena pubescens</i> (Bark) (1700-3000)	★	★	★	★	★	★	★	★	★	★	★	★
<i>Justicia adhatoda</i> (Leave) (50-100)			★	★	★	★	★	★	★	★	★	
<i>Paederia foetida</i> (Leave) (100-200)	★	★	★	★	★	★	★	★	★			
<i>Centella asiatica</i> (Leave) (100-150)	★	★	★	★	★	★	★	★	★	★	★	★
<i>Tinospora cordifolia</i> (Leave) (450-700)						★	★	★	★	★	★	

Rare/Endangered plants	Common/Least concern plants
★ Observed in the market	□ Naturally available months
□ Not observed in nature and market	

Figure 6

Availability of highest scoring plants with their (mini. and maxi.) market price.