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RESEARCH COMMUNICATION

Ethnomedicinal practices for the management of skin diseases by Ao tribe of Nagaland, India

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Abstract

The Ao is the major tribe of Nagaland and an inhabitant of the Mokokchung district. They rely solely on medicinal plants to cure a wide range of dermatological disorders. The uses of these plants are neither thoroughly investigated nor documented. To create new herbal medication with their traditional knowledge, proper documentation and phytopharmacological study are needed. Therefore, the present study was targeted to document the medicinal plants utilised by the Ao tribe along with their methods of preparation and mode of administration for treating dermatological disorders. The study was carried out in different villages of the Mokokchung district using a pre-structured questionnaire format and group discussions selecting 32 traditional healers. Two quantitative indices, the relative frequency of citation (RFC) and fidelity level (FL) were employed to evaluate the importance of plants. The current study reported 32 different plant species belonging to 25 families that are used to treat 11 different skin disorders. The plant parts that were most frequently utilised included the leaves, accounting for 59.37 % and the roots, which comprised 12.50 %. The highest RFC showed by *Butea monosperma* (Lam.) Kuntze (0.90), *Lantana camara* L., *Scoparia dulcis* L., *Vitex negundo* L. (0.87 each). The species are namely *Abroma augustum* (L.) L.f., *B. monosperma, Calotropis gigantea* (L.) W.T. Aiton, *Leucas aspera* (Willd.) Link, *Ocimum tenuiflorum* L. and *V. negundo* are found with 100 % FL. The findings of the present study are expected to be helpful for future research on drug design and development.

Keywords: ethnomedicine; fidelity level; herbal drug; India; Nagaland; relative frequency; skin treatment

Introduction

Dermatological disorders represent a significant public health challenge, affecting millions of individuals globally each year. These conditions can impact people of all ages and rank among the four most prevalent causes of human diseases (1, 2). Common dermatological disorders include eczema, rashes, pigmentation issues, scabies, acne and warts, often resulting from bacterial and fungal infections. While many individuals resort to allopathic medications for treating skin disorders, these treatments can lead to various side effects that may adversely affect other organs. Consequently, traditional medicine emerges as a preferable option for managing skin disorders, given its minimal side effects and cost-effectiveness (3). Furthermore, climate change influences the prevalence of numerous skin diseases, particularly in tropical regions. Northeastern India, characterised by high humidity and a tropical climate, fosters the rapid proliferation of various diseases, especially dermatological conditions. Additionally, many residents of Northeast India, particularly in Nagaland, engage in agriculture and related activities, exposing them to various sensitisers and skin infections. Living in remote hilly areas with limited access to modern medical treatments, they often rely on traditional remedies to address skin disorders and other health issues (4). In addition to its rich biodiversity, the state of Nagaland is home to a remarkable ethnic diversity and boasts unique folk healing practices (5). Folk healing and folk remedies have been essential components of numerous ethnic communities for a long time including the Ao, Sümi, Lotha, Angami, Rengma, Chakhesang, Pochury, Chang, Konyak, Kuki, Phom, Rengma, Sangtam, Tikhir, Yimkhiung and Zeme-Liangmai of Nagaland. The state harbours a total of 17 major Naga tribes, all of which engage in rich traditional healing practices. Among these ethnic groups, the Ao tribe is particularly notable (6). They are settled in different villages in Mokokchung district. The Ao tribe own extensive folk knowledge regarding the application of bioresources for sustenance (7). They employ folk healing methods and folk medicine to treat a variety of ailments, utilising numerous herbal preparations to address dermatological and other health issues.

In recent years, numerous researchers have explored the medicinal applications of flora for various health ailments in Nagaland (7, 8). However, a systematic ethnomedicinal study specifically addressing skin issues in Nagaland yet to be worked out. Consequently, there remains a significant gap in the documentation of medicinal plant diversity and the traditional uses of folk formulations for treating different diseases. Therefore, the present

study aims to document the diversity of medicinal plants traditionally employed in the treatment of skin disorders by Ao tribe, selecting the Mokokchung district. This documentation will provide essential baseline information for future investigations and will also contribute to drug design and development.

Materials and Methods

Study area

The Ao tribe inhabits the Mokokchung district, a significant area in Nagaland that spans 1719 sq km. This district is bordered to the north by Jorhat in Assam, with Wokha to the west, Tuensang to the east and Zunheboto to the south. (Fig. 1). Geographically, it is positioned between 26°32' N and 94°51' E. The district falls in the Eastern Himalayan-North East Hills, characterised by sub-tropical and temperate climates. The study concentrated on the Ao tribe and was conducted across various villages in Mokokchung district (Table 1). The district's natural vegetation is characterised by coniferous flora and subtropical evergreen rainforests (9).

Ethnomedicinal survey

An ethnomedicinal survey was conducted among the Ao tribe to document the medicinal plants used to cure different dermatological problems by following standard methods (10–12). To document the traditional treatment of dermatological disorders, a validated questionnaire format was used. The questionnaire form mainly focused on the demographic information of traditional healers, the names of local plants, the methods used to prepare and the dosage of administration and the information was analysed using quantitative methods and compared with previously published findings. Prior informed consent (PIC) was also obtained from traditional healers before collecting information about their practices.

Collection of specimens and taxonomic identification

With the help of herbal healer's species are collected, which are used in the traditional healing practices for the management of various skin ailments. The collected plant sample was identified by the regional flora of Nagaland (13) and names were updated using "The World Flora Online" (14). Herbarium specimens were prepared following standard methods of plant taxonomy (15) and stored in the Raw Drug and Herbarium (NEIAFMRH) of NEIAFMR, Pasighat, Arunachal Pradesh.

Data analysis and statistical evaluation

The data was examined with an MS Excel sheet. Information on the plant species, including scientific name, local name, family, parts used, voucher specimen number, preparation process, dose and mode of administration, was chronicled. Relative frequency citations (RFCs) and fidelity level (FL) were investigated.

Relative frequency of citation

Relative frequency of citation (RFC) signifies the importance of each species in the study area. This index theoretically varies from 0 to 1 and was calculated by using the following formula (16).

$$RFC = FCs/N$$

Where,

RFC = Relative Frequency Citation (It ranges from 0 to 1)

FC_S = Number of informants who cited the use of a particular plant species.

N = Total number of informants interviewed.

Fidelity level percentage

It measures certain plant species used by informants to treat ailments. The fidelity level (FL) percentage is calculated by the following formula (17).

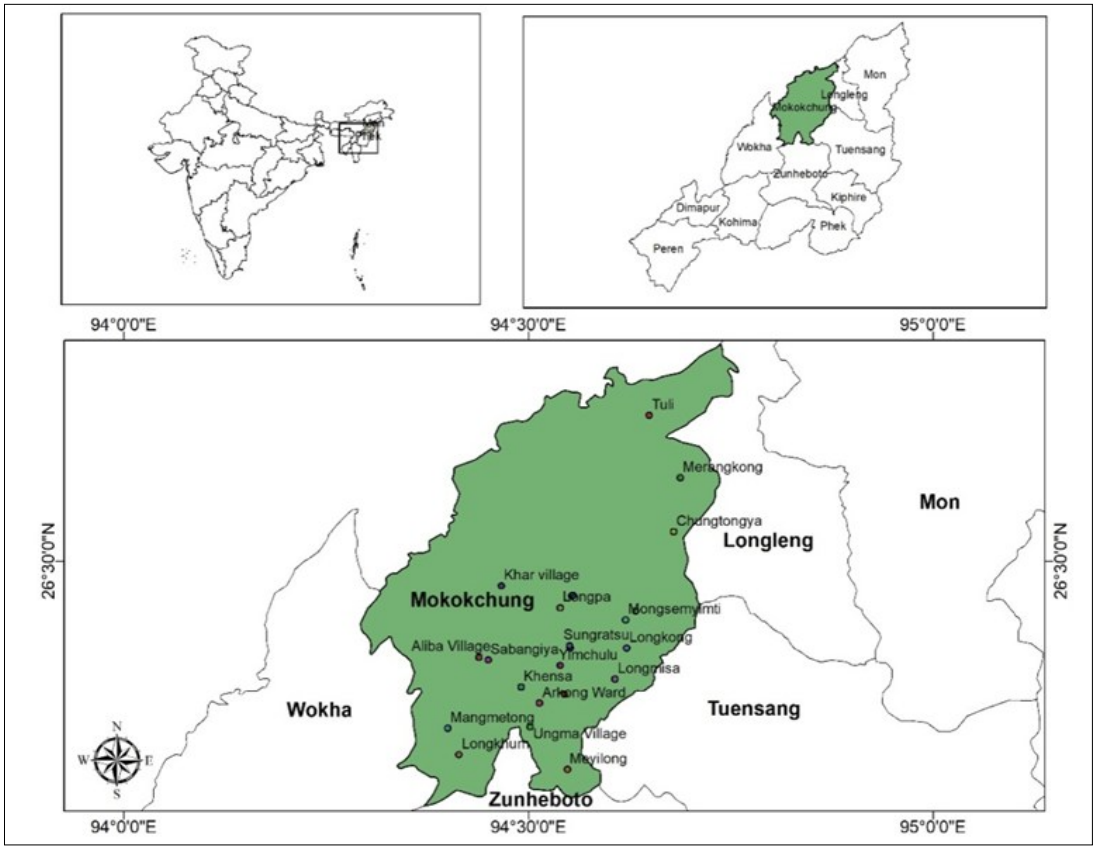

Fig. 1. Map showing the study site: Mokokchung district, Nagaland, India (Source : QGIS version 3.44).

Floristic analysis

The current research documented 32 species of medicinal plants belonging to 25 families, among which 50 % species are herbs, followed by shrubs (31.25 %), climbers (6.25 %) and trees (12.5 %) (Table 3, Fig. 2). Two most prevalent families used in the treatment are Fabaceae (6 species) and Lamiaceae (3 species). The other families were represented by the fewest species (1 species). Out of the 32 species, 21 species are collected from the wild and eleven are cultivated. Concerning the parts of plants used for preparing the traditional medicine for skin disease treatment are leaves, roots, latex, fruit, stems, bulbs, rhizomes and seeds. The whole plants of a few species are also used by traditional healers. However, the composition and plant parts vary from healer to healer. In the present study, leaves (59.37 %) were reported to be the maximum plant parts used in the folk formulation either by singly or mixed preparation followed by roots (12.50 %), latex, seeds, fruit (6.25 % each) and bulbs and rhizomes (3.12 % each) (Fig. 3). The traditional formulation for herbal remedies used for the administration of skin disorders comprise paste, extract, boil, latex and powder (Fig. 4).

Skin diseases and their treatment by ethnomedicine

A total of 11 different forms of dermatological disorders, such as swelling, scabies, boils, burns, ringworm, eczema, abscesses, ulcers, carbuncles, allergies and rash, were recorded in the study (20-46) (Table 4). Most people utilise herbal-based traditional medicine to treat all these skin disorders. Ringworm is a skin disease that has the maximum treatment with plant species. About 7 species are used to treat ringworms, followed by 6 species for scabies, 5 species for allergies, 3 species for eczema, 2 species each for abscesses, carbuncles, ulcers and burns and the lowest number of plant species (1 each) for boils, swelling and rash (Fig. 5).

Quantitative analysis

The relative frequency citation

The RFC values ranged from 0.03 to 0.90 (Table 2). The highest RFC was recorded for *Butea monosperma* (Lam.) Kuntze (0.90), followed by *Lantana camara* L., *Scoparia dulcis* L., *Vitex negundo* L. (0.87 each), *Azadirachta indica* A. Juss. (0.84), *Drymaria cordata* (L.) Willd. ex Schult., *Senna alata* (L.) Roxb. (0.81 each), *Aloe vera* (L.) Burm.f., *Vigna mungo* (L.) Hepper (0.78 each), *Lawsonia inermis* L. (0.75),

Table 3. Ethnomedicinal plants used against skin diseases

Sl No.	Family	Botanical name (Voucher sp. no.)	Local names in Ao Dialect	Growth habit	Parts used	RFC	FL %
1	Amaryllidaceae	*Allium sativum* L.	Lahsung	Herb	Bulbs	0.25	90.47
2	Apiaceae	*Centella asiatica* (L.) Urb.	Longs okorok	Herb	Leaves	0.09	95
3	Apocynaceae	*Calotropis gigantea* (L.) Dryand. (Acc No	Kutjakmoli	Shrub	Leaves	0.43	100
4	Araceae	*Colocasia esculenta* (L.) Schott.	Lungt ong	Herb	Stem	0.21	83.33
5	Asphodelaceae	*Aloe vera* (L.) Burm.f.,	Alo naro	Herb	Leaves	0.78	87.5
6	Asteraceae	*Eclipta prostrata* (L.) L. (Acc No NEIAFMRH	Atsungjem	Herb	Leaves	0.28	96.55
7	Basellaceae	*Basella alba* L. (Acc No NEIAFMRH 001036)	Zua A obaon u	Herbs	Leaves	0.15	80
8	Caricaceae	*Carica papaya* L. (Acc No NEIAFMRH 001039)	Mama ju	Shrubs	Latex	0.06	84.61
9	Caryophyllaceae	*Drymaria cordata* Willd. Ex Schult. (Acc No	Pipiw a	Herbs	Leaves	0.81	92
10	Euphorbiaceae	*Ricinus communis* L. (Acc No NEIAFMRH 001058)	Pakati bawaa	Shrubs	Leaves	0.28	85.71
11	Fabaceae	*Butea monosperma* (Lam.) Kuntze.	Tzube nnaro	Tree	Leaves	0.90	100
		Entada phaseoloides (L.) Merr. (Acc No NEIAFMRH	Suhzu ng	Climber	Seeds	0.65	82.60
		Flemingia strobilifera (L.) W. T. Aiton. (Acc No	Tzutsa	Shrubs	Root	0.56	73.68
		Mimosa pudica L.(Acc No NEIAFMRH 001052)	Maya knaro	Herbs	Roots	0.06	91.66
		Senna alata (L.) Roxb. (Acc No NEIAFMRH 001060)	Kor	Shrubs	Leaves	0.81	76.47
		Vigna mungo (L.) Hepper. (Acc No NEIAFMRH	Kala dal	Herbs	Seeds	0.78	72.41
12	Lamiaceae	*Leucas aspera* Link. (Acc No NEIAFMRH 001051)	Sinus Mozut ong	Herbs	Leaves	0.46	100
		Ocimum tenuiflorum L. (Acc No NEIAFMRH	Nangbara	Herbs	Leaves	0.62	100
		Vitex negundo L. (Acc No NEIAFMRH 001062)	Tzubu	Tree	Leaves	0.87	100
13	Lythraceae	*Lawsonia inermis* L. (Acc No NEIAFMRH 001050)	Mekong	Shrubs	Leaves	0.75	88.88
14	Malvaceae	*Abroma augustum* (L.) L.f.	Karai	Shrub	Roots	0.18	100
15	Meliaceae	*Azadirachta indica* A. Juss.	Neem tu	Tree	Leaves	0.84	93.75
16	Moraceae	*Ficus religiosa* L. (Acc No NEIAFMRH 001047)	Aku	Tree	Latex	0.50	85.71
17	Oxalidaceae	*Oxalis corniculata* L. (Acc No NEIAFMRH 001054)	Waro yisu	Herbs	Leaves	0.31	50
18	Piperaceae	*Piper nigrum* L. (Acc No NEIAFMRH 001056)	Waro yisu	Climber	Fruits	0.43	91.30
19	Plantaginaceae	*Scoparia dulcis* L. (Acc No NEIAFMRH 001059)	Buning	Herbs	Leaves	0.87	80.95
20	Plumbaginaceae	*Plumbago zeylanica* L. (Acc No NEIAFMRH	Nayang Naro	Herbs	Roots	0.31	85.18
21	Polygonaceae	*Persicaria hydropiper* (L.) Delarbre. (Acc No	Mirchinaro	Herbs	Leaves	0.40	84.21
22	Rutaceae	*Citrus limon* (L.) Osbeck. (Acc No NEIAFMRH	Ongshe	Shrubs	Fruit	0.18	50
23	Solanaceae	*Datura metel* L. (Acc No NEIAFMRH 001043)	Metok suben	Shrubs	Leaves	0.09	89.47
24	Verbenaceae	*Lantana camara* L. (Acc No NEIAFMRH 001049)	Akhat mulin aro	Shrubs	Leaves	0.87	91.66
25	Zingiberaceae	*Curcuma longa* L. (Acc No NEIAFMRH 001042)	Wakorong	Herb	Rhizome	0.03	64.28

Table 1. Details of the surveyed areas in the Mokokchung district of Nagaland

Surveyed villages	Geo coordinates
Aliba Village	Latitude: 26°22'52.99" N; Longitude: 94°26'19.23" E
Anaki	Latitude: 26°68'57.89" N; *Longitude: 94°71'18.15*" E
Arkong Ward	Latitude: 26°19'28.88" N; Longitude: 94°30'49.74" E
Changki	Latitude:26°.41'94.32 N; Longitude:94°38'799.47 E
Chuchuyimlang	Latitude: 26°26'17.73" N; Longitude: 94°37'57.27" E
Chuchuyimpang Village	Latitude: 26°20'7.66" N; Longitude: 94°32'39.30" E
Chungtongya	Latitude: 26°32'11.43" N; Longitude: 94°40'45.40" E
Khar village	Latitude: 26°28'9.97" N; Longitude: 94°27'59.03" E
Khensa	Latitude: 26°20'39.65" N; Longitude: 94°29'27.34" E
Longchem	*Latitude: 26°61'56.72*" N; *Longitude: 94°43'38.76*" E
Longjang	Latitude: 26°27'28.52" N; Longitude: 94°33'18.54" E
Longjang Village	Latitude: 26°27'24.99" N; Longitude: 94°33'12.66" E
Longkhum	Latitude: 26°15'38.95" N; Longitude: 94°24'50.65" E
Longkong	Latitude: 26°23'33.35" N; Longitude: 94°37'16.46" E
Longmisa	Latitude: 26°21'15.17" N; Longitude: 94°36'24.68" E
Longpa	Latitude: 26°26'33.32" N; Longitude: 94°32'21.41" E
Mangmetong	Latitude: 26°17'36.37" N; Longitude: 94°24'1.06" E
Merangkong	Latitude: 26°36'10.63" N; Longitude: 94°41'14.93" E
Meyilong	Latitude: 26°14'33.55" N; Longitude: 94°32'53.27" E
Mongsemyimti	Latitude: 26°25'39.38" N; Longitude 94°37'12.52" E
Sabangiya	Latitude: 26°22'40.23" N; Longitude: 94°27'0.54" E
Satsu	Latitude: 26°35'42.72" N; Longitude: 94°39'93.42" E
Sungratsu	Latitude: 26°23'32.78" N; Longitude: 94°33'5.95" E
Sungratsu	Latitude: 26°23'43.87" N; Longitude: 94°33'2.65" E
Tuli	Latitude: 26°40'48.51" N; Longitude: 94°38'57.05" E
Ungma Village	Latitude: 26°17'42.78" N; Longitude: 94°30'7.69" E
Yimchalu	Latitude: 26°22'15.40" N; Longitude: 94°32'21.72" E

$$FL(\%) = (N_p / N) \times 100$$

Where,

N_p= The number of informants who independently reported using specific plant species for treating a particular ailment.

N = Total number of informants who mentioned the plant species for any ailment.

Results

Demography of informants

A total of 32 traditional healers were identified in the present investigation and their traditional methods for treating skin disorders have been documented. Traditional knowledge is the most prevalent in the category over 70 years, followed by those between 61 and 70 years (22.812 %), 51 to 60 years (21.88 %) and 41 to 50 years (12.5 %). This illustration indicates that older generations still rely on traditional medicine while younger generations show less interest in traditional healing practices (18, 19). Among the 32 healers, 19 (59.38 %) are males and 13 (40.62 %) are females. The education qualifications of the healers were also investigated and it was recorded that most healers had primary education (46.88 %), non-formal education (28.12 %), secondary education (15.62 %) and 9.38 % healers have graduated degrees. Regarding livelihood, about 46.88 % of respondents are employed in agriculture, while 34.37 % of respondents are purely engaged in traditional healing practices for their livelihood and the rest (18.76 %) are working as labour. Most of the respondents (78.12 %) claimed to obtain their healing knowledge from their parents and the rest (21.88 %) obtained it from neighbours, relatives and friends. The demographic data of the respondents was provided in Table 2.

Table 2. Demographic data of traditional healers

Sl. No	Variable	Categories	No. of persons	Percentage
1	Gender	Male	19	59.38 %
		Female	13	40.62 %
2	Age group	< 40 years	Nil	00
		41–50 years	4	12.5 %
		51–60 years	7	21.88 %
		61–70 years	9	28.12 %
		> 70 years	12	37.5 %
3	Education	No formal education	9	28.12 %
		Primary education	15	46.88 %
		Secondary education	5	15.62 %
		Graduate	3	9.38 %
		Postgraduate	Nil	00
4	Profession	Traditional healer	11	34.37 %
		Farmer	15	46.87 %
		Labor	6	18.76 %
5	Source of knowledge	Family inheritance	25	78.12 %
		Self-interest	7	21.88 %

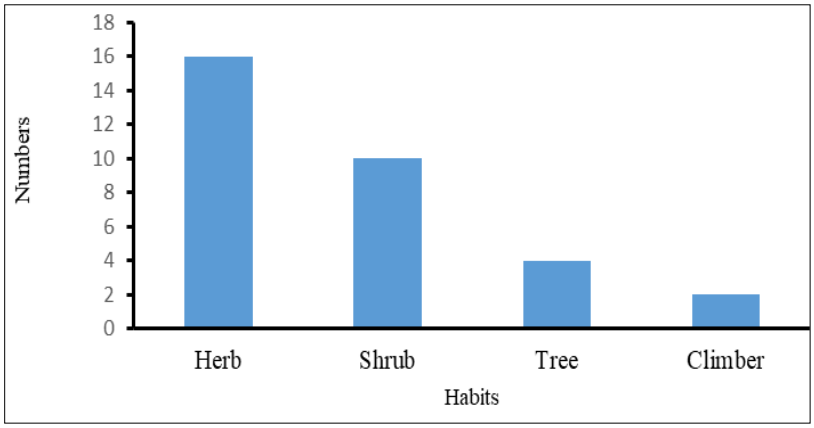

Fig. 2. Habit of medicinal plants traditionally utilised to treat skin disorders.

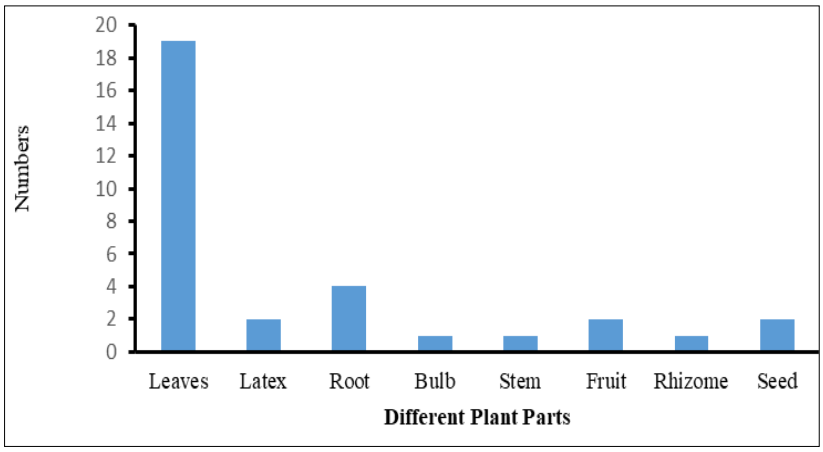

Fig. 3. Plant parts used versus the number of species.

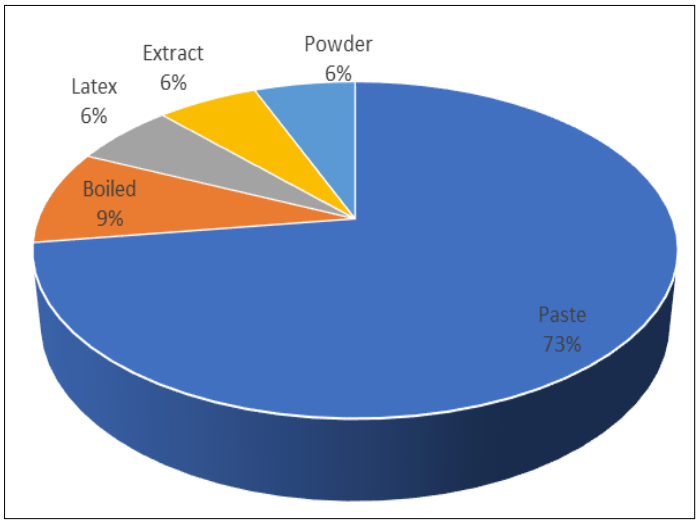

Fig. 4. Forms of formulation used in ethno-dermatological practices.

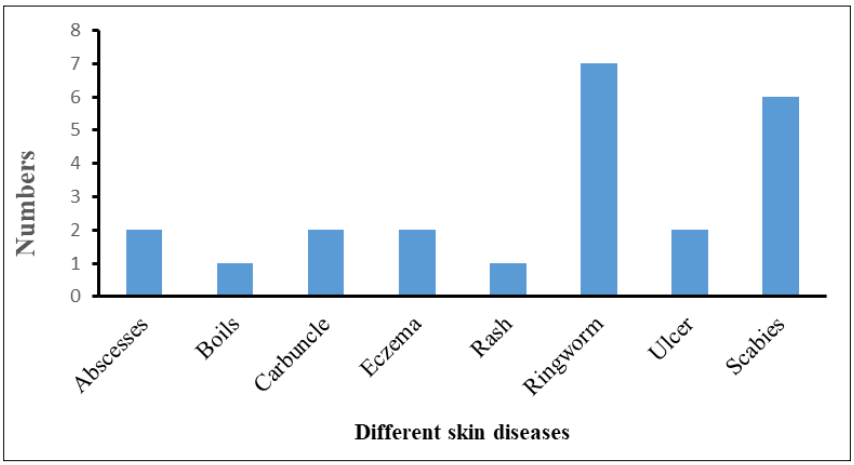

Fig. 5. Number of plant species used against skin diseases.

Table 4. Herbal formulations for treating skin diseases by Ao in Mokokchung district, Nagaland, India

Sl. No.	Specific skin disease	Species	Mode & dose of administration	Reference
1	Abscesses	*Lawsonia inermis*	Crushed 30-40 leaves, paste is applied to the infected area one time daily for 2 days	(20)
		Vitex negundo	Crushed 15-20 leaves, paste is applied to the diseased area one time per day for 6 days	(21)
2	Boils	*Drymaria cordata*	Crushed 30 to 40 leaves, paste applied once each day for 7 days	(22)
3	Burn	*Aloe vera*	Mashed 2 leaves, paste applied twice for a day on the burn site for 3 days.	(23)
		Basella alba	Crushed 7 leaves, paste is applied to the diseased area 1 time daily for 5 days	(24)
		Scoparia dulcis	20 gm of fresh leaves crushed, paste is applied to infected area 3 times per day for 9 days	(25)
4	Carbuncles	*Centella asiatica*	20–25 fresh leaves crushed, paste is applied to the infected region once each day for 7 days	(26)
		Ricinus communis	Crushed 4 leaves, paste is applied to the infected area once per day for 5 days	(26)
5	Eczema	*Curcuma longa*	Crushed 10 g of fresh rhizome, paste is applied to the infected area once per day for 4 days	(22)
		Datura metel	Crushed 10-15 leaves with a sprinkle of salt and paste is applied once every day for 8 days	(27)
6	Allergy	*Allium sativum*	Smashed 2 bulbs and paste applied 2 times per day for 5 days	(27)
		Azadirachta indica	Boiling 80–100 leaves in 10 liters of water and take a bath for 3 days, with boiling water once every day	(28)
		Butea monosperma	Boiling 60–70 leaves in 20 liters of water and take a boiled-water bath for 3 days, once a day	(29)
7	Ringworm	*Citrus limon*	Crushed of one fruit and 10 drops of the extract to the affected area	(30)
		Entada phaseoloides	Crushed 10 seeds boil in 10 liters of water and take a bath twice daily for 3 days	(31)
		Calotropis gigantea	Crushed 5 leaves and paste applied to the infected region twice daily for 3 days	(32)
		Carica papaya	Crushed 5 leaves and paste applied to the diseased portion twice daily for 3 days	(33)
		Eclipta prostrata	Crushed 15 to 20 leaves and paste applied to the infected area two times a day for 8 days	(34)
		Ficus religiosa	Collect 15-20 ml of fresh latex, then mix with a small amount of salt and apply 5 drops of latex to the infected region 3 times per day for 7 days	(35)
		Lantana camara	15-20 leaves crushed with 2 gm of fire ash and paste is applied once daily for 6 days	(36)
		Ocimum tenuiflorum	Crushed 20 fresh leaves and paste apply twice daily for 9 days	(37)
		Piper nigrum	15-20 fruits crushed into powder and one tablespoon of powder mixed with 3 drops of sesame oil was administered to the infected region 3 times in a day for 10 days	(38)
8	Ulcer	*Senna alata*	Crushed 15–20 leaves and paste is applied to the infected region once per day for 7 days	(39)
		Persicaria hydropiper	Crushed 20–30 leaves and paste is applied to the infected region once per day for 7 days	(40)
9	Rash	*Mimosa pudica*	Crushed 10 g. of fresh roots and paste are applied to the diseased area 3 times per day for 6 days.	(41)
10	Scabies	*Abroma augustum*	Crushed 20 g. of fresh root, paste applied on the infected area 1 time per day for 6 days	Not reported for skin
		Flemingia strobilifera	Crushed 20 g. of the fresh root fresh is applied to the diseased area one time per day for 10 days	(26)
		Leucas aspera	Crushed 20–25 leaves and paste applied to the infected area one time every day for 6 days	(42)
		Oxalis corniculata	50-60 leaves crushed and 5 ml of the extract apply on the infected area once a day for 8 days	(43)
		Plumbago zeylanica	Crushed 20 g. of fresh root and paste is applied to the infected area once every day for 10 days.	(44)
11	Swelling	*Vigna mungo*	15–20 seeds ground and powdered is applied to the diseased area one time per day for 3 days	(45)
		Colocasia esculenta	3 stems are crushed and paste is applied to the affected area 1 time per day for 4 days	(46)

Entada phaseoloides (L.) Merr. (0.65), *Ocimum tenuiflorum* L. (0.62) and other species show less RFC value. The *B. monosperma* is the most frequently used plant for medicinal purposes, which is supported by other studies (47, 48). Plant species with high RFC values can be further investigated to explore their potential in the development of new herbal remedies (49).

Fidelity level

Abroma augustum (L.) L.f., *B. monosperma, Calotropis gigantea* (L.) W.T.Aiton, *Leucas aspera* (Willd.) Link, *O. tenuiflorum* and *V. negundo* represent the plant species with 100 % FL, followed by *Eclipta prostrata* (L.) L. (96.55 %), *Centella asiatica* (L.) Urb. (95 %), *A. indica* (93.75 %), *D. cordata* (92 %), *L. camara, Mimosa pudica* L. (91.66 % each), *Piper nigrum* L. (91.30 %), *Allium sativum* L. (90.47 %), *Datura metel* L. (89.47 %) and other plant species which showed the least FL. According to a previous report, *C. gigantea* displayed a 100 % FL; the outcomes reported here corroborate these findings (50).

Discussion

The findings of this study reveal the potential of traditional healing practices for managing skin disorders. A total of 32 plant species, belonging to 32 genera and 25 families, were identified as being traditionally used by the Ao tribes for the treatment of various skin ailments. Among these families, the Fabaceae and Lamiaceae families contributed the highest number of species, each with 3. This aligns with observations from other studies (51). In this study, leaves were reported as the most used plant part in folk formulations, comprising 59.37 % of the total, whether used individually or in mixtures. This finding is consistent with previous research (51), which indicates that leaves exhibit a high level of effectiveness against skin conditions (52, 53). The 32 medicinal plant species reported here also hold significance within the Indian system of medicine for skin diseases and the traditional healing practices of the Ao are also found to be acceptable in the management of dermatological disorders. Notably, 15 of these species, including *A. vera*, *Curcuma longa* L., *Ficus religiosa* Forssk., *A. sativum*, *C. asiatica*, *Calotropis gigantea* (L.) W.T.Aiton, *E. prostrata*, *B. monospermum*, *M. pudica*, *O. tenuiflorum*, *Lawsonia inermis* L., *Azadirachta indica* A.Juss., *Oxalis corniculate* L., *C. limon* and *C. longa*, are also mentioned in the Ayurvedic system of medicine (54). This study highlights a novel application of *A. augustum*, showcasing its efficacy in treating scabies. Previously, this species had been noted for its use in managing diabetes (55). While *Basella alba* was reported to be used for treating leukoderma in earlier studies (56), this research identifies its application for burns. Similarly, *Flemingia strobilifera* (L.) W.T.Aiton has been indicated in this study for treating scabies, although it was previously known for treating ringworm (57, 58). *Piper nigrum* seeds were used here for treating ringworms, whereas prior studies had reported their use for eczema (59, 60). Interestingly, the leaves of *P. nigrum* have also been documented as treatment for ringworm (61, 62). Earlier studies showed that the seeds of *Ricinus communis* were utilised for the treatment of carbuncles (63). However, the present study reported that the leaves are used in the treatment of carbuncles. Based on the quantitative studies *A. augustum, B. monosperma, C. gigantea, Leucas aspera* (Willd.) Link, *O. tenuiflorum* and *V. negundo* show highest RFC and FL values. The biological activities of these plants' species like *B. monosperma* (64), *C. gigantea* (65), *L. aspera* (66), O. *tenuiflorum* (67), *V. negundo* (68), have been reported, which validate the traditional utilisation of these species in the management of various skin ailments. To enhance the effectiveness of their formulations, healers often added supplementary ingredients such as salt, sesame oil and fire ash. They tend to favour wild medicinal plant species over domesticated ones, believing that wild plants possess greater efficacy. To ensure the conservation of these medicinal plant species, healers cultivate them in their natural habitats rather than in home gardens. This study highlights that natural forests are a crucial source of raw materials for folk medicine used by healers. Therefore, it is essential to maintain these forests to protect against the extensive and unsustainable harvesting of medicinal plants, which are rapidly becoming less abundant. Furthermore, with the advent of modernisation and the widespread availability of allopathic medicines, traditional healing practices and knowledge are progressively diminishing in popularity among the younger generation. Consequently, there is a pressing need for further scientific investigations to validate folk remedies and treatments for skin disorders.

Conclusion

The Ao tribe employs a unique customary approach to the treatment of skin disorders, suggesting a recovery period of 3 to 20 days. The 32 medicinal plant species discussed here also play an important role in the Indian system of medicine for treating skin diseases. Additionally, the traditional healing practices of the Ao community have proven to be effective in managing dermatological disorders. Their folk medicines are based on practical evidence, relying exclusively on natural remedies to address skin conditions and other human ailments, largely due to the shortcomings and inaccessibility of the modern healthcare system. This traditional knowledge is not only more cost-effective but also associated with fewer adverse effects, making its preservation more crucial. Furthermore, it is vital to engage future generations in these practices. Many healers source medicinal ingredients from the forests; however, human activities have significantly diminished these areas, putting numerous medicinal plants at risk of endangerment and extinction. Many of these plants thrive only in forests or natural habitats and cannot be cultivated. This study highlights the essential role that natural forests play as a primary source of raw materials for the folk medicine utilised by healers. Therefore, it is imperative to conserve these forests to protect against the overexploitation and unsustainable harvesting of medicinal plants, which are rapidly becoming scarce. The present study serves as fundamental documentation of the diversity of medicinal plants traditionally used in ethnodermatological practices, an area that lacks detailed phytochemical investigation data. Consequently, it is urgent to explore the phytochemical properties, bioactivity, toxicity and pharmacognosy of all traditionally used medicinal plants before they face extinction, especially in the realm of drug discovery and development.

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Authors' contributions

AB designed the work. AB and JP carried out the field survey and prepared the herbarium. AB and JP drafted the manuscript. AB and DB identified and authenticated the plant specimens. AB supervised and presented an in-depth evaluation of the research. GY, I, IL and RT reviewed the work and the manuscript. All authors have read and approved the final manuscript.

Compliance with ethical standards

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