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Cross-cultural comparison of medicinal plants used to treat infections in northern Thailand

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Drug resistance in pathogenic microorganisms threatens both human and animal health. This has prompted the search for new antimicrobial drugs, including ones from plant-derived medicines. Some researchers have suggested that medicinal plants used by multiple cultures are more likely to be pharmacologically active. We interviewed 808 informants across seven ethnic groups in northern Thailand about their traditional knowledge of medicinal plants. Plants used to treat infections were compared and agreement about a particular use of a plant was evaluated using the "frequency of citation." When agreements were found between two or more informants, we searched for confirmation in other studies for medicinal uses and biological activities reported for that particular plant species. Of the 808 informants, 103 mentioned 199 distinct plant uses of 143 plant species to treat 21 different "infection" disorders. Of the 199 plant uses, 114 were mentioned by two or more informants; 15 plant uses were shared between different ethnic groups and 55 plant uses were shared within the same ethnic group and had identical or similar uses mentioned in other studies sometimes in distantly located cultures. The convergent information suggests the bioactivity of a certain plant that may have been discovered independently. However, the remaining 44 plant uses that were shared within the same ethnic group are here reported for the first time with considerable agreement among informants. These new plant uses should be given high priority in bioscreening for new antimicrobial drugs.

Thai Abstract?

Key Words: Antimicrobial resistance; Antimicrobial activity; Ethnobotany; Ethnomedicine; New drug discovery; Traditional medicine

Introduction

Infectious diseases are caused by pathogenic microorganisms and they can be classiflied based on pathogens causing the infections, i.e., bacterial, parasitic, viral, and fungal diseases, respectively. Infectious diseases have become a major threat to humans, and, at the same time, growing resistance to pharmaceutical drugs increasingly threatens the effective prevention and treatment of diseases caused by microorganisms (Pommerville 2014; WHO 2016). Colistin is the last resort for treating life threatening infections caused by Enterobacteriaceae, a family of Gram-negative bacteria that includes many familiar pathogens, such as *Escherichia coli* and *Yersinia pestis*. Recently the World Health Organization reported that resistance to colistin has been detected in several countries. Antibiotic resistance is present in all countries, in some cases, affecting more than half of the patients. In many European countries, as well as in Japan and South Africa, there have been failures in the treatment with the last resort of medicine for gonorrhea (third generation cephalosporin antibiotics) caused by emerging new resistance mechanisms of the bacteria. Such new resistance mechanisms have also been detected in tuberculosis, HIV, influenza, malaria, and many other infectious diseases (WHO 2016). In addition to occurring in microorganisms, drug resistance is also found in gastrointestinal helminthes in humans and animals (Saddiqe et al. 2013). Therefore, new antimicrobial drugs and anthelmintics are needed. One potential source of new drugs is traditional plant-derived medicines (Namita and Mukesh 2012).

According to the WHO, about three-quarters of the world’s population depends on traditional herbal medicine for their health care needs (Gilani and Rahman 2005). There have been efforts to duplicate the effective traditional medicine used by traditional healers to develop new western anti-infection medicine (Vijayakumar et al. 2016).

Documented ethnomedical systems (e.g., Ayurveda, Traditional Chinese Medicine, Unani Tibb) and non-documented traditional medicine of different ethnic groups (i.e., ethnomedicine) are seen as valuable short-cuts in the search for and selection of candidate plant species for screening of biologically active compounds for new drug discovery (Cowan 1999; Katiyar et al. 2013; Schultes 1994). The history of drug discovery and development confirms that ethnomedicinal-based screening of floras have a higher chance of success than a random screening approach (Albuquerque 2010; Cox and Balick 1994). Significant examples of successful drug discovery based on ethnomedicinal usage by indigenous people or folk medicincal system include the discovery of quinine from the bark of Cinchona (*Cinchona pubescens* Vahl) for treating malaria, reserpine from the Indian snake root (*Rauvolfia serpentina* (L.) Benth. ex Kurz) for treating hypertension, and morphine and codeine from the opium poppy (*Papaver somniferum* L.) for treating pain (Cox and Balick 1994; Williams 2006).

To increase hit rates in phytomedicinal exploration, researchers have used ethnobotanical indices, which incorporate the number of uses, persistence of use over time, frequency of use, and agreement about use (Saslis-Lagoudakis et al. 2011; Tardío and Pardo-de-Santayana 2008). Besides the use of ethnobotanical indices, other mathematical techniques including comparison of plant uses can also help to validate the use of a species for a particular use (e.g., Bennett and Husby 2008; Bletter 2007). Use of one species for the same purpose in different cultures may be due to knowledge transfer or independent discovery (Bletter 2007). The latter is more likely with greater linguistic differences and greater geographic differences (Johnson 2006). Agreement on use across cultures may increase the probability of therapeutic efficacy (Bletter 2007; Heinrich et al. 1998; Saslis-Lagoudakis et al. 2011). For instance, Roersch (2010) reviewed the ethnomedicinal uses of *Piper umbellatum* L. across three continents (America, Africa, Asia) and recorded its traditional use across different cultures in 24 countries and found that it is used with a high degree of cross-cultural consensus (i.e., use for treatment of wounds) which was supported by scientific evidence for the related activities; i.e., antioxidant activity which play an important role in wound healing. Similarily, in small-scale communities (e.g., a village), biological activity (i.e., antibacterial activity) in laboratory test of medicinal plants was correlated with frequency of mention (i.e., citation) of plant use, giving support to the empirical knowledge on plant use of the inhabitants of the community (Hernández et al. 2003).

In this study, we compare the medicinal plants used to treat infectious diseases across seven different cultures (i.e., ethnic groups) in northern Thailand; namely, the Tai Yuan (or "Khon Müang" which is their self-designed name), Hmong, Mien (sometimes called "Yao"), Lahu, Lisu, Lua and Khamu (also known as Khmu or Kammu). The Tai Yuan are the main ethnic group and constitute the majority of the population in northern Thailand. The Hmong, Mien, Lahu, and Lisu are ethnic groups that originate in southern China and they were forced to migrate southward into upper Indochina in the 19th century by the invasion and political pressure from the Han Chinese (Perve 2006). The Lua is a sub-group of the Lawa people originating in the areas of Thai-Lao border where they now live, particulary in the mountains in Nan Province (Dessaint 1981). Likewise, the Khamu is a small ethnic group believed to be the aboriginals to northern Laos and surrounding areas. They currently live in Laos, Vietnam, Thailand, China, and the United States (Nguyen et al. 2009). In general, we aimed to determine whether there was agreement in use of a certain plant species among them. For species mentioned for a treatment of particular condition by more than one informant, we searched the literature for similar uses.

When that was the case we searched for information about their biological activity, especially whether it had been confirmed in the laboratory.

<H1>**Methods**

<H2>STUDY SITES AND ETHNIC GROUPS

Data about plants used to treat infections were collected in 16 villages representing seven different cultures (i.e., ethnic groups) in northern Thailand. Twelve of the villages were in Nan Province and four in Chiang Mai Province (Table 1).

<H2>DATA COLLECTION

Ethnobotanical surveys were carried out from 2007 to 2011 in Nan Province and from 2014 to 2017 in Chiang Mai Province. Data collection followed the technique of ethnobotanical inventory or field interview suggested by Martin (1995). In each village, people with specialist plant knowledge (i.e., traditional healers) were asked for their consent to engage in the study and selected as local key informant(s). Totally, there were 28 key informants who consented to engage in the surveys in the 16 villages (i.e., 1–3 informants per village; Table 1).

The surveys of traditional knowledge from local key informants were made every other month in all habitats where we expected to find useful plants, including home gardens, cultivated fields, and nearby forests. The key informants were asked about vernacular names, part used, mode of preparation, and routes of administration of each medicinal plant. The interviews were conducted by the first author in Thai language with the assistance of a translator when the informants were not fluent in Thai. Initial identifications were based on the first author's previous knowledge of the flora. These initial identifications were subsequently confirmed with voucher specimens (81 out of 96 species presented in Appendix 1 - Electronic Supplementary Material, ESM) deposited at the herbarium QBG and with the help of a specialist at the Queen Sirikit Botanical garden (QSBG) in Mae Rim, Chiang Mai, Thailand. Species for which no vouchers were collected were well known cultivated plants, such as, e.g., the papaya (*Carica papaya* L.), garlic (*Allium sativum* L.), galangal (*Alpinia galanga* (L.) Willd.), lemongrass (*Cymbopogon citratus* (DC.) Stapf), sugarcane (*Saccharum officinarum* L.), the pantropical weed *Calotropis gigantea* (L.) Dryand., and the ornamental *Aglaonema*, etc. Botanical names of plant species follow The Plant List (The Plant List 2013).

After the field surveys with the 28 key informants were completed, all plant species reported as medicinal by the key informant in a given village were subjected to open-ended questionnaire interviews with local residents in each village to determine consensus of their medicinal use(s). We interviewed 780 general informants from the 16 villages, i.e., 60 people per village in Nan Province and 15 people per village in Chiang Mai Province (Table 1). During the interview, pictures of the medicinal plants were shown to each informant to avoid misunderstandings concerning the identity of plant names used. All informants were asked about the medicinal uses of each species for treating health conditions using the same questions as we had asked to the key informants, i.e., none of the informants were guided by medicinal uses mentioned by the key informants but, instead, they were free to mention all medicinal use(s) they knew for a given plant species. Whenever informants, who could not communicate well in Thai language, encountered a problem in not being able to define what the symptom was called in

Thai, they were asked to say it in their ethnic language or explain the symptoms to the translator who then translated that into Thai language for the record.

<H2>DATA ANALYSIS

Since the ethnobotanical data obtained through the interviews with key informants in the field surveys and questionnaire interviews with general informants were independent, the two data sets were pooled as one dataset. Only data related to the use of medicinal plants to treat infections were compared. The symptoms fit in the category ‘infections’ in the *Economic Botany Data Collection Standard* (Cook 1995).

The discrete event in which an informant mentions the use of a plant species for the treatment of a particular infective symptom is here defined as a “citation.” To evaluate the degree of agreement among informants concerning the ethnobotanical use of a particular medicinal plant for treating specific infective conditions, we used the term “frequency of citation” (Tardío and Pardo-de-Santayana 2008), i.e., total citation for the species for such use.

Plant use data were compared both within and between the studied ethnic groups. Agreement concerning use of plants was therefore categorized into three types; i.e., 1. agreement between different ethnic groups, 2. agreement between different villages inhabited by the same ethnic group; and 3. agreement between informants of the same ethnic group inhabiting the same village. Use of the same plant species by the same route of administration to treat the same infective condition that were mentioned by at least two informants from the same village were grouped as one “combined citation.” All “combined citations” from 16 villages were then compared and grouped based on plant species used to treat the same disorder as one “distinct use”. A “distinct use” of all plant species was also compared with other ethnobotanical studies or the relevant literature for confirmation.

<H1>**Results**

<H2>ETHNOBOTANICAL DATA FOR PLANTS USED TO TREAT INFECTIONS

One hundred and three informants (40 in Chiang Mai; 63 in Nan) out of 808 informants (28 key-informants, 780 general informants) participating in the field surveys and questionnaire interviews provided 955 citations for 143 plant species from 68 families used to treat 21 “infection” disorders. These were grouped into unspecified infection (e.g., fever), helminth worm infections, bacterial infections, viral infections, fungal infections, and protozoal infections (Table 2). Common ailments, such as fever, *tinea pedis*, ringworm, cold, chicken pox, and shingles, were the most frequently reported infectious disorders. Medicinal plants were most often used to treat fever (61 spp.), ringworm (21 spp.), *tinea pedis* (20 spp.), and cold (19 spp.), respectively (Table 2).

<H2>COMPARISON OF MEDICINAL PLANTS USED TO TREAT INFECTIONS

In total, we counted 186 combined citations (including 870 single citations) relating to 96 plant species for the treatment of 20 different disorders (Table 2) whereas the remaining 85 citations relating to 64 species were reported by a single informant and not shared with others (Table 3). The shared uses were frequently reported for fever, *tinea pedis,* ringworm, chicken pox, and cold, whereas onychomycosis (*tinea unguium*) was the only disorder for which the use mentioned for its treatment was not shared (Table 2).

The comparison of 186 combined citations from 16 villages eventually resulted in 114 distinct uses, of which 15 were shared between two or more villages inhabited by different ethnic groups (Agreement type 1), 14 were shared between two or more villages inhabited by the same ethnic group (Agreement type 2), and 85 were shared between informants inhabiting the same village (Agreement type 3; Table 3). The 114 distinct uses are detailed in Appendix 1 (ESM) while the details of 85 citations reported by a single informant in a village (i.e., 85 distinct uses) are not shown.

Among the 15 distinct uses shared between different ethnic groups, the use of *Strobilanthes cusia* to treat fever showed the highest degree of agreement (96 citations; 11 villages; 4 ethnic groups), followed by the use of *Gmelina arborea* Roxb. to treat *tinea pedis* (76 citations; 10 villages; 4 ethnic groups), and the use of *Eleusine indica* (L.) Gaertn. to treat fever (38 citations; 6 villages; 4 ethnic groups), respectively (Appendix 1, ESM). For this type of agreement (type 1), four distinct uses related to the treatment of fever were shared between ethnic groups living in different provinces; i.e., *Ageratum conyzoides* (L.) L., *Artemisia vulgaris* L. (Lahu in Chiang Mai and Hmong in Nan), *Eleusine indica* (Khamu and Lua in Nan and Tai Yuan and Hmong in Chiang Mai), and *Mimosa pudica* L. (Mien in Nan and Tai Yuan in Chiang Mai).

Of the 14 distinct uses shared between villages inhabited by the same ethnic group, the use of *Toona sinensis* to treat chicken pox by the Hmong showed the highest degree of agreement (35 citations; 3 villages), followed by the use of *Stephania* sp. to treat ringworm by the Mien (19 citations; 3 villages), and *Verbena officinalis* L. to treat *tinea pedis* (18 citations; 3

villages), respectively (Appendix 1, ESM). For this type of agreement (type 2), only the use of *Verbena officinalis* to treat *tinea pedis* (athlete's foot) were shared between the Hmong in Nan and Chiang Mai Province whereas the remaining were uses shared between villages of the same ethnic group in Nan Province.

Of the 85 distinct uses shared between informants within a village of the same ethnic group, the use of *Toona sinensis* (Juss.) M.Roem. to treat dengue by the Hmong showed the highest degree of agreement (14 citations), followed by the use of *Pseudodrynaria coronans* (Wall. ex Mett.) Ching to treat shingles (12 citations) and *Chromolaena odorata* (L.) R.M.King & H.Rob. to treat fever (11 citations) by the Tai Yuan, and *Dianella ensifolia* (L.) DC. to treat cold by the Lua (10 citations), respectively (Appendix 1, ESM).

<H2>CONFIRMATION OF MEDICINAL PLANTS USED TO TREAT INFECTIONS

Comparing the 114 distinct uses with other published studies, we found similarity or associated biological activity for 70 distinct uses. We were unable to find any published evidence for 44 distinct uses reported by the informants in this study (Appendix 1, ESM).

Among the 70 distinct uses, confirmation was found for all 15 uses shared between ethnic groups (Type 1), 11 uses shared between villages of the same ethnic group (Type 2), and 44 uses shared between informants in a village of the same ethnic group (Type 3). Most uses were corroborated by surveys of medicinal plants or ethnobotanical studies in Thailand, other Asian countries such as China, Laos, India, Pakistan, Bangladesh, Philippines, Malaysia, and Indonesia as well as some distant countries such as the United States, Jamaica, Nigeria, Trinidad, Cameroon, Mauritius, and Zimbabwe. Besides, the confirmation included some studies focussed on particular plant species to verify their anti-infection activity (see Appendix 2, ESM). Sixty of those were corroborated by reports of use of the same plant species for treating the same disorders as documented here or by the confirmation of pharmacological activity of the same plant, three were corroborated by the reports to congeneric species used to treat the same disorders [i.e., *Selaginella* species for treating hepatitis (Setyawan 2009, 2011; Wang et al. 1998) vs. *Selaginella willdenowii* (Desv. ex Poir.) Baker; *Toona ciliata* M.Roem. for treating fever (Hossain et al. 2014) vs. *Toona sinensis*, and *Artemisia vulgaris* for treating fever (Ong and Kim 2014; Spring 1989) vs. *Artemisia verlotiorum* Lamotte], and seven were corroborated by the reports of the same plant species for treating disorders similar to what was reported by the informants in this study (i.e., disorders caused by the same type of microorganisms). For example, plant species mentioned for treating *tinea pedis* in this study, which included *Cheilocostus speciosus* (J.Koenig) C.D.Specht, *Gmelina arborea*, *Jatropha curcas* L., *Desmodium velutinum* (Willd.) DC., *Cardiospermum halicacabum* L., *Selaginella willdenowii*, and *Verbena officinalis*, were reported in other studies to be used for treating other fungal infectious disorders such as skin disease, eczema (ringworm), leprous skin, and itches.

The 44 distinct uses that were not corroborated in the published literature were all uses shared within an ethnic group. Of those, three uses were uses with high degree of agreement shared between villages (Type 2), i.e., the use of *Toona sinensis* to treat chicken pox by the Hmong (35 citations) including use of *Stephania* sp. (19 citations) and *Pellionia repens* (Lour.) Merr. (10 citations) to treat ringworm by the Mien, while the remaining 41 were plant uses shared within a village of a particular ethnic group (Type 3), including those aforementioned with the highest agreement in use such as the use of *Toona sinensis* to treat dengue by the

Hmong (14 citations), and *Dianella ensifolia* to treat cold by the Lua (10 citations)(Appendix 1, ESM).

Hence, based on the frequency of citation which reflects the degree of agreement in use of a given plant together with confirmation from other sources, we have determined species which could be additional interesting candidates in the search for new antimicrobial drugs by type of antimicrobial activities as detailed in Appendix 2 (ESM).

Discussion

The reports of 199 distinct uses of 143 plant species for treating 21 different disorders related to infections by key informants and general informants in this study reflects the large body of traditional knowledge related to infective conditions among the seven ethnic groups that we studied in northern Thailand (Tables 2 and 3). The used species include weeds (e.g., *Bidens pilosa* L., *Ageratum conyzoides*, *Eleusine indica*, *Imperata cylindrica* (L.) Raeusch., etc.), introduced species (e.g., *Senna alata* (L.) Roxb., *Mimosa pudica*, *Carica papaya*), as well as widespread species in the tropics (e.g., *Lycopodiella cernua* (L.) Pic. Serm., *Cyperus cyperoides* (L.) Kuntze, *Solanum americanum* Mill.). Because comparing usage between different cultures is an accepted way of highlighting bioactive plants and independent discovery by different ethnic groups provide evidence for bioactivity (Bletter 2007; Heinrich et al. 1998; Johnson 2006; Saslis-Lagoudakis et al. 2011), the agreements we found in 114 distinct uses of 96 species (Appendix 1, ESM) among the informants from the same and different ethnic groups imply that these plants may have therapeutic efficacy for certain kinds of infections. For medicinal uses shared within ethnic groups, the agreement in use may refer to ethnomedicinal knowledge inherited vertically from generation to generation and originating from the ancient ancestors of each ethnic group (Saslis-Lagoudakis et al. 2011). Some ethnomedicinal knowledge may be specific to an ethnic group, representing its intellectual identity, and that situation could be a reason for not being able to corroborate them in the published literature, like the 44 distinct uses presented in Appendix 1 (ESM). In contrast, for plant uses shared between ethnic groups living in the same province (i.e., Nan or Chiang Mai), convergent uses could be considered an indication of efficacy; however, independent discovery cannot be separated from horizontal exchange in this case because horizontal knowledge exchange could occur and lead to common ethnomedicinal use among cultures living in nearby villages and, therefore, shared plant uses may not indicate independent discovery in this case (Saslis-Lagoudakis et al. 2011). The confirmation of plant uses from other distantly located ethnic groups is therefore needed in this context so that the case for independent discovery can be made stronger. In our study, the confirmation of medicinal uses from the literature and ethnobotanical studies, especially those conducted in other distant countries, to all 15 distinct uses shared between ethnic groups lend support to the theory of independently discovered bioactivity of the associated plants, both in case of plant uses shared in the same and in different provinces. Likewise, the confirmations of 55 distinct uses shared within ethnic groups (i.e., 11 distinct uses shared between villages and 44 shared between informants in the same village) underline the therapeutic efficacy of ethnomedicinal uses passed on from their ancestors.

The results from cross-cultural comparison in our study, based on the frequency of citation that reflects the degree of agreement in use of a given plant, together with confirmation from other sources (Appendix 1 and 2, ESM), show that many plants highlighted for possible efficacy in treatment of infections here have been studied pharmacologically and their biological activities have been confirmed. For example, *Gmelina arborea*, *Verbena officinalis*, and *Senna alata* have been confirmed for their antifungal activity, *Strobilanthes cusia* (Nees) Kuntze for its antipyretic activity, *Acorus calamus* L. for its antipyretic and antiviral activities, *Combretum indicum* (L.) DeFilipps for its anthelmintic activity, *Plumbago zeylanica* L. for its antimalarial activity, *Drynaria quercifolia* (L.) J. Sm.for its antiviral activity, and *Hydrocotyle sibthorpioides* Lam. for its anti-hepatitis virus effect. Some plants have even been developed into new drugs, patented for their medical use, and integrated into the western medicinal practice such as *Lycopodiella cernua* and *Lysimachia christinae* Hance. However, we discovered that the antimicrobial activity related to a particular use of some plants of which uses have been highly agreed among informants and corroborated with uses by distantly located cultures (e.g., use of *Eleusine indica* to treat fever and *Ageratum conyzoides* to treat cold) has not been studied yet. Our study describes ethnomedicinal uses of many species that have not been previously reported for similar use(s) elsewhere, in spite of their wide distributions. Some of those have a high degree of consensus, e.g., *Dianella ensifolia* which was used for treating colds, *Pellionia repens* which was used for treating ringworm, and *Toona sinensis* which was used for treating various infectious disorders including fever, dengue, and chicken pox. These pharmacologically unstudied plants should therfore be placed in high priority in bioscreening for new antimicrobial drugs.

Conclusions and perspectives

Common patterns of ethnomedicinal uses found within an ethnic group may be attributed to traditional knowledge of the tribe being transmitted vertically from their ancient ancestors, whereas common patterns of ethnomedicinal use found among ethnic groups living near to each other could have resulted from knowledge exchanged horizontally between them, or they could stem from independent discovery of therapeutic efficacy of the plant for ethnic groups with increased distance between them. The convergent uses of some plants reported in our study with those reported in the literature or ethnobotanical studies in distantly located cultures suggest that the bioactivity of a certain plant that may have been discovered independently. Many of the plants highlighted for possible efficacy in treatment of infections here (i.e., plants with high agreement in their uses) have been studied pharmacologically and their biological activities have been confirmed. Some plant uses with high agreement among informants were corroborated with ethnobotanical uses by distantly located cultures but have not been studied for their biological activities, whereas some have been reported in our study for the first time. These pharmacologically unstudied plants should therfore be of interest to pharmacologists and given high priority when bioscreening for new antimicrobial drugs. Considering that the data in this study includes many uses with only a few citations, future research in this field should expand the sampling of both ethnicities and communities to provide more robust evidence. This could be done by coordinating some of the many ethnobotanical activities in Thailand and produce common protocols. As far as making the information available to the community members, they were already briefed about the research when it was ongoing. This work was carried out as part of the program of the ethnobotany group of Chiang Mai University, which is actively engaged in making their research results available to the community, for example through popular books such as that of Trisonthi et al. (2018).

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Table 1 Sixteen villages in northern Thailand where medicinal plants used to treat infections were studied and compared in a cross-cultural context.

Table 2 Frequency of citation and number of medicinal plants used to treat each of the 21 categories of infection related disorders [sensu Cook (1995)]. Agreement in use refers to the uses mentioned by at least two informants.

Table 3 Agreement among 103 informants in 16 villages from seven ethnic groups, concerning the use of medicinal plants for the treatment of infections, number of citations, number of combined citations, number of distinct uses, and number of species mentioned for each type of agreement.

Table 1 Sixteen villages in northern Thailand where medicinal plants used to treat infections were studied and compared in a cross-cultural context.

Ethnic group	**Province**	**Village**	**Coordinates**	**Altitude (masl)**	**Number of key informants**	**Number of general informants**	**Language family**
Hmong	Chiang Mai	Khun Mae Wak	18°39’15.68”N, 98°28’28.00”E	1316	1	15	Hmong-Mien
Hmong	Nan	Manee Pruek 1	19°26’22.84”N, 101°04’11.35”E	1252	2	60	Hmong-Mien
Hmong	Nan	Khang Ho	19°07’59.44”N, 100°56’00.38”E	220	2	60	Hmong-Mien
Hmong	Nan	Song Khwae	18°51’49.22”N, 100°38’08.69”E	200	2	60	Hmong-Mien
Khamu	Nan	Huai Pook	18°53’52.81”N, 100°40’53.28”E	220	1	60	Austroasiatic
Khamu	Nan	Huai Satang	19°32’03.64”N,	300	3	60	Austroasiatic

			100°52’13.92”E				
Khamu	Nan	Nam Pan	19°26’14.49”N, 100°40’39.96”E	350	1	60	Austroasiatic
Lahu	Chiang Mai	Pang Kued	19°15’33.05”N, 98°55’17.46”E	900	2	15	Sino-Tibetan
Lisu	Chiang Mai	Khun Jae	19°19’34.54”N, 99°19’13.12”E	1369	1	15	Sino-Tibetan
Lua	Nan	Joon	19°08’40.35”N, 100°55’35.74”E	220	2	60	Austroasiatic
Lua	Nan	Manee Pruek 2	19°24’53.21”N, 101°04’42.18”E	1280	3	60	Austroasiatic
Lua	Nan	Toei Klang	19°13’38.03”N, 101°3’43.70”E	850	1	60	Austroasiatic
Mien	Nan	Huai Labaoya	18°54’31.56”N, 100°40’05.30”E	200	2	60	Hmong-Mien
Mien	Nan	Huai Sanao	19°08’07.19”N,	220	2	60	Hmong-Mien

			100°56’02.79”E				
Mien	Nan	Santiphap	18°59’33.71”N, 100°39’16.50”E	350	1	60	Hmong-Mien
Tai Yuan	Chiang Mai	Mae Kam Pong	18°51’57.94”N, 99°21’7.00”E	1042	2	15	Tai-Kadai

Table 2 Frequency of citation and number of medicinal plants used to treat each of the 21 categories of infection related disorders [sensu Cook (1995)]. Agreement in use refers to the uses mentioned by at least two informants.

Type of infections	**Disorder treated**	**Questionnaire**		**Agreement in use**	
		# plant species used	**Frequency of citation**	**# plant species used**	**Frequency of citation**
Unspecified	Fever	62	400	37	372
Bacterial	Cholera (in animals; e.g., chicken, horses, pigs)	6	27	3	24
Bacterial	Gonorrhea	2	7	1	6
Bacterial	Hordeolum	2	10	1	9
Bacterial	Leprosy (in dogs)	3	4	1	2
Bacterial	Meningitis	1	1	1	2
Bacterial	Venereal diseases	3	5	1	3
Fungal	Onychomycosis (*Tinea unguium*)	1	1	-	-
Fungal	Ringworm (Tinea/Eczema)	21	89	12	80
Fungal	*Tinea pedis* (Athlete's foot)	20	140	13	133
Helminth worm	Helminth worm infections (e.g., ascariasis, gnathostomiasis, tapeworm)	11	28	5	22

Protozoal	Malaria	5	12	2	9
Viral	AIDS	2	7	1	6
Viral	Chicken pox	9	55	5	51
Viral	Cold	19	79	16	76
Viral	Dengue	1	14	1	14
Viral	Hepatitis	8	20	5	17
Viral	Influenza	3	4	1	2
Viral	Measles	3	8	2	7
Viral	Rabies	1	2	1	2
Viral	Shingles (*Herpes zoster*)	12	42	6	35
	Total	143	955	96	870

Table 3 Agreement among 103 informants in 16 villages from seven ethnic groups, concerning the use of medicinal plants for the treatment of infections, number of citations, number of combined citations, number of distinct uses, and number of species mentioned for each type of agreement.

Type of agreement	**Number of citations**	**Number of combined citations**	**Number of distinct uses**	**Number of plant species**
No agreement	85	85	85	64
Between ethnic groups	331	68	15	12
Within ethnic groups	539	118	99	85
Between village	188	33	14	13
Within village	351	85	85	76
Total	955	271	199	143