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Assessment of the importance of medicinal plants among communities around Khiat Ngong of Southern Laos

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Abstract

A field survey was launched to identify medicinal plants growing in the Khiat Ngong wetlands and surrounding forested areas of Pathoumphone District, Champasak Province in southern Laos. In this area, 418 plants representing approximately 250 species, belonging to at least 200 genera in 93 families of vascular plants, are used by traditional healers to treat more than 95 symptoms. A large number of species are used for treating fever. At least 14 plant species have not been previously reported for having medicinal properties. At least 10 have previously been investigated and have shown interesting biological activity by other researchers, signaling promising candidates for income-generating activities.

Key words

Conservation, Lao PDR, Medical Ethnobotany, Wetlands

Introduction

The earliest practices of traditional medicine in the Lao People's Democratic Republic (Lao PDR – also known as "Laos") are unclear. It is evident that Buddhist and Sino-Indian influences helped shape the traditional pharmacopoeia and methods in disease treatments. Well-documented medicinal practices started as early as the 14th century, during the time of the state of Lane Xang. Since then, medical traditions have been passed down orally through the centuries among different ethnic groups, as well as by way of written documents, including mulberry paper books and palm leaf manuscripts. Today, undeveloped forest covers more than forty per cent of the country, and at least seventy percent of the population lives in rural areas as subsistence farmers (IUCN, 2001). As a result, in the event of health problems, one easily turns to inexpensive local traditional herbal remedies for treatment.

Laos' rich biodiversity provides a wealth of herbal medicines to the rural population. To illustrate, Laos holds four Global 200 Eco-regions. These regions are examples of the richest, rarest, and most distinct of the Earth's diverse natural habitats, critical for biodiversity conservation and global sustainability (Olson and Dinerstein, 1998). Because it is home to some of the most abundant and intact ecosystems on the Indochina Peninsula, in 1993 the government of Laos designated a National Protected Area (NPA) network to conserve the key habitats and diverse ecosystems to help protect this important and beautiful area. It may be noted that at that time, the act of setting aside the protected natural areas was very progressive in the Indo-Malayan Realm (Berkmeuller *et al.,* 1995). Thus, today this network of 20 NPAs covers 14% of the country (MAF, 2005).

Understanding and taking appropriate measures to conserve this biodiversity may help to (a) reduce rural poverty and to significantly increase household incomes of the rural poor, (b) increase local trade of forest products, (c) secure equitable land access and tenure for forest related resources, and to (d) enhance restored forests (IUCN, 2010). There are additional reasons to encourage the sustainable use of wild medicinal plants. Over-harvesting and monoculture can lead to genetic loss, which will impair the opportunities of our children and future generations (Understanding Evolution, 2013). The use of medicinal plants can also help reduce the use of organ parts from wild animals, which are lost more rapidly as compared to plants.

One of Laos' NPA's, the Xe Pian NPA in southern Laos, covers more than 240,000 hectares (2,400 km^2) with a perimeter of 360 km. It contains large undisturbed landscapes and is one of the most important nature reserves in Laos, renowned for its extensive wetlands. Xe Pian ranks in the top 3 NPAs in Laos and in the top 10 in Southeast Asia (Ling 1999). It contains more than 29 different ecosystem types, which provide necessary habitats for a variety of wildlife. About 40 percent of the Xe Pian NPA harbors high-density evergreen/mixed forest. Another thirty percent is covered by medium-density evergreen/mixed forest, along with fifteen percent deciduous continuous cover. The remaining fifteen percent is broken up into evergreen/mixed mosaic, deciduous mosaic, evergreen wood and shrublands, grasslands, dry wood and shrublands, agricultural lands, and wetlands (Claridge, 1996).

Materials and Methods

Study Site : The survey took place in Pathoumphone District, Champasak province, in July 2009, and covered a distance of survey route of more than 35 km (Fig. 1).

Survey Team : The survey team consisted of a representative from the Institute of Traditional Medicine (ITM), a representative from the Champasak Provincial Agriculture and Forestry Office (PAFO), a local healer/guide, an ethnobotany researcher, and a photographer. Before the initiation of each excursion, the team met with the village heads to discuss the purpose of the trip and the field agenda for each activity. Each of the village heads then identified a local traditional healer who would guide the research team.

Data Recording : In order to give the healers more opportunity to identify which plants they use, they were asked to select the survey routes. Typical routes included a main dirt road or a smaller trail through the forest, or through wetlands or along a river by boat. Each healer led the team, stopping to point out plants along the way. Two members of the team kept records of the plants pointed out by the healers in the Lao language and script, while the third researcher kept a record of the common name of the plant in the Lao language and in the Roman script. Notes included the plant part, the disease, and a brief description of the plant. Through use of a Garmin GPSMAP 76CSx receiver, GPS coordinates and survey altitudes were also recorded. Other information recorded included new sightings of plants that had been reported by previous healers, sightings of plants noted for medicinal properties by other parties, and plants that could not be identified by the healer or research team. Two of the researchers also took photos of the plants. The ethnobotanical interviews were conducted as part of a University of Illinois at Chicago (UIC) IRB- approved ethnobotanical research protocol (#2007-0369).

Numbered voucher herbarium specimens were collected to document the interviews for select plants that were bearing fruit or flowers, and notes on their field characteristics, collection location, collection date, as well as other relevant field data were recorded. These specimens serve as an important record of the plant and are imperative for accurate taxonomic identification. If the plant was large enough and held enough fruits or flowers, up to six herbarium specimens were collected. Each of these specimens consisted of a clipping of around 20 cm long of a plant part holding leaves and fruits and/or flowers. To keep the specimens from mold, they were pressed flat into newspapers, bundled, and soaked in a mixture of water and ethanol. The bundles were placed in a heavy-duty plastic bag and sealed. After returning to the laboratories in Vientiane, the plastic bags were opened and the specimens were removed from each bundle to be pressed in new, dry newspapers. They were then stacked between corrugated cardboard and dried in a heated metal box.

Two sets of fully dried herbarium specimens and their respective field data were deposited at the ITM's herbarium in Vientiane, while the remaining sets were sent to the John G. Searle Herbarium of the Field Museum of Natural History in Chicago, USA. Taxonomic determination was initially performed at the herbarium of the ITM and later finalized at the Field Museum herbarium in Chicago. If no herbarium specimens were collected, tentative identifications were made based on comparison of photographs with identified specimens, and by using the common names in published works, including those by Vidal (1959), Inthakoun and Delang (2011), Ho (1993) and the ITM (2007).

Data Analysis : At the end of each day, notebooks were cross-checked for consistency of common plant names, diseases, and plant parts. A typed list was then compiled by two of the researchers; one in the Lao script and language, another in the Roman script and English language. Both lists contained the plant common name, the disease treated, and the plant part used. These lists were combined into a single Excel spreadsheet that included data on the GPS coordinates, the scientific names (if available at that time), and the dates. If the

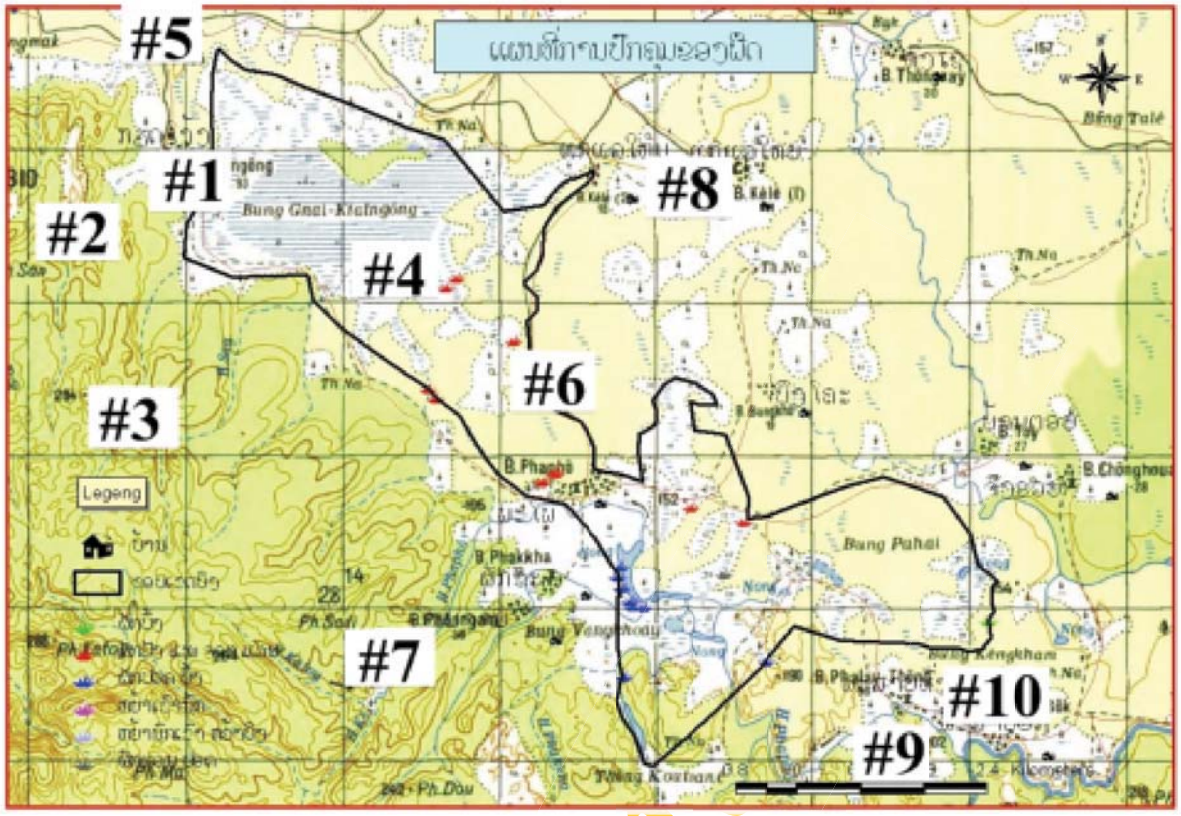

Fig. 1 : Map of the study site. This map depicts the study sites in Khiat Ngong wetlands of southern Laos, marked by numbers. Map adapted from IUCN (2009).

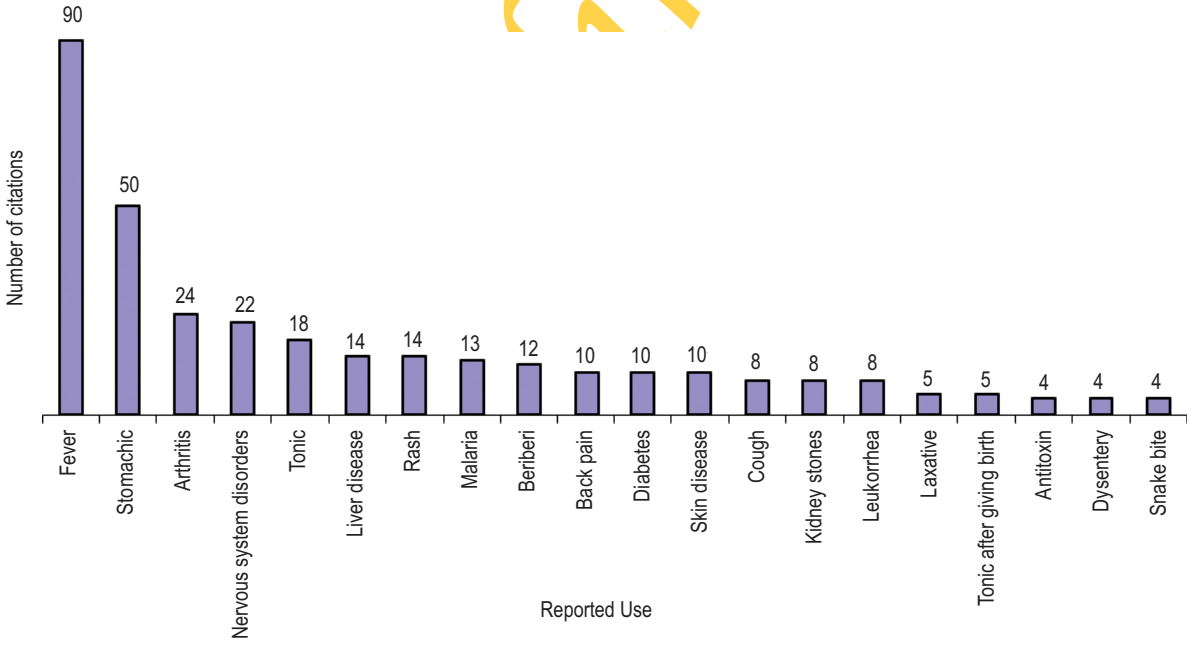

Fig. 2 : Most commonly reported uses of medicinal plants. These uses for medicinal plants were reported four or more times by the healers.

Table 1 : Informant Agreement ratio

Use	Number of use reports (N_{ur})	Number of taxa used (N_t)	*IAR*
Leukorrhea	8	7	0.14
Fever	90	79	0.12
Arthritis	24	22	0.09
Malaria	13	12	0.08
Stomachic	50	48	0.04

The Informant Agreement Ratio (IAR) for different ailment categories showed a slight level of consensus for only five of the ailments mentioned, according to the formula IAR = (Nur – Nt)/(Nur – 1). Values approaching 1 signal consensus

Table 2 : Most commonly used medicinal plants

Plant local name	Scientific name	Plant part used	Traditional use in Laos	Usefulness in public health
Dok Hak	*Calotropis gigantea* (L.) W.T. Aiton (Asclepiadaceae)	latex	Dog bite	Topical application of this plant speeds up wound-healing (Deshmukh *et al.,* 2009). It is a procoagulant and aids in blood clot hydrolysis (Rajesh *et al.,* 2005). Oral ingestion in rats has exhibited analgesic, anticonvulsant, anxiolytic and sedative effects (Argal and Pathak, 2006; Pathak and Argal, 2007).
Kheuah Khao Ho	*Tinospora crispa* (L.) Hook. f. & Thomson (Menispermaceae)	rhizome, stem	Malaria	Antimalarial effect seen in vivo in mice with *Plasmodium yoelii* treated with a crude extract of *Tinospora crispa* (Rungruang and Boonmars 2009). Antimalarial effect also demonstrated by Najib *et al.* (1999).
Khi Fai Nohk Khoum	*Elephantopus scaber* L. (Asteraceae)	root	Tonic	This plant has a marked hepatoprotective effect (Lin *et al.* 1995; Lin *et al.* 1991; Rajesh and Latha 2001).
Kohk Khoun	*Cassia fistula* L. (Fabaceae)	stem	Laxative	A natural anthraquinone laxative, also documented in Nigeria (Abo *et al.* 2001).
Mai Sak	*Tectona grandis* L. f. (Verbenaceae)	root	Stomachic, Dysentery	Extracts reduce gastric mucosal injury, possibly by inhibition of the proton pump (Singh *et al.,* 2010). A bark extract inhibited *Listeria monocytogenes* and methicillin resistant *Staphylococcus aureus* (Neamatallah *et al.,* 2005). Lapachol, a naphthaquinone isolated from the roots, was found to have an anti-ulcerogenic effect in rats and guinea pigs (Goel *et al.,* 1987).
Mak Lin Mai	*Oroxylum indicum* (L.) Kurz (Bignoniaceae)	root	Fever, Malaria, and Rash	This plant also has documented use in Nepal (Joshi and Joshi, 2005). Root bark has the ability to enhance immune responses, which may be beneficial for all three of these ailments. The root bark also has documented antioxidant properties (Zaveri *et al.,* 2006).
Mouk Nyai	*Holarrhena antidysenterica* (L.) Wall. (Apocynaceae)	root, stem	Diarrhea	This plant has been observed as an anti-diarrheal agent (Gilani *et al.,* 2010; Kavitha *et al.,* 2004), and contains alkaloids that inhibit *Escherichia coli* adhesion (Kavitha and Niranjali, 2009). However, pyrrolizidine alkaloids have been isolated from it and it has exhibited hepatotoxic properties (Arseculeratne *et al.,* 1981).
Nya Mak Khai Lang	*Phyllanthus urinaria* L. (Euphorbiaceae)	whole plant	Back pain	Glochidone and stigmasterol both exhibit activity against neurogenic and inflammatory pain (Catapan *et al.,* 2009). Gallic acid ethyl ester produces systemic, spinal and supraspinal antinociception in mice (Santos *et al.,* 1999).
Philah	*Punica granatum* L. (Punicaceae)	leaf, stem	Intestinal parasites	The compounds ellagic acid, gallagic acid, punicalins, and punicalagins exhibited antimicrobial activity against *Escherichia coli, Pseudomonas aeruginosa, Candida albicans, Cryptococcus neoformans,* methicillin-resistant *Staphylococcus aureus* (MRSA), *Aspergillus fumigatus* and *Mycobacterium intracellulare* (Reddy *et al.,* 2007). Extracts also active against *Entamoeba histolytica* (Calzada *et al.,* 2006), and intracellular amastigotes causing leishmaniasis (Garcia *et al.,* 2010).
Tua Sa Det	*Sophora japonica* L. (Fabaceae)	leaf	Fever with rash	Major source of the antiinflammatory agent, sophoricoside (Kim *et al.,* 2003; Min *et al.,* 1999).
Wan Fai	*Zingiber cassumunar* Roxb. (Zingiberaceae)	leaf, rhizome	Stomachic	Contains (E)-1-(3,4-dimethoxyphenyl) but-1-ene, resulting in antiinflammatory and analgesic activity (Ozaki *et al.,* 1991).

These are ten of the most commonly used medicinal plant species identified through this research and also identified by other independent research. The plants have biomedically-confirmed beneficial health properties for the same or similar ailments that were cited by the healers in Laos. Plants are listed by alphabetical order of the common name

healer had said that the plant could be used to treat multiple ailments, a separate entry was created for each ailment.

A library and online search were performed using the collected plant's scientific name as the search term. This helped to determine whether a species in the list had been previously recorded with the same or different medicinal uses in the literature or whether the species has biomedical experimental data that support the healing qualities claimed by the healers. The following online databases were searched: NAPRALERT[sm] (http://www.napralert.org/), SciFinder® (www.cas.org/products/sfacad/index.html), PubMed (www.ncbi.nlm.nih.gov/pubmed), embase® (www.elsevier.com/wps/find/bibliographicdatabasedescription.cws_home/523328/ description#description), and the Web of Science® (thomsonreuters.com/products_services/science/science_products/a-z/web_of_science/).

While the purpose of this study was qualitative, an attempt was made to extract some quantitative data by looking at the degree of consensus among the healers' reports through the use of the Informant Agreement Ratio (*IAR*) (Trotter and Logan 1986). This formula compares the frequency of an ailment mentioned by the healers to the number of remedies used to treat that ailment. The values range from 0.00 to 1.00, where a higher value indicates a greater consensus among healers about a remedy. The following formula is used: $IAR = (N_{ur} - N_t)/(N_{ur} - 1)$, where N_{ur} designates the number of times that a plant is reported for a specific use and N_t is the total number of species used by all of the informants for that use.

Results and Discussion

Seven male healers participated in the study, ranging from 44 to 72 years old, with an average age of 59 years. While the importance of surveying both males and females has been demonstrated (Pfeiffer and Butz, 2005), this study made no preference as to the gender of the healers, and all the healers who were chosen by the heads of each village happened to be males. A total of 750 plants were recorded, some of them more than once. A list of 331 different individual plants used to treat more than 95 symptoms was prepared. Duplicate sets of the herbarium specimens of 116 collections were deposited at ITM Herbarium in Vientiane and at John G. Searle Herbarium at the Field Museum of Natural History in Chicago, USA. Of 387 collections identified to the species level, 350 were of medicinal use. Due to time constraints, not all plants that were seen could be recorded. This study supports the findings reported in other ethnobotanical studies, namely that common species are more likely to be reported for their medical value than rare species (Johns and Kimanani 1991; Johns *et al.,* 1990; Phillips 1996). Indeed, majority of medicinal plants cited in this study were found commonly throughout Laos.

Consistent with reports from other parts of Laos, the majority of medicinal plants cited by the healers were used to treat fever (Elkington *et al.,* 2012), as depicted in Fig. 2. Many plants identified in the present survey were also used to treat multiple ailments by individual healers, but *Ficus glomerata* Roxb. was the only plant reported by two separate healers to treat the same affliction, namely, fever. Although fever is often associated with malaria, which is frequent in Laos, fevers are indicative of many other ailments. This separation between malaria symptoms and other fevers was demonstrated by four of the healers in this study, who cited plants specifically used for malaria (*khai nyoung*). It is also interesting to note that liver disease was among the ten most commonly treated ailments. It has been reported that liver cancer is the leading cancer among the people of Laos (WHO, 2008), with lower survival rates than those seen in many other ethnic and national groups (Kwong *et al.,* 2010). The Informant Agreement

Table 3 : Plants with no previous biomedical research found

Local name	Scientific name	Family	Plant part used	Traditional use in laos
Ehn Ohn	*Cleghornia malaccensis* (L.) W.T. Aiton	Apocynaceae	root	Beriberi
Ii Tou Pa	*Hedyotis macrosepala* L.	Rubiaceae	root, stem	Arthritis and tonic
Kan Tohng	*Colubrina javanica* Kurz.	Rhamnaceae	fruit, leaf, root	Fever
Kheuah Khao Kep	*Jasminum nobile* Clarke.	Oleaceae	stem	Tuberculosis, nervous system disorders
Khem Nyai or Khem Xang	*Ixora balansae* Bartl. ex DC.	Rubiaceae	root	Fever
Kohk Khao San	*Memecylon harmandii* Guill.	Melastomaceae	branch and stem	Diabetes
Nya Kohm Pao	*Scleria kerrii* Turrill	Cyperaceae	root	Beriberi and Edema
Sai Kai Noy	*Jasminum nervosum* Lour.	Oleaceae	root and stem	Stomachic
Sam Koy Kheuah	*Hiptage candicans* Hook.f. var. *latifolia* Nied.	Malpighiaceae	stem	Stomachic
Xii Nam	*Actephila championiae* (Dalzell) Müll. Arg.	Euphorbiaceae	stem	Stomachic / Distended stomach
Tang Beu or Dok Meng Ka Bheuah	*Mussaenda densiflora* Ridl.	Rubiaceae	stem	Nervous system disorders, Back pain tonic when mixed with EtOH.

This table lists the eleven plants cited in this survey for which no previous biomedical research has been found. Plants are listed by alphabetical order of the common name

Table 4 : Most commonly used medicinal plants

Local Name	Scientific name	Family
Dheuah Kieng	*Ficus glomerata* Roxb.	Moraceae
Dok Deng	*Pterocarpus indicus* L.	Fabaceae
Dok Euang	*Costus speciosus* (J. König) Sm.	Costaceae
Dok Sohn Noy	*Jasminum sambac* (L.) Aiton	Oleaceae
Hem Kheuah	*Coscinium usitatum* P.	Menispermaceae
Hing Hai	*Crotalaria* sp.	Fabaceae
Hohm Seng Meuang	*Flemingia latifolia* Benth.	Fabaceae
Hua Sam Sip	*Stemona cochinchinensis* Gagn.	Stemonaceae
Ii Tou Pa	*Mentha arvensis* L.	Lamiaceae
Jan Deng	*Pterocarpus indicus* L.	Fabaceae
Ka Ka Lao	*Lagerstroemia macrocarpa* Wall.	Lythraceae
Kha Nheng Nyai	*Limnophila aromatica* (Lam.) Merr.	Plantaginaceae
Khen Nang	Undetermined	
Kheuah Ba Bohn	*Entada glandulosa* Gagnep.	Fabaceae
Kheuah Houn	Undetermined	
Kheuah Kap Kay Noy	*Epidendrum* sp.	Orchidaceae
Kheuah Khao Kep	*Jasminum nobile* Clarke.	Oleaceae
Kheuah Khao Mouak	*Securidaca inappendiculata* Hassk.	Polygalaceae
Kheuah Lin Het	*Tetracera loureiri* (Finet & Gagnep.) Pierre ex Craib	Dilleniaceae
Kheuah Mak Hen / Padohng Ngo	*Tiliacora* cf. *triandra* Diels	Menispermaceae
Kheuah Mak Tek	*Celastrus paniculatus* Willd.	Celastraceae
Kheuah Xai Xou	*Capparis horrida* L.	Capparidaceae
Kheuah Sai Tan	*Aganosma marginata* (Roxb.) G. Don.	Apocynaceae
Khem Deng	*Ixora stricta* Roxb.	Rubiaceae
Khem Khao	*Ixora pendula* Jack	Rubiaceae
Khi Fai Nohk Koum	*Elephantopus mollis* L.	Asteraceae
Khi Hen	*Vitex altissima* L.f.	Verbenaceae
Khi Min Kheuah	*Combretum latifolium* Roxb.	Combretaceae
Khi Min Pa	*Curcuma* sp.	Zingiberaceae
Kohk Bohk	*Irvingia malayana* Oliver	Irvingiaceae
Kohk Dou	*Pterocarpus macrocarpus* Kurz.	Fabaceae
Kohk Kahn	*Canarium* sp.	Burseraceae
Kohk Mak San	*Dillenia indica* L.	Dilleniaceae
Kohk Mak Som Po	*Tetramyxis pellegrinii* Gagn.	Simarubaceae
Kohk Pohk	*Parinari anamensis* Hance	(Rosaceae
Kohk Sa Kham	*Dalbergia* sp.	Fabaceae
Kohm Koy Loht Khohn Nam	*Desmodium heterocarpon* DC.	Fabaceae
Lep Meu Nang	*Schefflera elliptica* Harms.	Araliaceae
Ma Ha Mek	*Croton argyratus* Blume	Euphorbiaceae
Mai Xak	*Tectona grandis* L.	Verbenaceae
Mak Ka Dam Phii	*Cymbidium* sp.	Orchidaceae
Mak Khi Mou	*Ormosia cambodiana* Gagn.	Fabaceae
Mak Lin Mai	*Oroxylum indicum* Vent.	Bignoniaceae
Mii Hohm	*Litsea* sp.	Lauraceae
Niao Deng	*Jatropha gossypifolia* L.	Euphorbiaceae
Nohm Yan	*Barringtonia pauciflora* King	Lecythidaceae
Nya Khiou / Sap Heng	*Eupatorium odoratum* DC.	Asteraceae
Nya Kohm Pao	*Scleria kerrii* Turrill	Cyperaceae
Phai Song Khao	*Toxocarpus villosus* (Blume) Decne.	Asclepiadaceae
Phak Kout Noy	*Lycopodium* sp.	Lycopodiaceae
Phak Mai	Undetermined	
Phak Poht Kohk / Kao Bohk	*Catharanthus roseus* G. Don.	Apocynaceae
Phak Wen	Undetermined	
Phii Phouan	*Uvaria rufa* Blume	Annonaceae
Pik Kai Dam	*Clinacanthus nutans* (Burm.)	Acanthaceae
Phou Pa	*Piper* sp.	Piperaceae

Siao Kheuah	*Bauhinia pottsii* G. Don	Fabaceae
Xii Nam	*Actephila championiae* (Dalzell) Müll. Arg.	Euphorbiaceae
Sohm Kohp	*Hymenodictyon excelsum* Wall.	Rubiaceae
Sa Mat Khiao / Sa Mat Nyai	*Micromelum falcatum* (Lour.) Tanaka	Rutaceae
Tang Beu / Dok Meng Ka Bheuah	*Mussaenda densiflora* Ridl.	Rubiaceae
Tin Tang	*Anomianthus dulcis* Schumach. & Thonn. or *Uvaria cordata* Schumach. & Thonn.	Annonaceae
Tong Pa	Undetermined	
Toum Ka Kheuah	*Strychnos nux-blanda* A. W. Hill or *S. lucida* R.Br.	Loganiaceae

These plants were the most commonly reported for having medicinal uses by the healers. All of the plants in this table were reported by at least two different healers. The plants are listed in alphabetical order of their common names

Ratio (IAR) showed a slight level of consensus around only five of the ailments mentioned, according to the formula IAR = (Nur – Nt)/ (Nur – 1). Values approaching 1 signal more consensus. For others, each time that an ailment was mentioned, a new plant was proposed for its treatment (Table 1).

Table 2 illustrates the efficacy of some plants, as demonstrated by literature review. These plants were common throughout the region. Because of a growing interest in medicinal plants and rural hiking-based tours, local tour-guides can point out these plants and their uses to tourists, citing that results of biomedical research supports traditional uses. All of these plants can be harvested and sold at local markets, as well as used medicinally by the local population.

No previous biomedical research was found for the plants listed in Table 3, signaling the potential for collaboration between the local population and research institutions. Within this context, a new, sustainable supply of medicinal plants may be an integral component of economic development (Bennett, 1992; Reid *et al.,* 1993). Table 4 lists the plants that were most commonly reported. All of these plants were reported by at least two different healers.

The major obstacles faced in this study were translation difficulties and inconsistencies in plant common names. Some of the common names of the plants cited by the healers referred to more than one species. For example, *Tin Tang* was reported by the same healer for two different plants. *Toum Ka Kheuah* was cited by two different healers, referring to two different species of the same genus, in both cases to treat fever.

It was unfortunate that more time could not be spent with each healer. It is often believed that a plant part should be collected during a certain season and/or time of day for maximum efficacy. Being able to observe collection procedures by the healers should allow these and similar questions to be answered. It would also be beneficial to widely distribute names and photographs of medicinal plants for younger generations, emphasizing that the use of plants for medicine is more sustainable than the use of wild animals.

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References

Abo, K.A., A.A. Adeyemi and A.O. Sobowale: Microscopic evaluation and seasonal variations of anthraquinone glycosides of cultivated *Cassia fistula* Linn. *Afr. J. Medi. Med. Sci.,* **30**, 9-12 (2001).

Argal, A. and A.K. Pathak: CNS activity of *Calotropis gigantea* roots. *J. Ethnopharmacol.,* **106**, 142-145 (2006).

Arseculeratne, S.N., A.A. Gunatilaka and R.G. Panabokke: Studies on medicinal plants of Sri Lanka: Occurrence of pyrrolizidine alkaloids and hepatotoxic properties in some traditional medicinal herbs. *J. Ethnopharmacol.,* **4**, 159-177 (1981).

Bennett, B.C.: Plants and People of the Amazonian Rainforests. *Bioscience,* **42**, 599-607 (1992).

Berkmeuller, K., T. Evans, R. Timmins and V. Vongphet: Recent advances in nature conservation in the Lao PDR. *Oryx,* **29**, 253-260 (1995).

Calzada, F., L. Yepez-Mulia and A. Aguilar: In vitro susceptibility of *Entamoeba histolytica* and *Giardia lamblia* to plants used in Mexican traditional medicine for the treatment of gastrointestinal disorders. *J. Ethnopharmacol.,* **108**, 367-370 (2006).

Catapan, E., F.N. Moreno, M. Luis Busi da Silva, M.F. Otuki, R. Niero, V.C. Filho, R. Augusto Yunes and A.M. Viana: Protocols for in vitro culture and phytochemical analysis of *Phyllanthus* species (Euphorbiaceae). *Meth. Mole. Biol.,* **547**, 167-177 (2009).

Claridge, G.: An Inventory of Wetlands of the Lao PDR. Bangkok, Thailand: White Lotus Press (1996).

Deshmukh, P.T., J. Fernandes, A. Atul and E. Toppo: Wound healing activity of *Calotropis gigantea* root bark in rats. *J. Ethnopharmacol.,* **125**, 178-181 (2009).

Elkington, B.G., K. Sydara, J.F. Hartmann, B Southavong and D.D. Soejarto: Folk epidemiology recorded in palm leaf manuscripts of Laos. *J. Lao Studies,* **4**, 1-14 (2012).

Garcia, M., L. Monzote, A.M. Montalvo and R. Scull: Screening of medicinal plants against *Leishmania amazonensis*. *Pharmaceutical Biol.,* **48**, 1053-1058 (2010).

Gilani, A.H., A. Khan, A.U. Khan, S. Bashir, N.U. Rehman and S.U. Mandukhail: Pharmacological basis for the medicinal use of *Holarrhena antidysenterica* in gut motility disorders. *Pharmaceutical Biol.*, **48**, 1240-1246 (2010).

Goel, R.K., N.K. Pathak, M. Biswas, V.B. Pandey and A.K. Sanyal: Effect of lapachol, a naphthaquinone isolated from *Tectona grandis*, on experimental peptic ulcer and gastric secretion. *J. Pharmacy Pharmacol.*, **39**, 138-140 (1987).

Ho, P.H. and Cay Co Viet Nam: An Illustrated Flora of Viet Nam. Three vols. Montreal: Mekong Printing (1993).

Inthakoun, L., C.O. Delang and Lao Flora: A checklist of plants found in Lao PDR with scientific and vernacular names. Morrisville, NC: Lulu Enterprises, Inc., (2011).

ITM. Medicinal Plants and Herbs of Laos. Vol. 1. Vientiane, Lao PDR: Traditional Medicine Research Center, Ministry of Public Health (2007).

IUCN. The Role of Forest Food Resources in Village Livelihood Systems: A Story of three villages in Saravan, Lao PDR. Vientiane (2001).

IUCN. Map of the Kiatngong Wetlands (2009).

IUCN. About Livelihoods and Landscapes. Gland, Switzerland, 2010. International Union for Conservation of Nature. June 11, 2013. <http://www.iucn.org/about/work/programmes/forest/fp_our_work/fp_our_work_initiatives/fp_our_work_ll/fp_livelihoods_landscapes_about/>.

Johns, T. and E.K. Kimanani: Test of a chemical ecological model of the origins of medicinal plant use. *Ethnobotany*, **3,** 1-10 (1991).

Johns, T., J.O. Kokwaro and E.K. Kimanani: Herbal remedies of the Luo of Siaya District, Kenya: Establishing Quantitative Criteria for Consensus. *Economic Botany*, **44**, 369-381 (1990).

Joshi, A.R. and K. Joshi: Ethnobotany and Conservation of Plant Diversity in Nepal: Status, Bibliography and Agenda for Sustainable Management. Kathmandu: RubRick, 2005.

Kavitha, D., and S. Niranjali: Inhibition of enteropathogenic *Escherichia coli* adhesion on host epithelial cells by *Holarrhena antidysenterica* (L.) WALL. *Phytoth. Res.,* **23**, 1229-1236 (2009).

Kavitha, D., P.N. Shilpa and S.N. Devaraj: Antibacterial and antidiarrhoeal effects of alkaloids of *Holarrhena antidysenterica* WALL. *Ind. J. Experi. Biol.,* **42**, 589-594 (2004).

Kim, B.H., E.Y. Chung, B.K. Min, S.H. Lee, M.K. Kim, K.R. Min and Y. Kim: Anti-inflammatory action of legume isoflavonoid sophoricoside through inhibition on cyclooxygenase-2 activity. *Planta Medica*, **69**, 474-476 (2003).

Kwong, S.L., S.L. Stewart, C.A. Aoki and Jr. M.S. Chen: Disparities in hepatocellular carcinoma survival among Californians of Asian ancestry, 1988 to 2007. *Can. Epidemiol. Biomar. Prev.,* **19**, 2747-2757 (2010).

Lin, C.C., C.C. Tsai and M.H. Yen: The evaluation of hepatoprotective effects of Taiwan folk medicine. *J. Ethnopharmacol.,* 45, 113-123 (1995).

Lin, C.C., M.H. Yen and H.F. Chiu: The pharmacological and pathological studies on Taiwan folk medicine (VI): The effects of *Elephantopus* scaber subsp. oblanceolata, *E. mollis* and *Pseudoelephantopus spicatus*. *Ame. J. Chin. Med.,* **19**, 41-50 (1991).

Ling, S.: Biological System of Prioritization for Protected Areas in the Lao PDR. Vientiane: The Wildlife Conservation Society (1999).

MAF.: National Forest Cover Assessment. Vientiane: Ministry of Agriculture and Forestry (2005).

Min, B., S.R. Oh, H.K. Lee, K. Takatsu, I.M. Chang, K.R. Min and Y. Kim: Sophoricoside analogs as the IL-5 inhibitors from *Sophora japonica*. *Planta Medica,* **65**, 408-412 (1999).

Najib Nik A., N. Rahman, T. Furuta, S. Kojima, K. Takane and M. Ali Mohd: Antimalarial activity of extracts of Malaysian medicinal plants. *J. Ethnopharmacol.*, **64**, 249-254 (1999).

Neamatallah, A., L. Yan, S.J. Dewar and B. Austin: An extract from teak (Tectona grandis) bark inhibited *Listeria monocytogenes* and methicillin resistant *Staphylococcus aureus*. *Letters App. Microbiol.,* 41.1, 94-96 (2005).

Olson, D.M. and E. Dinerstein: The Global 200: A representation approach to conserving the earth's most biologically valuable ecoregions. *Conserv. Biol.*, **12**, 502-515 (1998).

Ozaki, Y., N. Kawahara and M. Harada: Anti-inflammatory effect of *Zingiber cassumunar* Roxb. and its active principles. *Chem. Pharm. Bull.*, **39**, 2353-2356 (1991).

Pathak, A.K. and A. Argal: Analgesic activity of *Calotropis gigantea* flower. *Fitoterapia,* **78**, 40-42 (2007).

Pfeiffer, J.M. and R.J. Butz. Assessing cultural and ecological variation in ethnobiological research: The importance of gender. *J. Ethnobiol.,* **25**, 240-278 (2005).

Phillips, O.L.: Some quantitative methods for analysing ethnobotanical knowledge. Selected Guidelines for Ethnobotanical Research: A Field Manual. Ed. Alexiades, MN. Bronx, New York The New York Botanical Garden, 171-197 (1996).

Rajesh, M.G. and M.S. Latha: Hepatoprotection by *Elephantopus scaber* Linn. in CCl4-induced liver injury. *Ind. J. Physiol. Pharmacol.*, **45**, 481-486 (2001).

Rajesh, R., Raghavendra, C.D. Gowda, A. Nataraju, B.L. Dhananjaya, K. Kemparaju and B.S. Vishwanath: Procoagulant activity of *Calotropis gigantea* latex associated with fibrin (ogen) olytic activity. *Toxicon,* **46**, 84-92 (2005).

Reddy, M.K., S.K. Gupta, M.R. Jacob, S.I. Khan and D. Ferreira: Antioxidant, antimalarial and antimicrobial activities of tannin-rich fractions, ellagitannins and phenolic acids from *Punica granatum* L. *Planta Medica,* **73**, 461-467 (2007).

Reid, W.V., S. Laird, C. Meyer, R. Gamez, A. Sittenfeld, D. Janzen, M Gollin and C. Juma: Biodiversity Prospecting: Using resources for sustainable development. Washington, D.C.: World Resources Institute (1993).

Rungruang, T. and T. Boonmars: In vivo antiparasitic activity of the Thai traditional medicine plant--*Tinospora crispa*--against *Plasmodium yoelii*. *Southeast Asi. J. Tropical Medi. Pub. Hlth.,* **40**, 898-900 (2009).

Santos, A.R., R.O. De Campos, O.G. Miguel, V. Cechinel-Filho, R.A. Yunes and J.B. Calixto: The involvement of K+ channels and Gi/o protein in the antinociceptive action of the gallic acid ethyl ester. *Euro. J. Pharmacol.,* **379**, 7-17 (1999).

Singh, N., N. Shukla, P. Singh, R. Sharma, S.M. Rajendran, R Maurya and G. Palit: Verbascoside isolated from *Tectona grandis* mediates

gastric protection in rats via inhibiting proton pump activity. *Fitoterapia*, **81**, 755-761 (2010).

Trotter, R.T. and M.H. Logan: Informant consensus: A new approach for identifying potentially effective medicinal plants. Plants in indigenous medicine and diet. Bedford Hills, New York: Redgrave, 91-112 (1986).

Understanding Evolution. Monoculture and the Irish Potato Famine: cases of missing genetic variation. Berkeley, 2013. Ed. Evolution, U. University of California Museum of Paleontology. June 11, 2013.

Vidal, J.: Noms Vernaculaires de Plantes en Usage au Laos. Extrait du Bulletin de l'Ecole Francaise d'Extrême-Orient, Tome XLIX, fascicule 2. Paris: l'Ecole Francaise d'Extrême-Orient (EFEO) (1959).

WHO. International Agency for Research on Cancer: GLOBOCAN 2008 Fast Stats: Lao People's Democratic Republic. 2008. World Health Organization. May 8, 2012.

Zaveri, M., P. Gohil and S. Jain: Immunostimulant activity of n-butanol fraction of root bark of *Oroxylum indicum*, vent. *J. Immunotoxicol.*, **3**, 83-99 (2006).