Ethnomedicinal Knowledge of Pwo People in Northern Thailand

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Abstract
Background: Northern Thailand is the home of many ethnic groups who possess great knowledge of ethnomedicine, so it is the location with the highest number of ethnobotanical studies in Thailand. However, the Pwo have never been included in. Therefore, this study is the first ethnobotanical study of Pwo people.

Methods: In this study, 50 Pwo informants from 8 villages in Omkoi district were interviewed about their ethnomedicinal knowledge. They were asked about the vernacular name(s) and uses of plant species found in their villages and nearby forests.

Results: A total of 122 ethnomedicinal species with 930 use-reports were recorded. Leaves were the most preferred plant part and decoction was the most preferred preparation method. Herbs were the most favored life form of ethnomedicinal plants used by Pwo people. Asteraceae, Fabaceae, and Zingiberaceae were the three most dominant plant families, which contributed 22% of the total species. Most plants with high Use value (UV) values were common species which also found and reported in other ethnobotanical studies however, the exception was Garcinia pedunculata Roxb. ex Buch.-Ham. Although only a single individual was found in nearby forests, but it was commonly used by Pwo people in the studied sites. The five ailments with high recorded IAR included: injuries, muscular-skeletal system, pain, respiratory systems, and digestive systems. These ailments were directly related to the life-style of Pwo people.

Conclusion: The comparison between the species found in this study and a study of Sgaw Karen in a nearby area showed that their knowledge differed from each other in both species and their uses despite their close proximity. The results emphasize the importance and the need of ethnobotanical studies although in the areas where many studied have been carried out. The more understanding of the traditional knowledge would increase our chance of understanding and identification of medicinal properties of plants. The results would lead to the discovery and development of new pharmaceutical substances to improve human life quality.

Background
Since the dawn of civilization, humans have had to cope with various diseases. Medicinal plants were
one of the keys to prolonging human life [1], and civilization. Until now, medicinal plants still have an important role in daily life, especially for people who live in rural areas which included about half the global population [2]. Moreover, 90% of the population in developing countries still rely on traditional medicinal plants for their primary health [3]. The uses of medicinal plants differ from place to place and ethnicity to ethnicity depending on the plant diversity around them. Southeast Asia is the harbor of biodiversity and cultural diversity which is reflected in the great variety systems of traditional medicine [4]. Ethnobotany of medicinal plants examines the relationship between biological and cultural parts of the environment [5]. Ethnobotanical study of medicinal plants is an important key to bringing local medicinal plant knowledge into the purview of science and conserving them.

Northern Thailand is home to more than 20 ethnic groups [6]. These ethnic groups possess unique ethnobotanical knowledge which differs between groups. Despite the rich diversity in both ethnicity and plants, there have been only about 20 ethnobotanical publications from northern Thailand and only seven publications about Karen [4,7–12]. This is the highest number for any ethnic group. However, all these Karen ethnobotanical publications focus only Sgaw Karen, which was the largest group of Karen. There was no earlier Pwo ethnobotanical publication, so this is the first publication of Pwo ethnobotanical research.

In this study we investigated the ethnomedicinal plants used by Pwo people to i) document the ethnomedicinal knowledge of Pwo people for their ethnomedicinal plants which included the details of preparations and application, ii) compare the uses of medicinal plant by Pwo people to the medicinal plants used elsewhere in Thailand iii) compare the importance of each ethnomedicinal species to the Pwo communities.

Materials And Methods
Study sites
The ethnobotanical investigation was carried out in eight Pwo villages in Nakian sub-district, Omkoi district, Chiang Mai province (Fig. 1). The elevations of the studied sites ranged between 938–1460 m.a.s.l. (Table 1). All villages were located in valleys surrounded by dry evergreen forest. However, Kong Po Tai was also close to mixed deciduous forest because this village was located at
low elevation. Nakian sub-district was located about 30 km from the center of Omkoi district. U-toom village was the center of the sub-district while other villages were located about 7–25 km away from this village. The villages were connected by a dusty road which sometimes was impassable in the rainy season. Swidden rice agriculture was practiced in all studied villages along with paddy rice farming. In two villages only swidden agriculture was practiced (Table 1). All Pwo people in this study are animists and Buddhist.

Table 1
Basic information and number of informants in eight Pwo villages in Na Kian sub-district, Omkoi district, Chiang Mai Province, Thailand where the ethnomedicinal investigation was carried on.

| Village name   | Coordinates                  | Elevation (m.a.s.) | Vegetation* | Distance from Sub-district center (k.m.) | Rice practice   |
|----------------|------------------------------|--------------------|-------------|------------------------------------------|-----------------|
| Bai Na         | N17°51'43.74“ E098°08'17.88“ | 1180.0             | DEF         | 20                                       | Swidden         |
| Kong Po Tai    | N17°50'21.54“ E098°10'54.08“ | 938.0              | DEF/MDF     | 10                                       | Paddy/Swidden   |
| Mae Khong      | N17°43'18.84“ E098°10'42.48“ | 1040.0             | DEF         | 25                                       | Paddy/Swidden   |
| Na Kian        | N17°47'31.26“ E098°09'07.08“ | 1260.0             | DEF         | 20                                       | Paddy/Swidden   |
| Sa-ngin Klang  | N17°53'59.26“ E098°14'06.47“ | 1243.0             | DEF         | 15                                       | Swidden         |
| Sa-ngin Neua   | N17°51'00.96“ E098°13'53.82“ | 1400.0             | DEF         | 8                                        | Paddy/Swidden   |
| Tang Tee       | N17°50'51.48“ E098°10'58.86“ | 950.0              | DEF         | 7                                        | Paddy/Swidden   |
| U-toom         | N17°50'55.92“ E098°12'55.44“ | 1460.0             | DEF         | 0                                        | Paddy/Swidden   |

*Vegetation: DEF : Dry Evergreen Forest; MDE : Mixed Deciduous Forest

Data collection
Field surveys were made every two month from October 2017 to September 2019. The ethnobotanical data were collected from 4–15 informants from each village. The interviews were carried out in the Pwo language with the help of local guides. The informants were informed about the purpose of the study and asked for their consent to provide their ethnomedicinal knowledge. Field surveys were conducted in villages, home gardens, agricultural areas, and nearby forests. During field surveys, the ethnomedicinal data were recorded using a semi-structured interview. The recorded data included the vernacular names, uses of the plant, the parts used, methods of preparation, and routes of administration.

Plant identifications and categorization
Between the ethnobotanical surveys, plants were photographed and the collected for future identification. The identification was done at the Queen Sirikit Botanic Garden Herbarium (QBG herbarium) and the specimens were deposited there. The botanical names and families were verified by The Plant List version 1.1 based on APGIII [13]. The ailment categories and parts used followed the Economic Botany Data Collection Standard [14]. The life forms of plants were adopted from Thai Plant Names Tem Smitinand [15].

Data analysis

Use value (UV)

The UV was used to compare the importance of species used by the informants [16]. The index was calculated as

$$UV = \frac{\sum U_i}{n} \quad \text{where } U_i \text{ is the number of use-reports from each informant for a species } i \text{ and } n \text{ is the total number of informants (in this study, } n = 50).$$

Use values are high when plants had more use-reports from the informant, and approach zero when there was no use-report.

Informant Agreement Ratio (IAR)

This index measured the agreement among the informants about which plants to use for any particular use category [17,18]. The index can be calculated as

$$IAR = \frac{(N_{ur} - N_t)}{(N_{ur} - 1)} \quad \text{where } N_{ur} \text{ is the number of use-reports for a particular use category and } N_t \text{ is the number of taxa used for that use category cited by all informants. The IAR value was ranged between 0–1. The value 1 indicated that only a single species was used by all informants for a particular category while the value 0 meant each informant used different species for a use category, i.e., there was no agreement among the informants.}$$

Comparing ethnomedicinal plants used by Pwo people to medicinal plants in Thailand

Plants used by the Pwo people were compared to the ethnomedicinal plant list for Thailand compiled by Phumthum et al. (2018) [19] from 64 reports from throughout Thailand. Plants that were identified to only genus level were excluded from this comparison.

Results And Discussion
The ethnomedicinal plants used by Pwo

A total of 122 ethnomedicinal species from 111 genera and 62 families were recorded from 50 Pwo informants (Table 2). The most dominant families were Asteraceae (10 species 8.19%), Fabaceae (9 species 7.37%), and Zingiberaceae (8 species 6.55%) (Fig. 2).

Table 2

| FAMILY           | Scientific names                  | Local name         | Use value (UV) | Part used and application* | Preparation** | Route of administration | Voucher number |
|------------------|-----------------------------------|--------------------|----------------|----------------------------|----------------|-------------------------|----------------|
| ACANTHACEAE      | Andrographis sp.                  | Ta-Phu-E-Khae      | 0.06           | Lf: Wounds                 | Po De          | Poultices Oral          | W. Pongamornkul 5239 |
|                  | Justicia adhatoda L.              | Se-Ta-Ro           | 0.08           | Rt: Chest pain, Stomachache St, Lf: Asthma Lf: Wounds | De In Po       | Oral Poultices           | W. Pongamornkul 03912 |
|                  | Justicia gendarussa Burm. f.      | Ta-Se-Khae         | 0.2            | Rt: Cough Wp: Muscle pain St, Lf: Pain St, Lf: Fever | De Bu In       | Oral Poultices Poultices Bath | -               |
|                  | Pseuderanthemum sp.               | De-Ber-Du          | 0.04           | Lf: Stomachache, Nourishment | De             | Oral                    | W. Pongamornkul 4891, 5695 |
|                  | Thunbergia coccinea Wall. ex D. Don | Cho-Ka-La Mue      | 0.04           | Fl: Appetizing Fl: Cough   | Bu De          | Oral Poultices          | W. Pongamornkul 4879 |
|                  | Thunbergia laurifolia Lindl.      | Cho-Ka-La Pho      | 0.14           | Lf: Gastritis, Detoxification St, Lf: Hypertension St: Stomachache, Muscle pain | De De          | Oral Poultices Poultices Poral | W. Pongamornkul 03977 |
| ACORACEAE        | Acorus calamus L.                 | Pho-Bue-Lae        | 0.72           | Rt: Flatulence, Cough Wp: Fever Lf: Stomachache | Np De          | Oral Bath              | W. Pongamornkul 5334 |
| ADOXACEAE        | Sambucus javanica Blume           | Choe-Cha-Bi        | 0.32           | Rt: Stones, Diuretic Lf: Muscle pain, Pain, Postpartum period, Lf, St: Hemorrhoids | De Bu De       | Oral Poultices Poultices Poral | W. Pongamornkul 5121 |
| AMARANTHACEAE    |                                   |                    |                |                            |                |                         |                |
| Family               | Genus                  | Species                          | Common Name          | Pinyin           | Dosage | Route | Ref.          |
|----------------------|------------------------|----------------------------------|----------------------|-----------------|--------|-------|---------------|
| CArEA               | Amaranthus           | blitum L. subsp. oleraceus (L.) Costea | Mu-Lang-Du           | 0.04             | Wp: Stomachache, Leg pain | De     | Oral | W. Pongamornkul 4586 |
| ANACARDA CEAE       | Rhus chinensis Mill.  | Saeng-Chay                       | 0.18                 | Fr: Thirst, Cough, Diarrhea | Np In  | Oral | Oral | W. Pongamornkul 5145 |
| APIACEAE            | Centella asiatica (L.) Urb. | Thui-Phu-Nae-Du                   | 0.48                 | Wp: Flatulence, Cough, Stomachache | Np, De | Oral | Oral | W. Pongamornkul 4973 |
| ARECACEAE           | Ilex umbellulata (Wall.) Loes. | Seng-Je                          | 0.04                 | Fr: Stomachache | Np    | Oral | W. Pongamornkul 04274 |
| ARALIACEAE          | Trevesia palmata (Roxb. ex Lindl.) Vis. | Kai-Lang-Du                      | 0.02                 | Fl, Sd: Nourishment | De     | Oral | -             |
| ARISTOLOC HIAEAE    | Aristolochia tagala Cham. | Ya-Le-Mu-Du                      | 0.02                 | St, La: Pain     | De     | Oral | -             |
| ASPARAGACEAE        | Asparagus filicinus Buch.-Ham. ex D. Don | Pho-Khuai-Mi                     | 0.32                 | Rt: Muscle pain, Stomachache, Postpartum period, Diarrhea | De De  | Oral | W. Pongamornkul 4949 |
| Common Name                                      | Local Name | Specification | Stomachache | Flatulence | Bruised, Pain | De | Bu | Poultries | W. Pongamornkul | 3470 |
|-------------------------------------------------|------------|---------------|-------------|------------|---------------|----|----|-----------|----------------|------|
| *Acmella paniculata* (Wall. ex DC.) R. K. Jansen | Ta-Si-Khe-La | 0.16          |             |            |               |    |    |           |                 |      |
| *Ageratina adenophora* (Spreng.) R. M. King & H. Rob. | Nang-Ka-Bang | 0.94          |             |            | Anti-bleeding, Wounds |    |    | Po        | Poultries       | W. Pongamornkul | 3748 |
| *Blumea balsamifera* (L.) DC.                   | Pho-Nae    | 0.92          |             |            | Postpartum period, Muscle pain | Bu | Bu | Po        | Poultries       | W. Pongamornkul | 3750 |
| *Chromolaena odorata* (L.) R. M. King & H. Rob. | Cho-Pho-Ko | 0.88          |             |            | Stomachach, Flatulence, Anti-bleeding, Wounds |    |    | Po        | Oral Poultries  | W. Pongamornkul | 3751 |
| *Crascocephalum crepidioides* (Benth.) S. Moore | Ta-Bo-Du   | 0.04          |             |            | Flatulence    |    |    | Oral      | W. Pongamornkul | 3753 |
| *Decaneuropsis cf. eberhardtii* (Gagnep.) H. Rob. & Skvarla | Ya-Ke      | 0.42          |             |            | Appetizing, Muscle pain, Diabetes | De |    | De        | Oral Liniment   | -    |
| *Elephantopus scaber* L.                        | Ta-Chi-Ko  | 0.72          |             |            | Cough, Bruised, Insomnia |    |    | De        | Bath Oral       | W. Pongamornkul | 5180 |
| *Gerbera piloselloides* (L.) Cass.              | Ta-Chi-Ko  | 0.4           |             |            | Cough, Insomnia, Bruised, Nourishment | De |    | De        | Oral Liniment   | W. Pongamornkul | 5263 |
| *Microglossa pyrifolia* (Lam.) Kuntze           | Pho-Sa-Seng | 0.04          |             |            | Fever         | De |    | Bu        | Bath Liniment   | W. Pongamornkul | 5612 |
| *Tagetes erecta* L.                             | Pho-Pho    | 0.02          |             |            | Diarrhea      |    |    | Oral      | W. Pongamornkul | 5234 |

### BAEV

| Common Name                              | Local Name | Specification | Stomachache | Flatulence | Bruised, Pain | De | Bu | Liniment | W. Pongamornkul | 4560 |
|-------------------------------------------|------------|---------------|-------------|------------|---------------|----|----|----------|----------------|------|
| *Anredera cordifolia* (Ten.) Steenis      | Ta-Phe-La-Chae-Wa | 0.12          |             | Flue, Burn | Urinate, Nourishment |    |    | Po        | Oral Liniment   | W. Pongamornkul | 4560 |
| Family         | Species                          | Symp. | Use                        | Route | Source                        |
|---------------|----------------------------------|-------|----------------------------|-------|-------------------------------|
| BEGONIACEAE   | Begonia sp.                      | Ta-Chay-Ko | 0.12 Wp: Itching Po         | Poultices | W. Pongamornkul 4759 |
| BETULACEAE    | Betula alnoides                  | Mai-Mi-Kang | 0.58 St: Nourishment Bk: Muscle pain, Cough, Gastritis, Lassitude, Blood circulation De De | Oral Oral | W. Pongamornkul 4724 |
| BIGNONIACEAE  | Oroxylum indicum (L.) Kurz        | Du-Kae-Sae | 0.04 St: Anti-HIV Fl, Fr: Muscle pain De Np | Oral Oral | W. Pongamornkul 454 |
| BURSERACEAE   | Protium serratum (Wall. ex Colebr.) Engl. | Phi-Sae | 0.02 Fr: Vomiting Np | Oral | W. Pongamornkul 04238 |
| CELASTRACEAE  | Celastrus paniculatus Wild.      | Ble-Bang-Yo | 0.02 Rt: Dysuria De | Oral | W. Pongamornkul et al. 5088 |
| CLUSIACEAE    | Garcinia cf. pedunculata Roxb. ex Buch.-Ham. | Ko-Kuy-Sa | 0.76 Fr: Diabetes, Cancer, Flatulence Fr: Drunk, Stones, Hypertension, Headache, Lumbago, Diarrhea Fr: Insect bites Np, De De Po | Oral Oral Liniment | W. Pongamornkul 4869 |
| COMBRETACEAE  | Anogeissus acuminata (Roxb. ex DC.) Wall. ex Guillem. & Perr. | Seng-Cha-Kad | 0.02 Rt: Dizziness De | Oral | W. Pongamornkul 4694 |
| COMMELINACEAE | Commelina diffusa Burm.f.         | Phu-Du | 0.02 Lf: Cough Np | Oral | W. Pongamornkul 4712 |
| COSTACEAE     | Hellenia speciosa (J. Koenig) S. R. Dutta Specht | Su-Lay | 0.08 St: Snake bite Po | Liniment | W. Pongamornkul 3237 |
| CUCURBITACEAE | Gynostemma                  | Tu-Kha-Du | 0.02 Lf: Diabetes De | Oral | W. Pongamornkul 4712 |
| Plant Family | Common Name | DC. No. | Action |Recommended Use | Comments |
|-------------|-------------|---------|--------|----------------|----------|
| DAUVALLIACEAE | Momordica charantia L. | Ta-Si-Ku | 0.06 | St: Snake bite, St: Diuretic | Po De | Oral |
| | Davallia sp. | No-Ka-Chi-Sae | 0.16 | Wp: Muscle pain, Stones, Cough, Stomachache | De | Oral |
| EQUISETACEAE | Davallia sp. | Se-Blu-Mi | 0.12 | La: Abscess, Wounds and Bolls | Np | Liniment |
| | Falconerina insignis Royle | Seng-Chang-Chao | 0.06 | Lf: Postpartum blood circulation, Rt: Stomachache, Wp: Muscle pain | De De | Oral Oral Oral |
| | | Pha-Phea-Chay | 0.02 | Lf: Postpartum blood circulation | De | Oral |
| EUPHORBIA CEAE | Antidesma acidum Retz. | Nang-Sa-Sai | 0.02 | Lf: Pain | De | Bath |
| | Balakata baccata (Roxb.) Esser | Ta-Sae | 0.02 | Lf: Laxative | De | Oral |
| | Flueggea virosa (Roxb. ex Willd.) Voigt | Phu Che Sa | 0.02 | Fr: Alopecia | De | Bath |
| | Glochidion sphaerogynum (Müll. Arg.) Kurz | Cha-Mi-Thao | 0.02 | Rt: Stomachache | De | Oral |
| | | Pa-Na-Kho-Thao | 0.02 | Lf, Bk: Wounds | De | Oral |
| | | Sa-Klo | 0.02 | Rt: Cough | De | Oral |
| FABACEAE | Bauhinia sp. | Se-Na-O | 0.2 | Rt: Diarrhea, Lf: Stomachache, Flatulence, Stones | De De | Oral Oral |
| | Dalbergia sp. | Mi-Ta-Si | 0.36 | Wp: Muscle pain, Easy birth, Stomachache, Cough, Anthelmintic, Bleary-eyed, Insomnia | De In In | Oral Bath Bath Oral |
| | Millettia caerulea Baker | | | | | |
| | Mimosa pudica L. | | | | |
| Plant Name                           | Action (s)                    | Dose | Reference          |
|-------------------------------------|-------------------------------|------|--------------------|
| *Tadehagia triquetrum* (L.) H. Ohashi | Ta-Si-Choi-Bel                | 0.34 | Oral               |
|                                    | Itching, Fever, Dizziness     |      | W. Pongamornkul 4959 |
|                                    | Rt: Muscle pain, Stomachache  |      |                    |
|                                    | Lf: Asthma, Stones            |      |                    |
|                                    | Rt: Tonic, Anthelmintic       |      |                    |
|                                    | Rt, St, Lf: Stones            |      |                    |
|                                    | St: Stones                    |      |                    |
|                                    | Wp: Tonic, Anthelmintic       |      |                    |
|                                    | Rt, St, Lf: Fever             |      |                    |
|                                    | Ta-Si-Cho-Bel                |      | Oral               |
|                                    | Oral                          |      | Oral               |
|                                    | Oral                          |      | Oral               |
|                                    | Oral                          |      | Oral               |
| *Tamarindus indica* L.              | Ma-Khae-Sae                   | 0.04 | Oral               |
|                                    | Fr: Dizziness                 |      | Oral               |
|                                    | Bk: Cough                     |      | W. Pongamornkul 4765 |
|                                    | St, Lf: Blood tonic           |      |                    |
|                                    | St: Cough                     |      |                    |
|                                    | Fr: Cough                     |      |                    |
|                                    | Si-Phai                       | 0.04 | Oral               |
|                                    | Bk: Cough                     |      | Oral               |
|                                    | St: Hypertension              |      | Oral               |
| *Canscora decussata* (Roxb.) Schult. | Ta-Si-Bae-Mu                  | 0.1  | Oral               |
|                                    | Wp: Cough, Flatulence, Pain,  |      | W. Pongamornkul 3805 |
|                                    | cold                          |      |                    |
| *Callicarpa arborea* Roxb.          | Ka-Mae-Pho                    | 0.08 | Oral               |
|                                    | St: Diarrhoea                 |      | W. Pongamornkul 3465 |
|                                    | Fl: Flatulence                |      |                    |
| *Rotheca serrata* (L.) Steane & Mabb. | Du-Kaeo-Pho                  | 0.04 | Oral               |
|                                    | Lf: Stomachache               |      | W. Pongamornkul et al. 5085 |
|                                    | Fl: Muscle pain               |      |                    |
|                                    | Ta-Si-Bae-Mu                  | 0.04 | Oral               |
|                                    | Wp: Stomachache               |      | W. Pongamornkul 4530 |
|                                    | De                            |      |                    |
|                                    | De                            |      |                    |
| *Litsea cubeba* (Lour.) Pers.       | Li-O-Sae                      | 0.18 | Oral               |
|                                    | Rt: Muscle pain               |      | W. Pongamornkul 4533 |
|                                    | Fr: Flatulence                |      |                    |
|                                    | Fr: Stomachache, Fever        |      |                    |
|                                    | St, Lf, Fr: Aphthous ulcer    |      |                    |
|                                    | Ta-Ro-Pae                     | 0.12 | Oral               |
|                                    | Rt: Muscle pain               |      |                    |
|                                    | Rt: Stomachache, Cough        |      |                    |
|                                    | Po                            |      |                    |
|                                    | Np, De                        |      |                    |
|                                    | Oral                          |      |                    |
|                                    | Oral                          |      |                    |
|                                    | Oral                          |      |                    |
|                                    | Oral                          |      |                    |
| *Leea indica* (Burm. f.) Merr.      | Thu-Khu-Phae                  | 0.02 | Oral               |
|                                    | Rt: Latulence                 |      | W. Pongamornkul 4996 |
|                                    | Lf: Flatulence                |      |                    |
| *Scurrula parasitica* L.            | Seng-Phu-Thae                 | 0.02 | Oral               |
|                                    | St: Expectorate               |      | W. Pongamornkul 4848 |
|                                    | Lf: Expectorate               |      |                    |
|                                    | Ta-Si-Lae-                    | 0.04 | Oral               |
|                                    | Wp: Muscle                    |      |                    |
|                                    | De                            |      |                    |
|                                    | Oral                          |      |                    |
| Family            | Genus | Species                      | Plants | Type | Part     | Use                                                                 | People | Desc | Source     |
|-------------------|------|-----------------------------|--------|------|----------|----------------------------------------------------------------------|--------|------|------------|
| LYTHRACEAE        | Duabanga | grandiflora (DC.) Walp. | Ku     | 0.02 | Lf: Dry skin | Poultices W. Pongamornkul 5626                                        |        |      |            |
| MALVACEAE         | Sida | acuta Burm. f.              | Nang-Khu-Mi | 0.04 | Lf: Wounds | Poultices W. Pongamornkul 4485                                        |        |      |            |
| MELANTHIA CEAE    | Daiswa | polyphylia (Sm.) Raf. | Ta-Thi  | 0.16 | Tu: Gastritis, Backache, Cancer, Nourishment, Pain | Oral W. Pongamornkul 5321                                       |        |      |            |
| MELASTOMA TACEAE  | Melastoma | malabatricum L. subsp. malabatricum | Se-Sa-Phli | 0.06 | Rt: Cough Rt: Stones | De De | Oral Oral W. Pongamornkul 4756                                       |        |      |            |
| MENIAPERMACEAE    | Tinospora | crispa (L.) Hook. f. & Thomson | Seng-Khi-Mi | 0.1  | St: Muscle pain, Cough St: Nourishment St: Pain La: Rashes | De In Np Np | Oral Oral Oral Liniment W. Pongamornkul 03931 |        |      |            |
| MORACEAE          | Artocarpus | heterophyllus Lam. | Pa-Nuai-Sae | 0.02 | Fr: Cough | Np | Oral |            |
|                   | Ficus | hispida L. f.               | A-Nae-Sae | 0.02 | La: Abscess | Np | Liniment W. Pongamornkul 4619                                        |        |      |            |
|                   | Maclura | andamanica (King ex Hook. f.) C. C. Berg | Chu-Chae-Bong | 0.02 | Fr: Flatulence | Np | Oral | W. Pongamornkul 5622                                             |
| MUSACEAE          | Musa | acuminata Colla            | Du-Ku-Sae | 0.04 | Fl: Galactic | De | Oral |            |
| MYRICACEAE        | Myrica | esculenta Buch. -Ham. ex D. Don | Bel-Sa-Sae | 0.02 | Fr, Bk: Toothache | Np | Oral W. Pongamornkul 5343                                            |        |      |            |
| MYRTACEAE         | Psidium | guajava L.                | Phu-Sae-Mo | 0.48 | Lf: Diarrhea Wp: Pain Lf: Fr: Drunk, Flatulence Lf: Fr: Cough | Np Np Np Np | Oral Oral Oral Oral W. Pongamornkul 4983 |        |      |            |
| PHYLLANTHACEAE    | Syzygium | cumini (L.) Skeels | Ka-Mi   | 0.06 | BK: Diarrhea, Blood tonic | De | Oral | W. Pongamornkul 5016                                              |
| PHYLLANTHACEAE    | Phyllanthus | emblica L. | Ma-Lu-Sae | 0.62 | Fr, Ga: Cough Lf: Fever Rt: Stomachache Fr: | Np Np Np Np | Oral Bath | W. Pongamornkul 4551                                             |        |      |            |
| Plant Family | Species | Common Name | Parts Used | Conditions | Dose | Route | Reference |
|-------------|---------|-------------|------------|------------|------|-------|-----------|
| Piperaceae  | *Piper betle* L. | Pa-Lae | 0.02 | Lf: Shingles | Po | Poullices | - |
| *Piper cf. wallichii* (Miq.) Hand.-Mazz. | Pha-Lae | 0.04 | Rt: Backache | St: Laxative | De, De | Oral, Oral | W. Pongamornkul 4529 |
| Plantaginaceae | *Scoparia dulcis* L. | Ta-Si-Ko | 0.14 | Rt: Cough | Lf: Wounds | Wp: Fever, Pollakiurie | De, Po | Oral, Poullices, Oral | W. Pongamornkul 5034 |
| Poaceae | *Coix lachryma-jobi* L. | Phong-Mu-Thi | 0.08 | Rt: Dizziness, Hemorrhoid s | Rt, Sd: Nourishment | De, De | Oral, Oral | W. Pongamornkul 1967 |
| Polygalaceae | *Polygala chinensis* L. | Mai-Mi-Kang | 0.28 | Rt: Flatulence, Appetizing, Muscle pain | Wp: Stomachach e | De, De | Oral, Oral | W. Pongamornkul 5248 |
| Primulaceae | *Embelia sessiliflora* Kurz | Blae-Blang | 0.02 | Fr: Anthelmintic | Po | Oral | W. Pongamornkul 4476 |
| *Maesa glomerata* K. Larsen & C. M. Hu | Choi-Ne-Du | 0.08 | Lf: Wound and boils | Po | Poullices | |
| Pteridaceae | *Onychium siliculosum* (Desv.) C. Chr. | Pho-Khai-Mi | 0.06 | Rt: Stomachach e, Rt: Lumbago | Rt: Postpartum period | Po, In, De | Oral, Oral, Oral | W. Pongamornkul 5251 |
| Rhamnaceae | *Berchemia floribunda* (Wall.) Brongn. | Ta-Si-Pe-Ma-Ho | 0.16 | Rt: Stones | Bk: Hemorrhoid s | St: Nourishment | St, Lf: Pain | Rt, Bk: Paralysis | De, De, De | Oral, Oral, Oral | W. Pongamornkul 5585 |
| Rosaceae | *Prunus campanulata* Maxim. | Khong-Kho | 0.04 | Bk: Muscle pain, Nourishment | De | Oral | W. Pongamornkul 4579 |
| *Rubus ellipticus* Sm. | Wae-Chu-Sae | 0.02 | Lf: Canker | Bu | Poullices | W. Pongamornkul 4925 |
| Plant Family | Species | Part | Use | Preparation | Route |
|--------------|---------|------|-----|-------------|-------|
| RUBIACEAE    | Morinda angustifolia Roxb. | Rt, St | Jaundice | Oral | W. Pongamornkul 4849 |
|             | Mussaenda sp. | Rt, St | Pain | Oral | W. Pongamornkul 4581 |
|             | Paederia pilifera Hook. f. | Lf | Treating flatulence | Oral | W. Pongamornkul et al. 5910 |
|             | Uncaria cordata (Lour.) Merr. | Rt | Muscle pain | Oral | W. Pongamornkul 5596 |
|             | Clausena excavata Burm.f. | Lf | Intoxication, Muscle pain | Bath | W. Pongamornkul 4598 |
|             | Toddalia asiatica (L.) Lam. | Rt | Muscle pain | Oral | W. Pongamornkul 5142 |
|             | Zanthoxylum sp. | Bk, Fr | Toothache | Oral | W. Pongamornkul 5168 |
| RUTACEAE    | Clausena excavata Burm.f. | Lf | Intoxication, Muscle pain | Oral | W. Pongamornkul 5118 |
|             | Toddalia asiatica (L.) Lam. | Rt | Muscle pain | Oral | W. Pongamornkul 4540 |
| SANTALACEAE | Osyris lanceolata Hochst. & Steud. | Rt | Muscle pain | Oral | W. Pongamornkul 3165 |
| SAPOTACEAE  | Xantolis burmanica (Collett & Hemsli.) P. Royen | Bk | Stomachache | Oral | W. Pongamornkul 3075 |
| SAURURACEAE | Houttuynia cordata Thunb. | Lf | Dizziness | Smell Poultices | W. Pongamornkul 4544 |
| SCROPHULARIACEAE | Buddleja asiatica Lour. | St, Lf | Wound and Boils | Oral Liniment | W. Pongamornkul 5684 |
| SIMAROUBACEAE | Picrasma javanica Blume | Bk | Muscle pain | Oral | W. Pongamornkul 5684 |
| Common Name | Species | Code | Severity | Use(s) | Preparation Method | Source |
|-------------|---------|------|----------|--------|-------------------|--------|
| Physalis | angulata | Thu-Chi-Bong | 0.06 | Rt: Flatulence St: Nephropathy | De De | Oral Oral | W. Pongamornkul 3525 |
| Solanum | anguivi Lam. | Khang-Khae | 0.16 | St, Fr: Cough Fr: Pain, Sore throat Fr: Muscle pain | Np, De Np De | Oral Oral Oral | W. Pongamornkul 4550 |
| Solanum | torvum Sw. | Ta-Khang-Khae | 0.02 | Fr: Muscle pain | De | Oral | W. Pongamornkul 04208 |
| VITACEAE | | | | | | | |
| Cissus | javana DC. | Ta-Si-Si-Mo-Pang | 0.02 | Lf: Itching Bu | | Poultices | W. Pongamornkul 4987 |
| Tetrastigma | obovatum Gagnep. | Kuey-Cha-Sae | 0.02 | Fr: Morning sickness Np | | Oral | W. Pongamornkul 4457 |
| ZINGIBERACEAE | | | | | | | |
| Boesenbergia | rotunda (L.) Mansf. | Pho-Sa-Du | 0.06 | Rh: Flatulence Np | | Oral | W. Pongamornkul 3221 |
| Curcuma | longa L. | Yae-Bang | 0.9 | Rh: Stomachache Rh: Wounds Rh: Flatulence, Gastritis Rh: Insect Bites, Itching Rh, Fl: Fever, Cough | Np Po De Po De | Oral Poultices Oral Liniment Oral | W. Pongamornkul 2004 |
| Curcuma | rubescens Roxb. | Pho-Khae | 0.12 | Rh: Treating flatulence Rh: Fever Rh: Stomachache | De De Np | Oral Bath Oral | - |
| Hedychium | stenopetalum Lodd. | Pho-Sai | 0.02 | Rh: Stomachache Np | | Oral | W. Pongamornkul et al. 5103 |
| Zingiber | kerrii Craib | Pho-Ang | 0.12 | Rh, Fl: Flatulence Rh: Stomachache Fl: Nourishment | De Np Np | Oral Oral Oral | - |
| Zingiber | purpureum Roscoe | Pa-Lui | 0.68 | Rh: Postpartum period Rh: Flatulence, Hiccups, Hypertension, Stomachache, Diarrhea Rh: Sprain | De De Po | Oral Oral Poultices | W. Pongamornkul 4286 |
| Zingiber | officinale Roscoe | Eng | 0.22 | Rh: Cough Rh: Flatulence Rh: Stomachache Rh: Fever Np Bu De De | | Oral Oral Bath | - |
There was a total of 930 use reports which were categorized into 22 use categories. The digestive system category was the largest group with 39 spp. and 143 reports (Table 3). Other use categories that had more than 100 use records included muscular-skeletal system, respiratory system, and the pain and injuries categories, respectively.

Table 3
The number of used reports, species and IAR of each use category which were reported from 50 Pwo informants, from 8 villages in Na Kian sub-district, Omkoi district, Chiang Mai provinces, Thailand.

| Use categories               | No. of used report ($N_w$) | No. of species used ($N_s$) | IAR  |
|------------------------------|----------------------------|----------------------------|------|
| Injuries                     | 126                        | 15                         | 0.89 |
| Respiratory system           | 138                        | 35                         | 0.75 |
| Digestive system             | 143                        | 39                         | 0.73 |
| Muscular-skeletal system     | 140                        | 43                         | 0.70 |
| Pain                         | 133                        | 50                         | 0.63 |
| Endocrine system             | 14                         | 6                          | 0.62 |
| Nutritional disorders        | 46                         | 20                         | 0.58 |
| poisonings                   | 15                         | 7                          | 0.57 |
| Infections                   | 67                         | 32                         | 0.53 |
| Neoplasms                    | 5                          | 3                          | 0.50 |
| Skin/Subcutaneous Cellular Tissue | 14                    | 8                          | 0.46 |
| Pregnancy/Birth/Puerperium | 17                         | 10                         | 0.44 |
| Other                        | 19                         | 12                         | 0.39 |
| Genitourinary system         | 28                         | 19                         | 0.33 |
| Circulatory system           | 8                          | 7                          | 0.14 |
| Blood system                 | 2                          | 2                          | 0    |
| Metabolic system             | 2                          | 2                          | 0    |
| Inflammation                 | 2                          | 2                          | 0    |
| Sensory system               | 2                          | 2                          | 0    |
| Ill-defined symptoms         | 6                          | 6                          | 0    |
| Mental disorders             | 4                          | 4                          | 0    |
| Abnormalities                | 1                          | 1                          | -    |

Plant part uses, life forms, and method of preparation

Leaves were the most preferred part for use, followed by rhizomes/roots, and stems (Fig. 3). These parts contributed to more than 50% of total use-reports. Herbs were the most preferred life form, followed by trees. These life forms contributed to more than 50% of total species found in this study (Fig. 4). Decoction was the main method of preparation (Fig. 5) with half of use-reports prepared by this method.

Informant Agreement Ration (IAR)
The highest IAR (= 0.89) was observed in the injuries use category (Table 3). This category had 126 use-reports and 15 species used. The IAR of the digestive system category, which had highest number of use-reports, was 0.73 which was the third followed by the respiratory system category. Many use categories had IAR = 0 because the number of use-reports was equal to the number of species used. The IAR of the abnormalities category could not be calculated because the number of use-reports was 1 which made the divider in IAR formula equal to 0.

**Plant Use Values (UV)**

Use values ranged from 0.02 (use-report = 1) to 0.94 (use-report = 47) (Table 2). The most used species was *Ageratina adenophora* (Spreng.) R.M.King & H.Rob. (Asteraceae) which was used to stop bleeding. There were other three species in Asteraceae that also had high use values, including *Blumea balsamifera* (L) DC. (UV = 0.92), *Chromolaena odorata* (L.) R.M.King & H.Rob. (UV = 0.88) and *Elephantopus scaber* L. (UV = 0.72). *Chromolaena odorata* (L.) R.M.King & H.Rob. had the same uses as *A. adenophora* (Spreng.) R.M.King & H. Rob. while the other two were used differently. Example of other species with high UV included *Curcuma longa* L., *Garcinia pedunculata* Roxb. ex Buch.-Ham., *Acorus calamus* L., *Zingiber purpureum* Roscoe., *Phyllanthus emblica* L. and *Betula alnoides* Buch.-Ham. ex G.Don.

Comparing ethnomedicinal plants used by Pwo People to medicinal plants in Thailand

There were 10 species that were not presented in Phumthum et al. [19] which reviewed all medicinal plants reported in ethnobotanical studies across Thailand. These species included: *Phoenix loureiroi* Kunth, *Gerbera piloselloides* (L.) Cass., *Garcinia pedunculata* Roxb. ex Buch.-Ham., *Tupistra muricata* (Gagnep.) N.Tanaka, *Maclura andamanica* (King ex J.D. Hooker) C.C. Berg, *Myrica esculenta* Buch.-Ham. ex D. Don, *Prunus campanulata* Maxim., *Osyris lanceolata* Hochst. & Steud., *Solanum anguivi* Lam., and *Curcuma rubescens* Roxb. According to the best of our knowledge, these plants, except *Prunus campanulata* Maxim., was firstly published for their medicinal properties in Thailand.

**Discussion**

**Diversity of ethnomedicinal plants used by Pwo People**

The number of ethnomedicinal plants recorded from the Pwo in this study was as high for other ethnicities in northern Thailand [8,20–21] but lower than in the study of Tangjitman et al. (2013) [11],
which studied Sgaw Karen living in wide geographical ranges. This indicated that the Pwo also possess great knowledge of ethnomedicinal plants. It should be noted that the Pwo people are distributed in many parts of northern Thailand. The adaptation to the new land would result in the use of new plants [19]. More ethnobotanical investigation of the Pwo people in other locations could result in a great compilation of ethnobotanical knowledge.

The dominant families in this study were in accordance with those in other ethnobotanical studies in northern Thailand [8,11,20–22]. These families, Asteraceae, Fabaceae, and Zingiberaceae, are cosmopolitan families commonly known for their medicinal properties [23]. Moreover, these families were also listed as some of the largest families in Thailand [24].

Use of ethnomedicinal plants: parts; life forms; and preparation

Leaves are gathered more easily than other plant parts [25]. and are also full of secondary metabolites [26]. Moreover, gathering leaves is more sustainable than other parts because it rarely affects the survival or the reproduction of the plants. Leaves are one of the plant organs which contain many active compounds some of which possess valuable medicinal properties for humans [23]. Hypogenous organs, roots and rhizome, were also preferred by Pwo, the same as other ethnic groups [4,22,27]. These hypogenous organs normally possess a high content of secondary metabolites [28]. which could be used to cure many ailments.

Among the Pwo, herbs were the most frequently used life form, in accordance with ethnomedicinal studies for many other ethnic groups in northern Thailand [20–22]. This life form was easy to harvest and the preparation methods and extraction of active ingredient also was also easier than for other life forms.

Most ethnomedicinal plant parts were prepared by boiling in hot water (decoction). This is one of the easiest and simplest methods to extracted active ingredients from medicinal plants [29]. This method is commonly practiced among the ethnic groups in northern Thailand [30–31]. and other parts of the world [32–33].

Ethnobotanical indices

Use values (UV) indicate the relative importance of a specific species used by the informants. Plants
have high UV when they are extensively used and known by the informants. Many plants that were reported with high UV in this study were common species: most were widespread or commonly cultivated according to a study in the nearby area [34]. Some of them were widespread exotic species: *Ageratina adenophora* (Spreng.) R.M. King & H. Rob. and *Chromolaena odorata* (L.) R.M. King & H.Rob. This indicated the adaptation of the indigenous people to their new environments [20]. Most of these plants were used to cure common acute symptoms like bleeding wounds, diarrhea, or common illnesses like cough and headache. So it could be said that one of the factors that promoted the uses of plants in Pwo people is their common appearance in the area. This would allow the local people to become familiar with their properties, resulting in high probability of including them as part of the culture [35]. However, it should be noted that there was a species which had high UV but low prevalence and many species which had very low UVs but were also common species in the areas, e.g. *Senegalia rugata* (Lam.) Britton & Rose; *Toddalia asiatica* (L.) Lam.; *Solanum torvum* Sw., etc. These species were commonly found and used as vegetable in the studied site. It could be said that low UV of these plants did not indicate that they were unimportant but indicated that the local people were unaware of their medicinal properties [23]. That meant the medicinal knowledge of these plants was at risk of disappearing from the community [36].

One of the notable species is *Garcinia pedunculata* Roxb. ex Buch.-Ham (called ‘Ko-kuy-sa’ by local people). The fruit of plant used to treat many ailments, for example diabetes, flatulence, lumbago, etc. (Table 1). However, only a single tree was found in the nearby forest of the studied area but its fruits were widely and popularly used by Pwo people. The extensive use of this plant seemed to be limited to the Pwo people.

There were five use categories which reported both high informant agreement ratios (IAR) and high numbers of use-reports. This indicated that a well-defined selection of species is culturally important for treating these illnesses [17]. Normally the IAR also related to the prevalence of these ailments in the studied area. Most of the informants in this study were farmers so many ailments which related to the hard works in their fields showed high IARs. These included the ailments in the injuries, muscular-skeletal system, and pain categories. The respiratory systems category also had high IAR and Nur.
Plants are commonly used to cure respiratory disorders in many parts of the world [37]. Most of these plants in this category were used to treat the common cold and other related symptoms like cough which were common disorders in children [38]. Another use category with both high IAR and Nur among Pwo people was digestive system disorders. Digestive diseases are always reported as among the most important disorders among the ethnic groups in Thailand [4,20–22] The cause of the ailments could be drinking water from forest streams without boiling [4]. It should be noted that high IAR can also help in discovering potentially effective medicinal plants [17].

Comparison of ethnomedicinal plants

Among the 122 species found in this study there were 10 species (8.2%) whose uses were reported in Thailand for the first time. Although the number was not large, but it should be noted that more than 2,000 species were reported in Phumthum et al. (2018) [19] and the accumulation curve indicated that it represents a nearly complete set of used medicinal species in Thailand [19]. This shown that there is still a gap in our knowledge of plant used by local people. Especially, from the ethnic groups which were never been ethnobotanical studied before. Even though they lived in the same area other groups which have been studied for their ethnobotany before. It should be noted that only the plant names, but not use-reports, were compared.

Additionally, there was a significant relation between the UV of plants used by Pwo people and those reported in Phumthum et al. (2018) [19] (r = 0.53, p < 0.01, Pearson’s correlation test). The reason behind this could be that most of ethnomedicinal species with high UV were common species which could be found throughout Thailand, so users have more chance to encounter the same common plants which normally tended to have high UVs according to their frequency of appearance [39].

Conclusion

Ethnomedicinal plants still play important roles in the daily life of the Pwo people as witnessed by the great varieties of plants used. Moreover, their knowledge was differed from the Sgaw Karen who lived in the same area. The divergence of ethnomedicinal knowledge among the ethnic groups demonstrated the importance of ethnobotanical studies. In northern Thailand there are many ethnic groups on which few or no ethnobotanical studies have been carried out, so it is urgent at least to
document their knowledge before erosion as the result of urbanization or modernization. The loss of this knowledge means the loss of opportunities for discovering and developing many new products from them.

Declarations
Competing interests
The authors declare that they have no competing interests.

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Authors’ contributions
WP and NM carried out the field research. AI supervised the work. PP, BP and AI analyzed the data and wrote the manuscript. All authors read and approved the final manuscript.

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Availability of data and materials
Data generated and analyzed in this study are included in this published article.

Ethics approval and consent to participate
The authors informed the head of village about purposed of the studied and asked for permission from individuals’ informants.

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Figures
Figure 1

Location of 8 Pwo villages in Na Kian sub-district, Omkoi district, Chiang Mai Province, Thailand where the medicinal plants were studied.
Figure 2

The number of ethnomedicinal plant species found in each family*. 

* Asteraceae, Fabaceae, Zingiberaceae, Acanthaceae, Euphorbiaceae, Rubiaceae, Apiales, Lauraceae, Monocots, Rutaceae, Solanaceae.
The percentage of each plant parts which were used by 50 Pwo informants, from 8 villages in Na Kian sub-district, Omkoi district, Chiang Mai provinces, Thailand.
The percentage of each plant life from which were used by 50 Pwo informants, from 8 villages in Na Kian sub-district, Omkoi district, Chiang Mai provinces, Thailand.
Figure 5

The percentage of each method of preparation which were used by 50 Pwo informants, from 8 villages in Na Kian sub-district, Omkoi district, Chiang Mai provinces, Thailand.