Trop J Nat Prod Res, August 2025; 9(8): 3607 - 3624 ISSN 2616-0684 (Print)
ISSN 2616-0692 (Electronic)

Tropical Journal of Natural Product Research

Available online at https://www.tjnpr.org

Original Research Article

Ethnobotanical Knowledge of the Lao Isan Ethnic Group in Communities Surrounding Khakrang Creek, Mueang District, Maha Sarakham Province, Northeastern Thailand

Piyaporn Saensouk[1], Surapon Saensouk[2*], Thawatphong Boonma[2,3], Kamonwan Koompoot[4], Sarayut Rakarcha[5], Khamfa Chanthavongsa[6], Tammanoon Jitpromma[2]

[1]*Diversity of Family Zingiberaceae and Vascular Plant for Its Applications Research Unit, Department of Biology, Faculty of Science, Mahasarakham University, Kantarawichai, Maha Sarakham, Thialand*
[2]*Biodiversity Program, Diversity of Family Zingiberaceae and Vascular Plant for Its Applications Research Unit, Walai Rukhavej Botanical Research Institute, Mahasarakham University, Kantarawichai, Maha Sarakham. Thailand*
[3]*Brio Botanical Research Garden, 53 M.5 Ban Mai Village, Phikun Ok, Ban Na District, Nakhon Nayok, Thialand*
[4]*Diversity of Family Zingiberaceae and Vascular Plant for Its Applications Research Unit, Mahasarakham University, Kantarawichai, Maha Sarakham.*
[5]*Queen Sirikit Botanic Garden, The Botanical Garden Organization, Chiang Mai.*
[6]*Department of Biology, Faculty of Natural Science, National University of Laos, Vientiane.*

ARTICLE INFO

Article history:
Received 18 May 2025
Revised 15 June 2025
Accepted 24 June 2025
Published online 01 September 2025

ABSTRACT

This study explores the ethnobotanical knowledge of the Lao Isan ethnic group residing near Khakrang Creek in Mueang District, Maha Sarakham Province, Northeastern Thailand. Data were collected through ethnobotanical field surveys and semi-structured, open-ended interviews with 30 purposively selected participants, including traditional healers, local experts, elders, and villagers. Ninety-six plant species belonging to 83 genera and 35 botanical families were identified, with the Fabaceae, Asteraceae, and Convolvulaceae families being the most represented. The plants were categorized based on their use value (UV), highlighting species such as *Tamarindus indica* L., *Ipomoea aquatica* Forssk., *Momordica charantia* L., and *Phyllanthus emblica* L. for their significant roles in local practices. Traditional uses were classified into ten categories: animal fodder, appliances, cultural, ritual, belief-related practices, ecological service, fertilizer, food, fuel, and medicine. The Informant Consensus Factor (F_{ic}) and Fidelity Level (FL) values indicated strong consensus and consistent use of certain plants for specific ailments, particularly in the medicinal category. The study underscores the importance of preserving ethnobotanical knowledge, especially regarding medicinal plants, due to its significant contribution to community well-being and environmental sustainability. This research emphasizes the connection between cultural heritage, biodiversity conservation, and healthcare by documenting the diverse plant species and their traditional uses. The study calls for greater efforts to protect indigenous knowledge passed down through generations and the ecosystems that sustain these invaluable plants. Preserving these practices ensures that future generations benefit from plants' healing properties while safeguarding the natural world.

Keywords: Ethnobotany, Khakrang Creek, Lao Isan Ethnic, Maha Sarakham Province, Thailand

Introduction

Ethnobotanical knowledge is crucial in indigenous cultures, providing valuable insights into the relationship between people and their natural environment.[1,2] This knowledge encompasses using plants for food, medicine, construction, and rituals, often passed down through generations in rural communities.[3,4] In northeastern Thailand, the Lao Isan ethnic group has a rich tradition of utilizing local plants for various purposes, which forms an integral part of their cultural identity anddaily life.[5,6]

*Corresponding author. E mail: surapon.s@msu.ac.th
Tel: + 66-8-8029-3958

Citation: Saensouk P, Saensouk S*, Boonma T, Koompoot K, Rakarcha S, Chanthavongsa K, Jitpromma T. Ethnobotanical Knowledge of the Lao Isan Ethnic Group in Communities Surrounding Khakrang Creek, Mueang District, Maha Sarakham Province, Northeastern Thailand. Trop J Nat Prod Res. 2025;9(8): 3607 – 3624 https://doi.org/10.26538/tjnpr/v9i8.21

Official Journal of Natural Product Research Group, Faculty of Pharmacy, University of Benin, Benin City, Nigeria

However, with rapid urbanization and environmental changes, much of this traditional knowledge is at risk of being lost, underscoring the importance of documenting and preserving it for cultural heritage and ecological sustainability.[7]

The Lao Isan people primarily inhabit the northeastern region of Thailand, a landscape known for its diverse natural resources and unique environmental features.[8] One key geographical feature in this region is the Khakrang Creek in Mueang District, Maha Sarakham. Province, which has long been home to the Lao Isan community.[9] This creek, surrounded by forests, fields, and waterways, is home to various plant species vital to the local community's survival and cultural practices.[10] The relationship between the Lao Isan people and the plants in their environment is practical and deeply intertwined with their cultural identity and spiritual beliefs.[11]

Khakrang Creek offers an ideal setting for exploring the ethnobotanical knowledge of the Lao Isan people due to its ecological diversity and the continued reliance of the local community on the area's natural resources. The creek and its surroundings host various plant species, many serving practical functions such as healing and nourishment. They are integral to rituals central to the community's way of life. Documenting these plant species aimed to enhance our

understanding of how local people interact with their environment and how this knowledge has evolved.[12]

Fieldwork, including interviews with local elders and knowledge holders, is the primary method for gathering information about plant use within the Lao Isan community.[13,14] These qualitative methods, particularly ethnobotanical field surveys, and semi-structured interviews, are highly relevant to the research objectives, as they allow for the direct collection of traditional, orally transmitted knowledge from community members. This approach accurately captures plant species and their cultural, medicinal, and ecological contexts. Much of this knowledge is passed down orally and remains undocumented, mainly in scientific literature.[15] This study is crucial for preserving traditional knowledge of plant species and their uses, particularly medicinal plants.[16,17] Beyond identifying specific species, the research also examines these plants' cultural and ecological significance, including traditional harvesting methods, preparation techniques, and symbolic meanings within the Lao Isan cultural context.[18]

This research holds several important implications. Firstly, it contributes to preserving ethnobotanical knowledge among the Lao Isan people, creating a valuable foundation for future studies in traditional ecological knowledge and biodiversity conservation.[19] Secondly, this study offers practical insights that may inform broader conservation strategies and promote sustainable resource management practices in the region.[20] Finally, the study is vital in safeguarding the cultural heritage of the Lao Isan ethnic group. Hence, the study supports the intergenerational transmission of cultural practices and reinforces the community's enduring connection to their natural environment.[21]

The primary objective of this study is to document the ethnobotanical knowledge of the Lao Isan people along Khakrang Creek, focusing on the plant species used by the community for food, medicinal, and material purposes. It highlights the importance of plants in the daily lives of the Lao Isan people and the sustainable practices they employ in managing local resources. Also, the study will provide a comprehensive look into the region's interconnectedness of culture, environment, and resource management.

Unlike similar studies in the past, this focused on the Lao Isan community living along Khakrang Creek, which has received limited scholarly attention concerning the ecological and cultural significance of the area to date. This research addresses a critical gap in the documentation of regional ethnobotanical knowledge and sheds light on the community's adaptive strategies in response to environmental change. In doing so, it offers new insights into the evolving nature of traditional ecological knowledge within a specific and understudied cultural landscape.

Materials and Methods

Study area

The Khakrang Creek (Figure 1) is a stream that originates from Kaeng Loeng Chan (16°11′9.90″N, 103°16′11.34″E) and flows through Mueang District in Maha Sarakham Province before joining the Chi River (16°10′57.21″N, 103°26′55.79″E). This watercourse is a vital resource for the local community, playing a significant role in agriculture, domestic water use, and recreational activities. The stream and its surrounding areas are rich in plant biodiversity, providing a favorable environment that supports the settlement and traditional lifestyle of a large Lao Isan population in the region.

Data collection

The survey was conducted along Khakrang Creek in Mueang District, Maha Sarakham Province, Thailand, from February 2024 to March 2025. The study involved interviews with traditional healers, local experts, elders, and villagers.

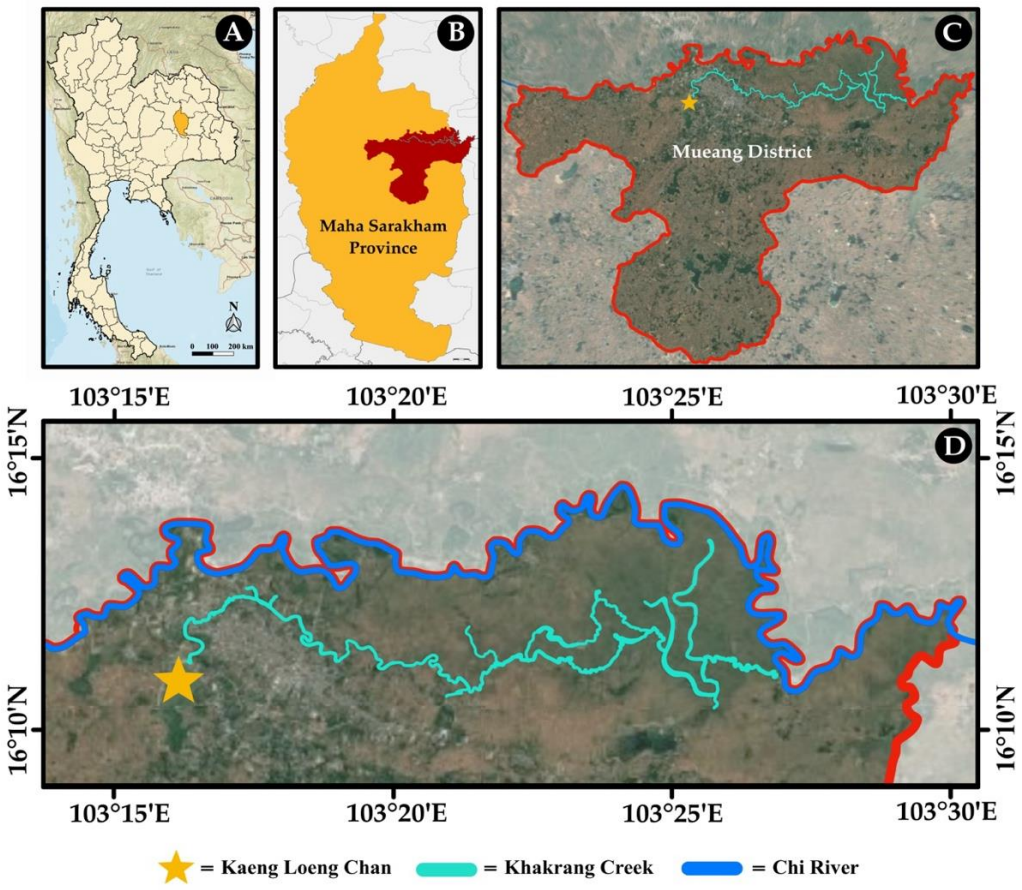

Figure 1. Figure 1. Maps of the study area. (A) Location of Maha Sarakham Province within Thailand; (B) Location of Mueang District (in red) within Maha Sarakham Province. (C) Map showing Khakrang Creek (light blue) in the northern part of Mueang District. (D) Detailed map of Khakrang Creek,

A total of 30 participants took part in open-ended interviews, offering valuable insights into local plant names, traditional uses, plant parts utilized, medicinal properties, preparation methods, and specific applications for medicinal purposes. The identified plant species were documented by recording their local names, photographing the specimens, and collecting samples for herbarium preparation. All collected specimens were deposited at the Vascular Plant Herbarium, Mahasarakham University (VMSU). The collected plant samples were examined for morphological characteristics under a stereoscopic microscope (Stemi 2000-C, Zeiss, Oberkochen, Germany). Precise measurements were obtained using a ruler and vernier caliper. Scientific names were identified using species identification keys and referenced taxonomic literature.[22-25] The nomenclature was further verified through the online database Plants of the World Online (POWO).[26]

Data analysis

Use Value (UV)

The Use Value (UV) represents the importance of a plant within a specific area and is determined using the following formula (equation 1).[27]

$$UV = \frac{\sum_I UV_{is}}{n_s}$$

Where UV indicates the total use value of the species, UV_{is} represents the use value of the species, and n_s denotes the number of informants interviewed for that species.

Informant consensus factor (F_{ic})

To evaluate the variability in the use of medicinal plants, the Informant Consensus Factor (Fic) was calculated using the following formula (equation 2).[28]

$$F_{ic} = \frac{n_{ur} - n_t}{n_{ur} - 1}$$

Where n_{ur} represents the total number of use reports within a specific use category, and n_t denotes the number of taxa used in that category. The F_{ic} value reflects the level of agreement among informants regarding the use of medicinal plants, with higher values indicating a greater consensus on the utilization of particular plant species for specific therapeutic purposes.

Fidelity Level (FL)

The Fidelity Level (FL) measures the proportion of informants who associated a specific plant species with treating a particular health condition in the study region. It is calculated using the following formula (equation 3).[29]

$$FL = \frac{I_p}{I_u} \times 100$$

Where Ip represents the number of informants who connected the plant to a particular ailment, and Iu denotes the number of informants who acknowledged the plant's medicinal use for any health issue.

Results and Discussion

The study evaluated a total of 96 plant species belonging to 83 genera and 35 botanical families (Table 1, Figure 2). The family Fabaceae accounted for the highest number of species (21 species, 21.88%), followed by Asteraceae (9 species, 9.38%) and Convolvulaceae (8 species, 8.33%). Other notable families include Poaceae (7 species, 7.29%), Amaranthaceae (5 species, 5.21%), and Malvaceae (4 species, 4.17%), with several families such as Acanthaceae, Cucurbitaceae, and Rubiaceae each contributing three species (3.13%).

Meanwhile, families like Anacardiaceae, Arecaceae, and Aristolochiaceae are each represented with just one species. This diverse range of plant families underscores the rich plant biodiversity in the area and the different ecological roles these species play across the region. The plant survey revealed the following distribution of species based on their origin. A total of 96 species were identified, with the majority being native species (51 species, 53.13%). Introduced species accounted for 43 species (44.79%), while one species (1.04%) was classified as doubtful in origin. One species (1.04%) was also identified as native and endemic to the region. These findings highlight the predominance of native species in the study area, with a notable presence of introduced species.

A comprehensive list of plant species and their corresponding use values used by the Lao Isan Ethnic Group along Khakrang Creek is provided in Table 1. The plants with high use values (≥ 0.600) are highly valued for their cultural, ritual, and practical applications. Among these, *Tamarindus indica* has the highest use value of 0.667, reflecting its significant role in local practices and traditions. Similarly, *Ipomoea aquatica* (UV = 0.633) and *Momordica charantia* (UV = 0.633) also exhibit high use values, underscoring their importance in daily life and their widespread use in the community. Other species with notable use values include *Phyllanthus emblica* (UV = 0.633), *Coccinia grandis* (UV = 0.600), and *Psidium guajava* (UV = 0.567), which are frequently utilized for a variety of purposes, including food, medicinal uses, and traditional practices.

Figure 2: Plants diversity in Lao Isan Ethnic Group Community along Khakrang Creek, Mueang District, Maha Sarakham Province.

ISSN 2616-0684 (Print)
ISSN 2616-0692 (Electronic)

Table 1: Diversity of plant species used by the Lao Isan Ethnic Group Along Khakrang Creek, Mueang District, Maha Sarakham Province, including their vernacular name, distribution, utilization, used parts, use value (UV), and voucher number.

No.	Family	Scientific name	Vernacular name	Distribution status for Thailand	Utilization	Used parts	UV	Voucher no.
1.	Acanthaceae	*Asystasia gangetica* (L.) T.Anderson	Ba Ya	Native	MD, ON	LE, WP	0.167	TJ384
2.	Acanthaceae	*Barleria strigosa* Willd.	Sang Korani	Native	MD, ON	LE, RO, WP	0.233	TJ385
3.	Acanthaceae	*Ruellia tuberosa* L.	Toi Ting	Introduced	ON	EP	0.267	TJ386
4.	Amaranthaceae	*Achyranthes aspera* L.	Phan Ngu	Native	AF	LE, WP	0.200	TJ387
5.	Amaranthaceae	*Alternanthera brasiliana* (L.) Kuntze	Banmairuroi Pa Farang	Introduced	ON	WP	0.300	TJ388
6.	Amaranthaceae	*Alternanthera philoxeroides* (Mart.) Griseb.	Phak PetNam	Introduced	AF	WP	0.100	TJ389
7.	Amaranthaceae	*Amaranthus viridis* L.	Phak Khom	Introduced	FD	LE	0.400	TJ390
8.	Amaranthaceae	*Gomphrena celosioides* Mart.	Banmairuroi Pa	Introduced	ON	WP	0.300	TJ391
9.	Anacardiaceae	*Spondias mombin* L.	Makok	Introduced	FD	FR	0.500	TJ392
10.	Apocynaceae	*Amphineurion marginatum* (Roxb.) D.J.Middleton	Khruea Sai Tan	Native	ON	WP	0.233	TJ393
11.	Apocynaceae	*Urceola polymorpha* (Pierre ex Spire) D.J.Middleton & Livsh.	Som Lom	Native	SP	FR, IF, LE	0.367	TJ394
12.	Arecaceae	*Borassus flabellifer* L.	Tan	Introduced	AP, FD	FR, LE	0.433	TJ395
13.	Araceae	*Lemna minor* L.	Nhae Pet	Native	CB, ES, FZ	WP	0.200	TJ396
14.	Araceae	*Pistia stratiotes* L.	Chok	Native	CB, ES, FZ	WP	0.233	TJ397
15.	Aristolochiaceae	*Aristolochia acuminata* Lam.	Krachao Phi Mot	Native	MD	IF, LE	0.233	TJ398
16.	Asteraceae	*Ageratum conyzoides* L.	Sap Ka	Introduced	MD	LE, RO, WP	0.100	TJ399
17.	Asteraceae	*Chromolaena odorata* (L.) R.M.King & H.Rob.	Sap Suea	Introduced	MD	LE, SM	0.100	TJ400
18.	Asteraceae	*Cyanthillium cinereum* (L.) H.Rob.	Mo Noi	Native	AF, FD, MD	LE	0.200	TJ401
19.	Asteraceae	*Eclipta prostrata* (L.) L.	Ka Meng	Introduced	AF, MD	LE, SM, WP	0.233	TJ402
20.	Asteraceae	*Emilia sonchifolia* (L.) DC.	Hu Plachon	Native	AF	WP	0.200	TJ403
21.	Asteraceae	*Praxelis clematidea* (Hieron. ex Kuntze) R.M.King & H.Rob.	Sap Maeo	Introduced	AF	WP	0.100	TJ404

No.	Family	Scientific name	Vernacular name	Distribution status for Thailand	Utilization	Used parts	UV	Voucher no.
22.	Asteraceae	*Sphagneticola trilobata* (L.) Pruski	Kradum Thong Lueai	Introduced	AF, ON	WP	0.167	TJ405
23.	Asteraceae	*Synedrella nodiflora* (L.) Gaertn.	Phak Khraet	Introduced	AF	WP	0.267	TJ406
24.	Asteraceae	*Tridax procumbens* L.	Tin Tukkae	Introduced	AF	WP	0.267	TJ407
25.	Boraginaceae	*Heliotropium indicum* L.	Ya Nguangchang	Introduced	MD	LE, WP	0.300	TJ408
26.	Cannabaceae	*Trema orientale* (L.) Blume	Phang Haen Yai	Native	MD	LE	0.167	TJ409
27.	Capparaceae	*Crateva religiosa* G.Forst.	Kum Bok	Native	FD	IF, LE	0.200	TJ410
28.	Casuarinaceae	*Casuarina junghuhniana* Miq.	Son Pra Di Phat	Introduced	FL, ON	SM, WP	0.167	TJ411
29.	Cleomaceae	*Cleome rutidosperma* DC.	Phak Sian Muang	Introduced	AF	WP	0.233	TJ412
30.	Cleomaceae	*Cleome viscosa* L.	Phak Sian Phi	Native	AF	WP	0.200	TJ413
31.	Combretaceae	*Terminalia catappa* L.	Hukwang	Native	ES, ON	WP	0.133	TJ414
32.	Commelinaceae	*Commelina benghalensis* L.	Phak Prap	Native	AF	WP	0.233	TJ415
33.	Commelinaceae	*Commelina diffusa* Burm.f.	Phak Prap Na	Native	AF	WP	0.233	TJ416
34.	Convolvulaceae	*Argyreia nervosa* (Burm.f.) Bojer	Bai Rabat	Introduced	ON	WP	0.167	TJ417
35.	Convolvulaceae	*Evolvulus nummularius* (L.) L.	Bai Tang Rian	Introduced	ON	WP	0.400	TJ418
36.	Convolvulaceae	*Hewittia malabarica* (L.) Suresh	Ching Cho Lek	Native	MD	LE, WP	0.300	TJ419
37.	Convolvulaceae	*Ipomoea aquatica* Forssk.	Phakbung	Native	AF, FD	LE, SM	0.633	TJ420
38.	Convolvulaceae	*Ipomoea cairica* (L.) Sweet	Phakbung Rua	Native	ON	WP	0.400	TJ421
39.	Convolvulaceae	*Ipomoea nil* (L.) Roth	Wan Phakbung	Introduced	ON	WP	0.333	TJ422
40.	Convolvulaceae	*Ipomoea obscura* (L.) Ker Gawl.	Sa Uek Dok Khao Lek	Native	AF	WP	0.300	TJ423
41.	Convolvulaceae	*Merremia hederacea* (Burm.f.) Hallier f.	Thao Sa Uek	Native	AF	WP	0.233	TJ424
42.	Cucurbitaceae	*Coccinia grandis* (L.) Voigt	Tamlueng	Native	FD	LE	0.600	TJ425
43.	Cucurbitaceae	*Momordica charantia* L.	Mara Khi Nok	Native	FD	FR, LE	0.633	TJ426

ISSN 2616-0684 (Print)
ISSN 2616-0692 (Electronic)

No.	Family	Scientific name	Vernacular name	Distribution status for Thailand	Utilization	Used parts	UV	Voucher no.
44.	Cucurbitaceae	*Trichosanthes costata* Blume	Khi Ka Dong	Native	AF	WP	0.233	TJ427
45.	Cyperaceae	*Actinoscirpus grossus* (L.f.) Goetgh. & D.A.Simpson	Phue	Native	AP, ON	LE, WP	0.167	TJ428
46.	Euphorbiaceae	*Euphorbia heterophylla* L.	Ya Yang	Introduced	AF, MD	IF, LE	0.100	TJ429
47.	Euphorbiaceae	*Euphorbia hirta* L.	Namnom Ratchasi	Introduced	AF, MD	SM, WP	0.067	TJ430
48.	Fabaceae	*Acacia auriculiformis* A.Cunn. ex Benth.	Krathin Narong	Introduced	AP, FL, MD	LE, SM	0.200	TJ431
49.	Fabaceae	*Afzelia xylocarpa* (Kurz) Craib	Ma Kha Mong	Native	AP, FL, MD	BK, SM	0.267	TJ432
50.	Fabaceae	*Albizia procera* (Roxb.) Benth.	Thon	Native	FD	LE	0.167	TJ433
51.	Fabaceae	*Bauhinia acuminata* L.	Siao Dok Lek	Introduced	FL, ON, SP	IF, SM, WP	0.300	TJ434
52.	Fabaceae	*Butea monosperma* (Lam.) Kuntze	Dok Chan	Introduced	CB, FL, MD, ON	IF, LE, RO, SM, WP	0.300	TJ435
53.	Fabaceae	*Cassia fistula* L.	Khun	Doubtful	AP, CB, FD, FL, MD, ON	FR, HW, SM, IF, WP	0.533	TJ436
54.	Fabaceae	*Crotalaria pallida* Aiton	Hing	Native	AF	WP	0.233	TJ437
55.	Fabaceae	*Delonix regia* (Bojer ex Hook.) Raf.	Hang Nokyung Farang	Introduced	MD, ON	RO, SM, WP	0.300	TJ438
56.	Fabaceae	*Leucaena leucocephala* (Lam.) de Wit	Krathin	Introduced	AF, FD, FL	FR, LE, SM	0.533	TJ439
57.	Fabaceae	*Macroptilium lathyroides* (L.) Urb.	Thua Phi	Introduced	AF	WP	0.367	TJ440
58.	Fabaceae	*Mimosa diplotricha* C.Wright	Maiyarap Lueai	Introduced	ES, FZ	WP	0.167	TJ441
59.	Fabaceae	*Mimosa pigra* L.	Maiyarap Lueai Yak	Introduced	FL, MD	LE, SM	0.167	TJ442
60.	Fabaceae	*Mimosa pudica* L.	Maiyarap	Introduced	MD	LE, SM	0.167	TJ443
61.	Fabaceae	*Neptunia oleracea* Lour.	Krachet Nam	Native	FD	LE, SM	0.533	TJ444
62.	Fabaceae	*Peltophorum dasyrhachis* (Miq.) Kurz	A Rang	Native	AP, MD	BK, SM	0.433	TJ445
63.	Fabaceae	*Pithecellobium dulce* (Roxb.) Benth.	Makhamthet	Introduced	FD, FL, MD	BK, FR, SM	0.400	TJ446

No.	Family	Scientific name	Vernacular name	Distribution status for Thailand	Utilization	Used parts	UV	Voucher no.
64.	Fabaceae	*Samanea saman* (Jacq.) Merr.	Cham Chu Ri	Introduced	FL, MD, ON	BK, LE, SM, WP	0.367	TJ447
65.	Fabaceae	*Senna garrettiana* (Craib) H.S.Irwin & Barneby	Samae San	Native	FD	LE	0.333	TJ448
66.	Fabaceae	*Senna siamea* (Lam.) H.S.Irwin & Barneby	Khilek	Native	FD, FL, MD	LE, SM	0.567	TJ449
67.	Fabaceae	*Sindora siamensis* Teijsm. ex Miq.	Ma Kha Tae	Native	AP, FL, MD	BK, FR, SM	0.533	TJ450
68.	Fabaceae	*Tamarindus indica* L.	Makham	Introduced	AP, CB, FD, FL, MD, ON, SP	BK, FR, IF, LE, SM, WP	0.667	TJ451
69.	Loranthaceae	*Dendrophthoe pentandra* (L.) Miq.	Kafak	Native	FL	SM	0.300	TJ452
70.	Lythraceae	*Lagerstroemia floribunda* Jack	Ta Baek	Native	FL, ON	SM, WP	0.300	TJ453
71.	Malvaceae	*Bombax anceps* Pierre	Ngio Khao	Native	AP, FD, FL	FR, SM	0.333	TJ454
72.	Malvaceae	*Bombax ceiba* L.	Ngio Daeng	Native	FD, FL, ON	FR, SM, WP	0.333	TJ455
73.	Malvaceae	*Sida acuta* Burm.f.	Ya Khat Bai Yao	Native	AF	WP	0.200	TJ456
74.	Malvaceae	*Sida rhombifolia* L.	Ya Khat	Native	AF	WP	0.233	TJ457
75.	Menispermaceae	*Tinospora baenzigeri* Forman	Chingcha Chali	Native (Endemic)	MD	IF, VN	0.367	TJ458
76.	Muntingiaceae	*Muntingia calabura* L.	Ta Khop Farang	Introduced	FD, FL	FR, SM	0.433	TJ459
77.	Myrtaceae	*Melaleuca glauca* (DC.) Craven	Praenglangkhuat	Introduced	ON	WP	0.467	TJ460
78.	Myrtaceae	*Psidium guajava* L.	Farang Khi Nok	Introduced	FD, FL	FR, SM	0.567	TJ461
79.	Olacaceae	*Olax scandens* Roxb.	Namchai Khrai	Native	MD	HW, RO	0.367	TJ462
80.	Oxalidaceae	*Oxalis corniculata* L.	Som Kop	Introduced	ON	WP	0.333	TJ463
81.	Phyllanthaceae	*Phyllanthus emblica* L.	Makham Pom	Native	MD	FR	0.633	TJ464
82.	Phyllanthaceae	*Phyllanthus reticulatus* Poir.	Kangpla Daeng	Native	FD, MD	FR, LE, RO	0.200	TJ465
83.	Poaceae	*Cenchrus pedicellatus* (Trin.) Morrone	Ya Khachon Chop	Introduced	AF, ON	WP	0.200	TJ466
84.	Poaceae	*Chrysopogon aciculatus* (Retz.) Trin.	Ya Chaochu	Native	AF	WP	0.233	TJ467

No.	Family	Scientific name	Vernacular name	Distribution status for Thailand	Utilization	Used parts	UV	Voucher no.
85.	Poaceae	*Dactyloctenium aegyptium* (L.) Willd.	Ya Pak Khwai	Native	AF	WP	0.167	TJ468
86.	Poaceae	*Digitaria ciliaris* (Retz.) Koeler	Ya Tin Nok	Native	AF	WP	0.133	TJ469
87.	Poaceae	*Eragrostis unioloides* (Retz.) Nees ex Steud.	Ya Khai Pu	Native	AF	WP	0.200	TJ470
88.	Poaceae	*Ischaemum rugosum* Salisb.	Ya Tadaeng	Native	AF	WP	0.167	TJ471
89.	Poaceae	*Urochloa mutica* (Forssk.) T.Q.Nguyen	Ya Khon	Introduced	AF	WP	0.133	TJ472
90.	Polygonaceae	*Persicaria madagascariensis* (Meisn.) S.Ortiz & Paiva	Ueang Phet Ma	Introduced	AF, FD	WP	0.233	TJ473
91.	Pontederiaceae	*Pontederia crassipes* Mart.	Phaktopchawa	Introduced	AP, FZ	LE, WP	0.233	TJ474
92.	Rubiaceae	*Knoxia roxburghii* (Spreng.) M.A.Rau	Ya Khamen	Native	AF	WP	0.167	TJ475
93.	Rubiaceae	*Morinda citrifolia* L.	Yo Ban	Native	CB, FD, MD	FR, IF, LE, RO	0.433	TJ476
94.	Rubiaceae	*Paederia foetida* L.	Tot Mu Tot Ma	Native	FD, MD	LE, WP	0.500	TJ477
95.	Typhaceae	*Typha angustifolia* L.	Thup Rue Si	Native	AP, ES	LE, WP	0.467	TJ478
96.	Vitaceae	*Cissus quadrangularis* L.	Phet Sang Khat	Introduced	MD, ON	VN, WP	0.433	TJ479

Note: Utilization; AF=animal fodder, AP=appliances, CB= cultural, ritual, and belief-related practices, ES=ecological service, FZ=fertilizer, FD=food, FL=fuels, MD=medicine, ON=ornamental purpose, SP=spices. Used parts; BK=bark, FR=fruit, HW=heart wood, IF=inflorescence, LE=leave, RO=root, SM=stem, VN=vine, WP=whole plant.

These plants demonstrate their essential role in local culture and livelihoods. The medium-use value *Senna siamea* category (0.400 - 0.590) includes species that provide moderate utility in local applications. Plants such as *Psidium guajava* (UV = 0.567), *Cassia fistula* (UV = 0.533), and *Leucaena leucocephala* (UV = 0.533) fall into this group, which are used for a range of practical and cultural purposes, though not as commonly as higher-use value species. The low-use value category (< 0.400) comprises species with more specialized or less frequent applications. Examples include *Achyranthes aspera* (UV = 0.200), *Lemna minor* (UV = 0.200), and *Cyanthillium cinereum* (UV = 0.200). While these plants may have specific uses in certain local practices, they are not as widely recognized or utilized in the community. This categorization of plant species by use value highlights the broad spectrum of plants contributing to local traditions and practices, with some species playing central roles in daily life and others being of more specialized or limited utility.

The traditional uses were classified into ten categories: animal fodder, appliances, cultural, ritual, and belief-related practices, ecological services, fertilizer, food, fuels, medicine, ornamental purposes, and spices. A detailed explanation of each category is provided below.

Thirty-two plant species from 12 families were documented as being used for animal fodder (Table 1, Figure 3).

The most represented families were Poaceae and Asteraceae, each with seven species, followed by Convolvulaceae and Fabaceae, each with three species. Other families, including Amaranthaceae, Cleomaceae, Commelinaceae, Cucurbitaceae, Euphorbiaceae, Malvaceae, Polygonaceae, and Rubiaceae, contributed one or two species each. Among these, 18 species were native, while 14 species were introduced. The presence of native and introduced species underscores their adaptability and ecological significance in traditional and modern livestock feeding systems. These species include a diverse range of herbaceous and grass plants, many of which are crucial in sustaining grazing animals across various ecosystems. A total of 11 plant species from six different families were identified as being used as appliances (Table 1, Figure 3). The Fabaceae family had the highest representation, with six species, while the other families, each represented by a single species, included Arecaceae, Cyperaceae, Malvaceae, Pontederiaceae, and Typhaceae. Six species were classified as native, four as introduced, and one as of uncertain origin. The plants identified exhibit a wide range of applications, primarily in producing furniture, household items, and raw materials for the paper industry. Species from the Fabaceae family, such as *Acacia auriculiformis*, *Afzelia xylocarpa*, *Peltophorum dasyrhachis*, *Sindora siamensis*, and *Tamarindus indica*, were predominantly used for their wood, which is suitable for crafting durable furniture and as an essential component in paper manufacturing. Additionally, *Cassia fistula*, from the same family, has found use in furniture making and household appliances, further highlighting the utility of this family. The Arecaceae family, represented by *Borassus flabellifer*, contributed to the production of ropes used in agricultural practices, particularly for tying livestock. *Actinoscirpus grossus*, a member of the Cyperaceae family, was woven into mats, serving as a traditional craft material.

ISSN 2616-0684 (Print)
ISSN 2616-0692 (Electronic)

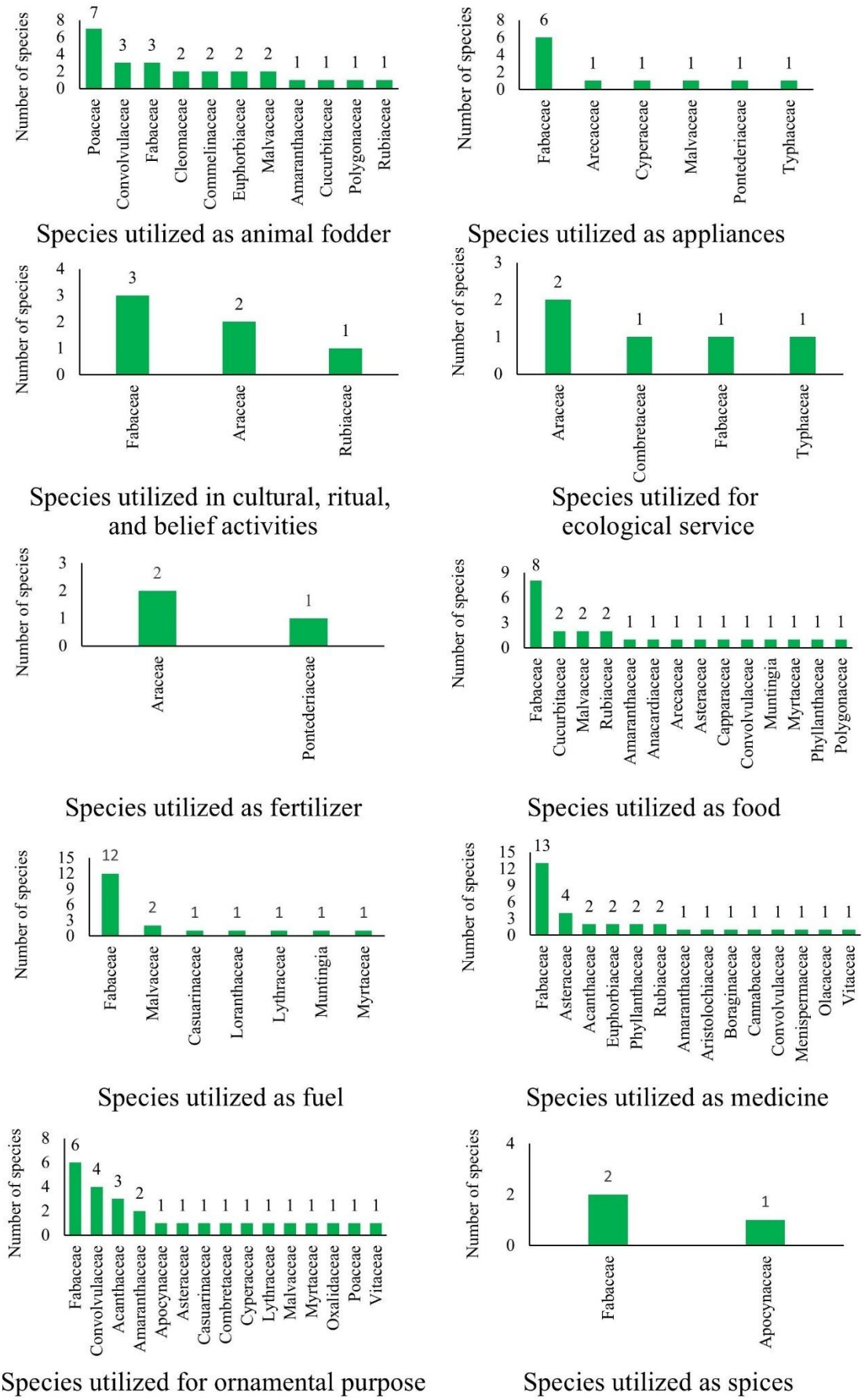

Figure 3: Distribution of plant species by family and their respective uses in each category.

The Malvaceae family, represented by *Bombax anceps*, provided fibers from its fruit for the creation of pillows and cushions, while *Pontederia crassipes* from the Pontederiaceae family yielded dried leaf stalks used for shock-absorbing materials. Lastly, the Typhaceae family, represented by *Typha angustifolia*, offered long, tough leaves commonly used in woven products such as mats, baskets, roofing materials, and ropes. The varied applications of these species highlight plant biodiversity's importance in supporting traditional practices and modern industries. The identified plants serve practical functions and represent a sustainable resource for numerous industries, contributing to local economies and environmental conservation.

A total of six species from three families were utilized in cultural, ritual, and belief-related practices (Table 1, Figure 3). The Fabaceae family was the most represented, with three species, followed by Araceae, with two species, and Rubiaceae, with one species. Among the Fabaceae, *Butea monosperma* and *Cassia fistula* are associated with beliefs that planting them in a household brings wealth, prosperity, honour, dignity, and respect. These plants hold significant cultural value in various traditions, symbolizing positive energy and good fortune for the family. The Araceae family, represented by *Lemna minor* and *Pistia stratiotes*, plays an essential role in ritual practices. Both species are placed in water jars, symbolizing the four ponds, and are commonly arranged around the pulpit during the Bun Pha Wet festival, an important cultural event. These plants contribute to the symbolism of water and purification in the festival, which is celebrated to honor ancestral spirits. In addition, *Morinda citrifolia*, from the Rubiaceae family, is used in house construction, with its leaves supporting the central pillar of the house. It is also used in the Bai Sri Su Kwan ceremony, which supports the bowls used during auspicious occasions. This species symbolizes strength and stability, both physically in construction and spiritually, during important cultural rites. Finally, *Tamarindus indica*, another species from the Fabaceae family, holds an essential place in belief practices. Planting a tamarind tree is believed to increase one's prestige, attract respect, and provide protection from evil, making it a powerful symbol of familial protection and social standing. These plants demonstrate the strong connection between flora and cultural practices, highlighting their role in promoting prosperity, spiritual well-being, and societal harmony. The varied uses of these species underscore the significance of plant symbolism in shaping cultural and ritualistic traditions.

Six species from four families were employed for ecological services (Table 1, Figure 3). The Araceae family had the highest representation of two species, while Combretaceae, Fabaceae, and Typhaceae each contributed one species. The plant species examined in this study demonstrate various applications, particularly environmental management, with significant potential in water and soil conservation efforts. *Lemna minor* is notably effective in conditioning water sources, especially in treating wastewater contaminated with organic substances and heavy metals. This makes it a valuable plant for phytoremediation, restoring water quality in polluted aquatic environments. Similarly, *Pistia stratiotes* are used in fish tanks and ponds as ornamental aquatic plants, providing shade for fish while simultaneously cleaning the water. Absorbing excess nutrients and pollutants is vital in maintaining ecosystem balance in confined water bodies. *Terminalia catappa* is another plant that supports water quality improvement, particularly in aquaculture, where it is placed in fish tanks and ponds to reduce waste accumulation, enhancing the overall cleanliness and balance of the water. In soil management, *Mimosa diplotricha* contributes by increasing the air spaces in the soil, making it loose, friable, and more capable of holding water, which is particularly beneficial for agricultural systems and land rehabilitation in arid regions. Finally, *Typha angustifolia* is an effective soil stabilizer with its extensive root system that prevents erosion along waterside areas. It can also be used as a soil cover material for perennial trees and fruit orchards, reducing moisture loss and protecting the soil from rainwater erosion. Together, these plants offer a range of ecological and environmental benefits, making them valuable for sustainable farming, aquaculture, and ecosystem restoration efforts.

Three species from two families were used as fertilizers (Table 1, Figure 3). The Araceae family was the most represented, with two species, while the Pontederiaceae family contributed one species. *Lemna minor*, *Pistia stratiotes*, and *Pontederia crassipes* are used as green manures in rice fields and can serve as raw materials for compost production.

A total of 24 species from 14 families were utilized as food (Table 1, Figure 3). The Fabaceae family had the highest representation with eight species, followed by Cucurbitaceae, Malvaceae, and Rubiaceae, each contributing two species. Other families, such as Amaranthaceae, Anacardiaceae, Arecaceae, Asteraceae, Capparaceae, Convolvulaceae, Muntingia, Myrtaceae, Phyllanthaceae, and Polygonaceae, each had one species.

Nineteen species from seven families were used as fuel (Table 1, Figure 3). The Fabaceae family was the most represented, with twelve species, followed by Malvaceae with two species. Casuarinaceae, Loranthaceae, Lythraceae, Muntingia, and Myrtaceae each contributed to one species. These species serve as vital fuel resources, supporting the community's cooking and heating needs.

Thirty-three species from 14 families were utilized for medicinal purposes (Table 1, Figure 3). The Fabaceae family was the most represented, with thirteen species, followed by Asteraceae, with four species. The Acanthaceae, Euphorbiaceae, Phyllanthaceae, and Rubiaceae families each contributed two species, while Amaranthaceae, Aristolochiaceae, Boraginaceae, Cannabaceae, Convolvulaceae, Menispermaceae, Olacaceae, and Vitaceae each had one species.

Twenty-six species from 15 families were utilized for ornamental purposes (Table 1, Figure 3). The Fabaceae family was the most represented, with six species, followed by Convolvulaceae, with four species. The Acanthaceae family contributed three species, while Amaranthaceae contributed two species. The Apocynaceae, Asteraceae, Casuarinaceae, Combretaceae, Cyperaceae, Lythraceae, Malvaceae, Myrtaceae, Oxalidaceae, Poaceae, and Vitaceae families each had one species.

A total of 3 species from 2 families were utilized as spices (Table 1, Figure 3). The Fabaceae family contributed two species, while the Apocynaceae family contributed one species. Villagers commonly add the young leaves of *Bauhinia acuminata* to curry dishes to impart a tangy flavour, such as in fish curry. *Tamarindus indica*, on the other hand, has various edible parts: young leaves, flowers, and fruits, all of which are used to add a sour taste to dishes like boiled fish and chicken. Additionally, the fruit of *T. indica* is a popular seasoning in papaya salad. *Urceola polymorpha*, often regarded as a wild vegetable, is widely used as a seasoning. This sour orange's most commonly used parts are the young leaves, flowers, and fruit.

The Informant Consensus Factor (F_{ic}) values for the medicinal plants identified in the study area (Table 2) indicate varying levels of agreement among informants regarding using different plant species for therapeutic purposes. The highest Fic values (1.00) were recorded for the central nervous system (1 species, 3 use reports), suggesting a strong consensus among informants, with a single plant species predominantly used for this ailment. Moderate F_{ic} values were observed in categories with a broader range of plant use. For example, the cardiovascular system group showed a F_{ic} of 0.89 (2 species, 10 use reports), and musculoskeletal and joint diseases had a F_{ic} of 0.86 (2 species, 8 use reports), indicating relatively high but somewhat varied agreement. The gastrointestinal system group had a F_{ic} of 0.81 (14 species, 70 use reports), reflecting moderate consensus, likely due to the diverse range of plant species used for treating various gastrointestinal ailments.

Other categories with moderate F_{ic} values include the infections group (0.76, 15 species, 59 use reports), which suggests a moderate level of agreement among informants, possibly due to the wide range of plant species employed in treating different infections. The drugs used in the poisoning and toxicology group (0.79, 4 species, 15 use reports) showed a moderate consensus, likely influenced by the diversity of plant species used in this category. The categories with lower F_{ic} values include ear, nose, oropharynx, and oral cavity (0.71, 5 species, 15 use reports), nutrition and blood (0.73, 4 species, 12 use reports), and obstetrics, gynecology, and urinary-tract disorders (0.73, 4 species, 12 use reports). These lower F_{ic} values suggest a more varied selection of plants for these ailments, resulting in a less pronounced consensus among informants.

Table 2: Informant consensus factor (F_{ic}) of plant species used by Lao Isan Ethnic Group Along Khakrang Creek, Mueang District, Maha Sarakham Province

Group of ailments	Total number of use reports (n_{ur})	The number of plant species (n_t)	F_{ic}
Cardiovascular system	10	2	0.89
Central nervous system	3	1	1.00
Drugs used in poisoning and toxicology	15	4	0.79
Ear, nose, oropharynx, and oral cavity	15	5	0.71
Gastro-intestinal system	70	14	0.81
Infections	59	15	0.76
Musculoskeletal and joint diseases	8	2	0.86
Nutrition and blood	12	4	0.73
Obstetrics, gynecology, and urinary tract disorders	12	4	0.73
Skin	24	7	0.74

The F_{ic} values suggest that stronger consensus is found when a single plant species is widely recognized for treating a specific condition, as seen in the central nervous system group. In contrast, categories with a higher number of plant species reflect a broader range of medicinal plant knowledge, resulting in more variation in usage and a lower degree of consensus, as seen in groups like the gastrointestinal system and infections.

The Fidelity Level (FL) values in this study provide insight into how consistently specific plant species treat particular ailments across different informants (Table 3). Higher FL values indicate that a plant is commonly linked to a specific disease, showing strong consistency in its use. In contrast, lower FL values suggest more diverse or varied plant applications.

The FL values for plants used for the Gastrointestinal System vary, with some plants showing high consistency in their uses. For example, *Acacia auriculiformis* (FL = 100.00) and *Tamarindus indica* (FL = 30.77) mainly treat diarrhea, reflecting their strong traditional association with this condition. The high FL for *A. auriculiformis* suggests it is widely recognized for treating diarrhea, while *T. indica* has a broader application, as reflected in its lower FL. Meanwhile, the FL values in the infections category are more varied, reflecting a wider range of plants used to treat infectious conditions. For instance, *Cassia fistula* (FL = 40.00) and *Mimosa pigra* (FL = 57.14) are used for parasitic infections and fever, respectively. Although both plants are commonly used for specific infections, the moderate FL values indicate that alternative plants are also used for similar purposes, suggesting some flexibility in their medicinal applications. Plants used for treating skin infections have generally low FL values, indicating a broader range of plants used for various skin conditions. However, *Hewittia malabarica* (FL = 100.00) shows a high level of fidelity in treating wounds, highlighting its strong and consistent use in this regard. In contrast, plants like *Afzelia xylocarpa* (FL = 33.33) and *Mimosa pudica* (FL = 14.29) have more varied applications for conditions such as wounds, rashes, and itching, reflected in their lower FL values.

Obstetrics, Gynaecology, and Urinary Tract Disorders: Plants in this group show mixed FL values. For example, *Barleria strigosa* (FL = 36.36) is used for various reproductive and urinary issues, including expelling lochia after childbirth and treating urinary tract inflammation. The moderate FL values suggest some variability in the use of plants for these conditions, as informants report different species for similar health concerns. Plants used for musculoskeletal and joint diseases, such as *Asystasia gangetica* (FL = 71.43), have a relatively high FL, indicating its strong association with treating joint pain and swelling. This suggests that some plants are more consistently used for musculoskeletal conditions, with a higher degree of agreement among informants.

Also, plants (herbals) used in poisoning and toxicology, e.g., *Cassia fistula* (FL = 50.00) and *Delonix regia* (FL = 55.56), show moderate FL values for treating insect bites, stings, and poisoning symptoms. The moderate FL values suggest several plants are used for these toxicological issues, indicating a more flexible approach to treating poisoning and related conditions. *Morinda citrifolia* (FL = 33.33) and Tamarindus indica (FL = 46.15) show moderate FL values for cardiovascular ailments. This suggests that various plants address conditions such as high blood pressure and heart diseases, with informants relying on different species for similar purposes.

This study provides a comprehensive account of the plant species utilized by the Lao Isan ethnic group along Khakrang Creek, focusing on their diversity, use value, and applications in traditional practices. A total of 96 plant species belonging to 83 genera and 35 botanical families were identified, highlighting the rich plant biodiversity in the region. Fabaceae was the most represented family, contributing 21 species, followed by Asteraceae and Convolvulaceae. This composition reflects these plants' significant ecological and cultural roles in the area, where plant diversity supports various uses across local livelihoods and cultural practices.[30] Our findings reveal similarities and distinctive patterns When compared with previous ethnobotanical studies conducted in northeastern Thailand and neighboring regions. For example, the predominance of Fabaceae aligns with earlier reports, highlighting its prominence in local medicinal and food systems.[5,6,8,18,19] However, this study's relatively high representation of Convolvulaceae appears more specific to the Khakrang Creek area, suggesting localized ecological or cultural factors influencing plant selection.[10,19] This unique taxonomic pattern contributes new data to the biocultural diversity of the region and reinforces the need for site-specific documentation. Furthermore, the total number of documented species exceeds some prior studies in similar settings, indicating the unique ethnobotanical knowledge preserved within the Lao Isan community.[31] These comparisons underscore the importance of localized fieldwork in capturing the nuances of traditional plant use across different ethnic and ecological landscapes.

The high diversity of species documented in this study is indicative of the ecological richness of the Khakrang Creek region. The predominance of native species (53.13%) compared to introduced species (44.79%) reflects a stable local ecosystem. However, the presence of non-native species suggests some level of ecological transformation or interaction with other regions.[32] This pattern aligns with findings from.[5], though earlier studies such as [8] reported lower proportions of introduced species, suggesting increased plant exchange in recent years. The presence of endemic species, particularly those with high cultural and medicinal use, underscores the importance of preserving local biodiversity to safeguard the ethnobotanical knowledge passed down through generations.[33] The assessment of use value (UV) categorizes plant species based on their cultural, medicinal, and practical applications, providing insight into the significance of these plants within local communities.[33] *Tamarindus indica*, *Ipomoea aquatica*, and *Momordica charantia* exhibited the highest use values (UV $\geq$ 0.600), underscoring their importance in daily life for practical and symbolic reasons.[34] These species represent key functional resources within the community and highlight the depth of traditional knowledge in selecting multipurpose plants. *Tamarindus indica*, in particular, holds a prominent place in the cultural and ritual practices of the community, reinforcing the concept that plants serve not only as practical resources but also as carriers of cultural meaning.[35] The categorization of plants by use value aligns with previous studies by [36], which emphasize the multifaceted roles of plants in traditional societies, where they often serve overlapping cultural, medicinal, and ecological functions.

Table 3: Fidelity Level (FL) of plant species used by the Lao Isan Ethnic Group Along Khakrang Creek, Mueang District, Maha Sarakham Province.

No.	Scientific name	I_p	I_u	FL	Used parts	Preparation	Method of uses	Ailments	Ailment groups
1.	*Acacia auriculiformis* A.Cunn. ex Benth.	5	5	100.00	Leaf	Dry it and brew with hot water to drink.	Drink	Treat diarrhea	Gastro-intestinal system
2.	*Achyranthes aspera* L.	3	5	60.00	Leave	Boil with water, then filter to get only the liquid.	Drink	Treat fever	Infections
		2	5	40.00	Whole plant	Boil with water, then filter to get only the liquid.	Drink	Treat parasitic infections	Infections
3.	*Afzelia xylocarpa* (Kurz) Craib	3	6	50.00	Bark	Dry it and brew it with hot water to drink.	Drink	Treat diarrhea	Gastro-intestinal system
		2	6	33.33	Stem	Dry it and brew with hot water to drink.	Drink	Treat skin diseases	Skin
		1	6	16.67	Bark	Grind	Apply to skin	Treat wounds	Skin
4.	*Ageratum conyzoides* L.	4	16	25.00	Whole plant	Boil with water, then filter to get only the liquid.	Drink	Treat and expel kidney stones	Obstetrics, gynecology, and urinary tract disorders
		1	16	6.25	Leave	Crush	Apply to skin	Treat wounds	Skin
		2	16	12.50	Leave	Crush	Apply to skin	Relieves itching and rashes	Skin
		3	16	18.75	Leave	Boil it with water, then filter it to get only the liquid.	Drink	Treat fever	Infections
		3	16	18.75	Root	Boil it with water, then filter it to get only the liquid.	Drink	Treatment of urinary tract inflammation	Obstetrics, gynecology, and urinary tract disorders
		2	16	12.50	Leave	Crush	Apply to skin	Treat skin diseases	Skin
		1	16	6.25	Leave	Crush	Apply to skin	Antidote for insect bites and stings	Drugs used in poisoning and toxicology
5.	*Aristolochia acuminata* Lam.	4	7	57.14	Leave	Boil it with water, then filter it to get only the liquid.	Drink	Relieves stomach pain, bloating and flatulence	Gastro-intestinal system
		3	7	42.86	Inflorescence	Boil it with water, then filter it to get only the liquid.	Drink	Treat constipation	Gastro-intestinal system
6.	*Asystasia gangetica* (L.) T.Anderson	5	7	71.43	Leave	Eat fresh	Eat	Relieve swelling and joint pain	Musculoskeletal and joint diseases
		2	7	28.57	Leave	Eat fresh	Eat	Treat parasitic infections	Infections
7.	*Barleria strigosa* Willd.	4	11	36.36	Whole plant	Boil it with water, then filter it to get only the liquid.	Drink	Diuretic	Obstetrics, gynecology, and urinary tract disorders
		3	11	27.27	Root	Boil with the root of *Senna tora* (L.) Roxb. and Phyllanthus reticulatus Poir. Filter to get only the liquid.	Drink	Expel lochia after childbirth	Obstetrics, gynecology, and urinary tract disorders
		4	11	36.36	Leave	Boil it with water, then filter it to get only the liquid.	Drink	Treat the flu	Infections
8.	*Butea monosperma* (Lam.) Kuntze	5	9	55.56	Seed	Grind finely and mix with lemon juice.	Apply to skin	Treat itching	Skin
		1	9	11.11	Inflorescence	Boil it with water, then filter it to get only the liquid.	Drink	Treat fever	Infections

No.	Scientific name	I_p	I_u	FL	Used parts	Preparation	Method of uses	Ailments	Ailment groups
		1	9	11.11	Root	Boil with water, then filter to get only the liquid.	Drink	Treats symptoms of flatulence and bloating	Gastro-intestinal system
		2	9	22.22	Leave	Boil with water, then filter to get only the liquid.	Drink	Treat parasitic infections	Infections
9.	*Cassia fistula* L.	1	10	10.00	Leave	Boil with water, then filter to get only the liquid.	Drink	Treat parasitic infections	Infections
		5	10	50.00	Fruit	Boil with water, then filter to get only the liquid.	Drink	Treating symptoms of poisoning	Drugs used in poisoning and toxicology
		4	10	40.00	Root	Grind	Apply to skin	Treat ringworm	Infections
10.	*Chromolaena odorata* (L.) R.M.King & H.Rob.	6	9	66.67	Stem	Boil with water, then filter to get only the liquid.	Drink	Relieves stomach pain, bloating and flatulence	Gastro-intestinal system
		1	9	11.11	Leave	Boil with water, then filter to get only the liquid.	Drink	Treat hemorrhoids	Skin
		2	9	22.22	Leave	Crush	Apply to skin	Treat bleeding disorders	Nutrition and blood
11.	*Cissus quadrangularis* L.	6	10	60.00	Vine	Crush, then filter to get only the liquid.	Drink	Treating septicemia	Infections
		4	10	40.00	Vine	Crush, then filter to get only the liquid.	Drink	Treat intestinal diseases	Gastro-intestinal system
12.	*Cyanthillium cinereum* (L.) H.Rob.	4	7	57.14	Leave	Boil with water, then filter to get only the liquid.	Drink	Treat fever	Infections
		3	7	42.86	Leave	Boil with water, then filter to get only the liquid.	Drink	Relieves stomach pain, bloating and flatulence	Gastro-intestinal system
13.	*Delonix regia* (Bojer ex Hook.) Raf.	5	9	55.56	Stem	Grind	Apply to skin	Antidote for insect bites and stings	Drugs used in poisoning and toxicology
		4	9	44.44	Root	Boil with water, then filter to get only the liquid.	Drink	Treat tuberculosis	Infections
14.	*Eclipta prostrata* (L.) L.	4	8	50.00	Leave	Boil with water, then filter to get only the liquid.	Drink	Treat gonorrhea	Infections
		1	8	12.50	Stem	Boil with water, then filter to get only the liquid.	Drink	Treat vaginal discharge	Obstetrics, gynaecology and urinary-tract disorders
		3	8	37.50	Stem	Crush	Apply to skin	Treat wounds	Skin
15.	*Euphorbia heterophylla* L.	2	3	66.67	Inflorescence	Boil with water, then filter to get only the liquid.	Drink	Treat bronchitis	Ear, nose, oropharynx and oral cavity
		1	3	33.33	Young leave	Eat fresh	Eat	Treat parasitic infections	Infections
16.	*Euphorbia hirta* L.	7	10	70.00	Whole plant	Boil with water, then filter to get only the liquid.	Drink	Treat nosebleeds	Nutrition and blood
		3	10	30.00	Stem	Boil with water, then filter to get only the liquid.	Drink	Treat gonorrhea	Infections
17.	*Heliotropium indicum* L.	4	7	57.14	Leave	Boil with water, then filter to get only the liquid.	Drink	Treat allergies	Skin
		1	7	14.29	Whole plant	Boil with water, then filter to get only the liquid.	Drink	Treatment of bladder stones	Obstetrics, gynaecology and urinary-tract disorders
		2	7	28.57	Whole plant	Boil with water, then filter to get only the liquid.	Drink	Treat asthma	Ear, nose, oropharynx and oral cavity

No.	Scientific name	I_p	I_u	FL	Used parts	Preparation	Method of uses	Ailments	Ailment groups
18.	*Hewittia malabarica* (L.) Suresh	7	7	100.00	Leave	Mix with leave of *Cordyline fruticosa* (L.) A.Chev. and smash	Apply to skin	Treat wounds and disinfect	Skin
19.	*Mimosa pigra* L.	4	7	57.14	Stem	Boil with water, then filter to get only the liquid.	Drink	Treat fever	Infections
		2	7	28.57	Stem	Boil with water, then filter to get only the liquid.	Drink	Treats dysentery	Infections
		1	7	14.29	Leave	Crush	Apply to skin	Treat wounds	Skin
20.	*Mimosa pudica* L.	3	6	50.00	Stem	Grind	Apply to skin	Treat hives	Skin
		3	6	50.00	Leave	Crush	Apply to skin	Antidote for insect bites and stings	Drugs used in poisoning and toxicology
21.	*Morinda citrifolia* L.	1	12	8.33	Leave	Boil with water, then filter to get only the liquid.	Drink	Treat diarrhea	Gastro-intestinal system
		2	12	16.67	Leave	Boil with water, then filter to get only the liquid.	Drink	Treat diabetes	Nutrition and blood
		5	12	41.67	Inflorescence	Boil with water, then filter to get only the liquid.	Drink	Treat cancer	Infections
		4	12	33.33	Root	Boil with water, then filter to get only the liquid.	Drink	Treating diseases of the cardiovascular system	Cardiovascular system
22.	*Olax scandens* Roxb.	3	5	60.00	Root	Boil with water, then filter to get only the liquid.	Drink	Treat sexually transmitted diseases	Infections
		2	5	40.00	Heart wood	Boil with water, then filter to get only the liquid.	Drink	Treat aches and pains	Musculoskeletal and joint diseases
23.	*Paederia foetida* L.	5	8	62.50	Whole plant	Boil with water, then filter to get only the liquid.	Drink	Diuretic treatment	Obstetrics, gynaecology and urinary-tract disorders
		3	8	37.50	Leave	Grind	Use externally	Treat headaches	Central nervous system
24.	*Peltophorum dasyrhachis* (Miq.) Kurz	4	5	80.00	Stem	Boil with water, then filter to get only the liquid.	Drink	Treats phlegm	Ear, nose, oropharynx and oral cavity
		1	5	20.00	Bark	Boil with water, then filter to get only the liquid.	Drink	Treats diarrhea	Gastro-intestinal system
25.	*Phyllanthus emblica* L.	3	5	60.00	Fruit	Eat fresh	Eat	Treat constipation	Gastro-intestinal system
		2	5	40.00	Fruit	Eat fresh	Eat	Treat cough	Ear, nose, oropharynx and oral cavity
26.	*Phyllanthus reticulatus* Poir.	6	10	60.00	Leave	Boil with water, then filter to get only the liquid.	Drink	Treat body aches and pains	Musculoskeletal and joint diseases
		3	10	30.00	Root	Grind	Apply to skin	Treat herpes, shingles	Infections
		1	10	10.00	Root	Boil with water, then filter to get only the liquid.	Drink	Reduce blood sugar	Nutrition and blood
27.	*Pithecellobium dulce* (Roxb.) Benth.	5	9	55.56	Fruit	Eat fresh	Eat	Cough relief, phlegm expulsion	Ear, nose, oropharynx and oral cavity
		4	9	44.44	Bark	Boil with water, then filter to get only the liquid.	Drink	Treat diarrhea	Gastro-intestinal system
28.	*Samanea saman* (Jacq.) Merr.	4	12	33.33	Bark	Boil with water, then filter to get only the liquid.	Drink	Treat diarrhea	Gastro-intestinal system

No.	Scientific name	I_p	I_u	FL	Used parts	Preparation	Method of uses	Ailments	Ailment groups
		6	12	50.00	Leave	Boil with water, then filter to get only the liquid.	Drink	Treat diarrhea	Gastro-intestinal system
		2	12	16.67	Leave	Crush	Apply to skin	Antidote for insect bites and stings	Drugs used in poisoning and toxicology
29.	*Senna siamea* (Lam.) H.S.Irwin & Barneby	7	10	70.00	Leave	Boil with water, then filter to get only the liquid.	Drink	Treat constipation	Gastro-intestinal system
		3	10	30.00	Leave	Boil with water, then filter to get only the liquid.	Drink	Laxative	Gastro-intestinal system
30.	*Sindora siamensis* Teijsm. ex Miq.	4	9	44.44	Bark	Dry it and brew with hot water to drink.	Drink	Treat chickenpox	Infections
		5	9	55.56	Fruit	Dry it and brew with hot water to drink.	Drink	Treat skin diseases	Skin
31.	*Tamarindus indica* L.	4	13	30.77	Leave	Boil with water, then filter to get only the liquid.	Drink	Laxatives, purgatives, and intestinal gas eliminators	Gastro-intestinal system
		6	13	46.15	Inflorescence	Dry it and brew with hot water to drink.	Drink	Reduce high blood pressure	Cardiovascular system
		3	13	23.08	Bark	Dry it and brew with hot water to drink.	Drink	Treat fever	Infections
32.	*Tinospora baenzigeri* Forman	5	11	45.45	Vine	Boil with water, then filter to get only the liquid.	Drink	Treat urinary tract diseases	Obstetrics, gynaecology and urinary-tract disorders
		6	11	54.55	Inflorescence	Dry it and brew with hot water to drink.	Drink	Relieves flatulence and bloating	Gastro-intestinal system
33.	*Trema orientale* (L.) Blume	4	10	40	Leave	Boil with water, then filter to get only the liquid.	Drink	Treat constipation	Gastro-intestinal system
		6	10	60	Leave	Boil with water, then filter to get only the liquid.	Drink	Laxative	Gastro-intestinal system

The study identified various traditional uses for plant species, spanning categories such as food, medicine, ecological services, and ritual practices. The most common uses involved medicinal and food-related species, with 33 species identified for medicinal purposes and 24 for food. This concentration of medicinal use underscores the community's reliance on local flora for primary healthcare, which remains a critical aspect of their resilience and self-sufficiency.[37] The use of plants such as *Acacia auriculiformis* and *Tamarindus indica* for treating gastro-intestinal disorders is consistent with findings from previous ethnobotanical studies by [38] and [39], which underscore the importance of locally sourced plants in managing common health conditions. In addition to their direct use in health and nutrition, many plant species serve as ecological services, such as water purification and soil stabilization. Plants like *Lemna minor* and *Pistia stratiotes*, utilized for water purification, exemplify the role of plants in ecosystem management and sustainable agricultural practices.[40] The finding that several species are used for ecological services such as phytoremediation and soil stabilization suggests that the community relies on plants for survival and actively engages in environmental stewardship.[41] These practices reflect an integrated knowledge system contributing to sustainable land use, highlighting these species' dual ecological and cultural significance.

Cultural and ritual uses of plants, such as the symbolic role of *Cassia fistula* and *Butea monosperma* in family prosperity and health, were also observed in this study. These species are integrated into rituals that signify social values, such as respect, protection, and the connection to ancestral spirits.[42,43] Using plants in rituals is common in many indigenous cultures, where plants symbolize spiritual well-being and safety.[44,45] This finding affirms the deep-rooted spiritual role of plants, which extends their importance beyond functional use into the realm of identity and belief. The role of plants like *Morinda citrifolia* in construction and ceremonies highlights the diverse ways plants are interwoven with cultural practices, contributing to the cultural fabric and social cohesion of the Lao Isan community.[46,47] The analysis of informant consensus and fidelity levels for medicinal plants reveals interesting patterns in the shared knowledge and practices within the community. High fidelity levels for plants such as *Acacia auriculiformis* and *Tamarindus indica* in treating gastrointestinal issues and infections confirm the reliability of these plants in traditional medicine.[48,49] These consensus-based results reinforce the cultural validation of plant efficacy and help prioritize species for future pharmacological studies. Lower fidelity levels for other categories, such as skin and musculoskeletal diseases, suggest a broader range of plant species being used, reflecting the diversity of therapeutic approaches in these areas.[50,51] This variability in plant use across categories may be attributed to the flexibility and adaptability of traditional medicine, where plant selection can vary based on local availability, personal experience, and socio-cultural factors.[52-54]

Conclusion

This study highlights the intricate relationship between the Lao Isan ethnic group and the diverse plant species along Khakrang Creek. It reveals a wealth of ethnobotanical knowledge embedded in their daily lives and traditional practices. Ninety-six plant species were documented, many of which serve multiple roles: medicinal, culinary,

and ecological, demonstrating the multifunctionality of plant use in the community. Some plant species frequently used illustrate the deep-rooted cultural significance and practical reliance on local flora. Most plants are employed for ecological services, including water purification and soil stabilization, evidence of the community's traditional ecological knowledge that supports local environmental stewardship. This research draws attention to the vulnerability of ethnobotanical knowledge in the face of environmental change and cultural shifts. There is a critical need for further documentation and protective measures to safeguard the plant species and the traditional knowledge systems associated with them. By integrating ethnobotanical knowledge into broader conservation strategies, this study contributes to biodiversity preservation and the protection of cultural heritage. The insights gained offer a valuable foundation for developing sustainable resource management practices that respect and incorporate indigenous perspectives, ensuring that ecological integrity and cultural identity are maintained for future generations.

Conflict of interest

The author declares no conflicts of interest.

Authors' Declaration

The authors hereby declare that the work presented in this article is original and that any liability for claims relating to the content of this article will be borne by them.

Acknowledgements

We want to thank Mahasarakham University for its financial support. We sincerely appreciate the Lao Isan ethnic communities along Khakrang Creek in Mueang District, Maha Sarakham Province, for their generous support and for sharing their invaluable knowledge of ethnobotany. We are also grateful to the Walai Rukhavej Botanical Research Institute and Mahasarakham University for providing the necessary facilities and resources during this study.

References

1. Habchaoui J, Saad I, Khomsi ME, Fadli M, Bourkhiss B. Ethnobotanical study of medicinal herbs in the Saïss Urban Commune (Region of Fez/Morocco). Trop. J. Nat. Prod. Res. 2023;7(11):5034-5039. doi: 10.26538/tjnpr/v7i11.3.
2. Sitanggang NDH, Zuhud EAM, Masy'ud B, Soekmadi. Ethnobotany of the Toba Batak Ethnic Community in Samosir District, North Sumatra, Indonesia. Biodiversitas 2022;23(12):6114-6118. Doi: 10.13057/biodiv/d231204.
3. Agustina L, Agustina P. Exploring urban ethnobotany: A case study of medicinal plants traded in Gede Hardjonagoro Market, Surakarta, Indonesia. Trop. J. Nat. Prod. Res. 2024;8(4):6839-6851. doi: 10.26538/tjnpr/v8i4.13.
4. Chikmawati T, Sulistijorini, Djuita NR, Prasaja D, Yamini THA, Miftahudin, Fakhrurrozi Y. Ethnobotany of food plants utilized by Malay Ethnic in Belitung District, Indonesia. Biodiversitas 2023;24(5):2977-2987. Doi: 10.13057/biodiv/d240552.
5. Niamngon T, Saensouk S, Saensouk P, Junsongduang A. Ethnobotanical of the Lao Isan Ethnic Group in Pho Chai District, Roi Et Province, Northeastern Thailand. Trop. J. Nat. Prod. Res. 2024;8(2):6152-6181. doi: 10.26538/tjnpr/v8i2.13.
6. Junsongduang A, Kasemwan W, Lumjoomjung S, Sabprachai W, Tanming W, Balslev H. Ethnomedicinal knowledge of traditional healers in Roi Et, Thailand. Plants 2020;9(9):1177. doi: 10.3390/plants9091177.
7. Saensouk P, Boonma T, Jitpromma T, Chen TV, Saensouk S. Ethnobotany of Piperaceae in Nakhon Nayok Province, Central Thailand. Biodiversitas 2025;(5)26:2416-2428. doi: 10.13057/biodiv/d260539
8. Junsongduang A, Nabundit O, Chinnawong P, Tanming W, Balslev H. Medicinal plants used by Tai Lao healers in Roi Et, Thailand. Res. Sq. 2021. doi: 10.21203/rs.3.rs-957563/v1.
9. Draper J, Garzoli J, Kamnuansilpa P, Lefferts L, Mitchell J, Songkünnatham P. The Thai Lao – Thailand's largest unrecognized transboundary national ethnicity. Nats. Nat. 2019;25(4):1131-1152. doi: 10.1111/nana.12523.
10. Saensouk P, Saensouk S, Hein KZ, Appamaraka S, Maknoi C, Souladeth P, Koompoot K, Sonthongphithak P, Boonma T, Jitpromma T. Diversity, ethnobotany, and horticultural potential of local vegetables in Chai Chumphol Temple Community Market, Maha Sarakham Province, Thailand. Horticulturae 2025;11(3):243. doi: 10.3390/horticulturae11030243.
11. Saensouk P, Ragsasilp A, Thawara N, Boonma T, Appamaraka S, Sengthong A, Daovisan H, Setyawan AD, Saensouk S. Ethnobotanical study of Acanthaceae family in Kantarawichai District, Maha Sarakham Province, Thailand. Biodiversitas 2024;25(8):2570-2582. Doi: 10.13057/biodiv/d250829.
12. Stagg BC, Dillon J. Plant awareness is linked to plant relevance: A review of educational and ethnobiological literature (1998–2020). Plants People Planet. 2022;4(6):579-592. doi: 10.1002/ppp3.10323
13. Jitpromma T, Saensouk S, Saensouk P, Boonma T. Diversity, traditional uses, economic values, and conservation status of Zingiberaceae in Kalasin Province, Northeastern Thailand. Horticulturae 2025;11(3):247. doi: 10.3390/horticulturae11030247.
14. Laohaprapanon S, Jitjum S, Panitset KYT, Sukmak N. Traditional healing practices and folk medicines in Thailand: A case study of Huai Yot District, Trang Province. Trop. J. Nat. Prod. Res. 2024;8(3):6537-6543. doi: 10.26538/tjnpr/v8i3.10.
15. Malapane OL, Chanza N, Musakwa W. Transmission of indigenous knowledge systems under changing landscapes within the Vhavenda community, South Africa. Environ. Sci. Pol. 2024;161:103861. doi: 10.1016/j.envsci.2024.103861.
16. Alum EU. The role of indigenous knowledge in advancing the therapeutic use of medicinal plants: challenges and opportunities. Plant Signal Behav. 2024;19(1):2439255. doi: 10.1080/15592324.2024.2439255.
17. Appamaraka S, Saensouk S, Saensouk P, Junsongduang A, Setyawan AD. Ethnobotanical knowledge of medicinal plants in the Don Pu Ta Forest by Kaloeng Ethnic Group, Sakon Nakhon Province, Northeastern Thailand. Biodiversitas 2023;24(8):4617-4635. Doi: 10.13057/biodiv/d240844.
18. Niamngon P, Saensouk S, Saensouk P, Junsongduang A. Ethnobotanical knowledge of Isaan Laos tribe in Khong Chai District, Kalasin Province, Thailand with particular focus on medicinal uses. Biodiversitas 2023;24(12):6793-6824. Doi: 10.13057/biodiv/d241242.
19. Phatlamphu N, Saensouk S, Saensouk P, Jungsongduang A. Ethnobotany of edible plants in Muang District, Kalasin Province, Thailand. Biodiversitas 2021;22(12):5425-5431. doi: 10.13057/biodiv/d221226.
20. Baghersad ZR, Piri K, Abdoli A, Mehrabian AR, Abdoli S. Importance of using ethnobiological knowledge for the conservation of medicinal plants biodiversity in the Lar region (Iran). J Med Plants By-Products. 2023;13(1):21-30. doi: 10.22092/jmpb.2022.357916.1457.
21. Pei S, Alan H, Wang Y. Vital roles for ethnobotany in conservation and sustainable development. Plant Divers. 2020;42(6):399-400. doi: 10.1016/j.pld.2020.12.001
22. Saensouk, P., Saensouk, S., Rakarcha, S., & Souladeth, P. Diversity and traditional uses of Convolvulaceae in That Phanom District, Nakhon Phanom Province, Thailand. Trop. J. Nat. Prod. Res. 2024;8(5),7120-7127. doi: 10.26538/tjnpr/v8i5.11
23. Saensouk P, Saensouk S, Hein KZ, Boonma T, Sengthong A, Rakarcha S. Studies on *Typhonium* (Araceae) of Thailand I: *Typhonium vinicolor*, a new species from Khon Kaen Province, Northeastern Thailand. PhytoKeys 2024;246:189-195. Doi: 10.3897/phytokeys.246.128778.
24. Saensouk P, Saensouk S, Hein KZ, Boonma T, Sengthong A, Rakarcha S, Warseno T. Studies on *Typhonium* (Araceae) of Thailand II: *Typhonium fornicatum*, a new species from Bueng Kan Province, Northeastern Thailand. Taiwania 2024;69(4):487-490. doi: 10.6165/tai.2024.69.487.

25. Hein KZ, Prehsler D, Saensouk S, Low SL. *Hayarum mirispathum* (Araceae -Aroideae): A new genus and species from Thailand. Taiwania 2025;70(1):65-74. doi: 10.6165/tai.2025.70.65.
26. Plants of the World Online, facilitated by the Royal Botanic Gardens, Kew. Available online: www.plantsoftheworldonline.org/ (accessed on 5 March 2025).
27. Phillips O, Gentry AH, Reynel C, Wilkin P, Galvez-Durand BC. Quantitative ethnobotany and Amazonian conservation. Conserv Biol. 1994;8(1):225-248. doi: 10.1046/j.1523-1739.1994.08010225.x
28. Heinrich M, Ankli A, Frei B, Weimann C, Sticher O. Medicinal plants in Mexico: healers' consensus and cultural importance. Soc Sci Med. 1998;47(11):1859-1871. doi: 10.1016/s0277-9536(98)00181-6.
29. Suwardi AB, Navia ZI, Mubarak A, Mardudi M. Diversity of home garden plants and their contribution to promoting sustainable livelihoods for local communities living near Serbajadi protected forest in Aceh Timur region, Indonesia. Biol Agric Hortic. 2023;39(3):170-182. doi:10.1080/01448765.2023.2182233.
30. Saensouk P, Saensouk S, Boonma T, Junsongduang A, Rakarcha S, Chanthavongsa K, Jitpromma T. Zingiberaceae in Roi Et Province, Thailand: Diversity, ethnobotany, horticultural value, and conservation status. Horticulturae. 2025;11(5):527. doi: 10.3390/horticulturae11050527
31. Numpulsuksant W, Saensouk S, Sanesouk P. Diversity and ethnobotanical study of medicinal plants in Ban Hua Kua, Kae Dam District, Thailand. Biodiversitas 2021;22(10):4349-4357. doi: 10.13057/biodiv/d221027
32. Ahmed DA, Sousa R, Bortolus A, Aldemir C, Angeli NF, Błońska D, Briski E, Britton JR, Cano-Barbacil C, Clark-Ginsberg A, Culic I, Cuthbert RN, Dick J, Dimarco RD, Essl F, Everts T, García-Berthou E, Hauer M, Kouba A, Kourantidou M, Kutschera U, Mammola S, Martín-Forés I, Morissette O, Nuñez MA, Olden JD, Pârvulescu L, Pergl J, Renault D, Rico-Sánchez AE, Russell JC, Soto I, Serhan Tarkan A, Uysal TU, Verreycken H, Vilizzi L, Wasserman R, Wehi P, Haubrock PJ. Parallels and discrepancies between non-native species introductions and human migration. Biol Rev. 2025;10(3):1365-1395. doi: 10.1111/brv.70004.
33. Wendimu A, Tekalign W, Bojago E, Abrham Y. Traditional ethnobotanical knowledge and ethnomedicinal use of plants in the Tropical Rift Valley of Ethiopia. Heliyon. 2024;10:e27528. doi: 10.1016/j.heliyon.2024.e27528.
34. Luo J, Li Q, He J, Yan J, Zhang S, Chang X, Wu T. Local knowledge of home garden plants in Miao ethnic communities in Laershan region, Xiangxi area, China. J Ethnobiol Ethnomed. 2024;20(37). doi: 10.1186/s13002-024-00676-x.
35. Al Yamini TH, Djuita NR, Chikmawati T, Purwanto Y. Ethnobotany of wild and semi-wild edible plants of the Madurese Tribe in Sampang and Pamekasan Districts, Indonesia. Biodiversitas. 2023;24(2):947–957. doi: 10.13057/biodiv/d240234
36. Fandohan A, Assogbadjo A, Kakaï GRL, Kyndt T, Caluwé E, Codjia J, Sinsin B. Women's traditional knowledge, use value, and the contribution of tamarind (*Tamarindus indica* L.) to rural households' cash income in Benin. Econ Bot. 2010;64:248-259. doi: 10.1007/s12231-010-9123-2.
37. Saensouk P, Saensouk S, Rakarcha S, Boonma T, Jitpromma T, Sonthongphithak P, Ragsasilp A, Souladeth P. Diversity and local uses of the Convolvulaceae family in Udon Thani Province, Thailand, with notes on its potential horticultural significance. Horticulturae. 2025;11(3):312. doi: 10.3390/horticulturae11030312.
38. Chukwurah GO, Okeke FO, Isimah MO, Enoguanbhor EC, Awe FC, Nnaemeka-Okeke RC, Guo S, Nwafor IV, Okeke CA. Cultural influence of local food heritage on sustainable development. World. 2025;6(1):10. doi: 10.3390/world6010010.
39. Tchatchedre M, Amoussa AM, Houinato M, Yedomonhan H, Lagnika L. Ethnobotanical survey and phytogeographical study of plant species from genus *Acacia* in BÃ©nin. J Med Plants Res. 2019;13(9): 199-212. doi: 10.5897/JMPR2019.6761.
40. Balkrishna A, Payal M, Dabhade RN, Singh A, Arya V. Ethnomedicine, phytochemistry, and anti-microbial proficiency of *Tamarindus indica* L. and its mediated nanoparticles. BioNanoSci. 2024;14:4238-4249. doi: 10.1007/s12668-024-01302-6.
41. Mustafa H, Gasim HT. Comparison of *Pistia stratiotes* and *Lemna minor* plants potentials in bioremediation of domestic wastewater. J Inst Engrs Malaysia. 2021;82(1):83. doi: 10.54552/v82i1.83.
42. Comberti C, Thornton TF, Wyllie de Echeverria V, Patterson T. Ecosystem services or services to ecosystems? Valuing cultivation and reciprocal relationships between humans and ecosystems. Glob Environ Change. 2015;34:247-262. doi: 10.1016/j.gloenvcha.2015.07.007.
43. Sharma D. Enumerations on phytochemical, pharmacological and ethnobotanical properties of *Cassia fistula* Linn: yellow shower. J Phytopharmacol. 2017;6(5):300–306. doi: 10.31254/phyto.2017.6509.
44. Rai A, Pandey VC, Singh AK, Ghoshal N, Singh N. *Butea monosperma*: a leguminous species for sustainable forestry programmes. Environ Dev Sustain. 2021;23:8492–8505. doi: 10.1007/s10668-020-00977-7.
45. Sutrisno IH, Akob B, Navia ZI, Nuraini, Suwardi AB. Documentation of ritual plants used among the Aceh tribe in Peureulak sub-district, East Aceh, Indonesia. Biodiversitas. 2020;21(11):4990–4998. doi: 10.13057/biodiv/d211102
46. Calvo-Díaz DY, Aguilar-Hernández L, Jiménez-Noriega MS, Torres-Montúfar A. Ritual use of rosa de borracho (*Clinopodium macrostemum* (Moc. & Sessé ex Benth.) Kuntze, Lamiaceae) in Oaxaca. Biodiversitas. 2023;24(9):5105–5112. doi: 10.13057/biodiv/d240955.
47. Almeida ES, de Oliveira D, Hotza D. Properties and applications of *Morinda citrifolia* (Noni): A review. Compr Rev Food Sci Food Saf. 2019;18(4):883-909. doi: 10.1111/1541-4337.12456.
48. Saensouk P, Saensouk S, Boonma T, Junsongduang A, Appamaraka S, Koompoot K, Chanthavongsa K, Jitpromma T. Ethnobotany of Lao Isan Ethnic Group from Na Chueak District, Maha Sarakham Province, Northeastern Thailand. Horticulturae. 2025;11(5):497. doi: 10.3390/horticulturae11050497
49. Rangra NK, Samanta S, Pradhan KK. A comprehensive review on phytopharmacological investigations of *Acacia auriculiformis* A.Cunn. Ex Benth. Asian Pac J Trop Biomed. 2019;9(1):1-11. doi: 10.4103/2221-1691.250263.
50. Mukherjee D, Deb J, Deb N, Saha S, Chakraborty S. Ethnopharmacological, phytochemical and pharmacological review on *Tamarindus indica* L. J Pharmacogn Phytochem. 2023;13(1):120-126. doi: 10.22271/phyto.2024.v13.i1b.14820.
51. Ghafouri S, Safaeian R, Ghanbarian G, Lautenschläger T, Ghafouri E. Medicinal plants used by local communities in southern Fars Province, Iran. Sci Rep. 2025;15(5742). doi: 10.1038/s41598-025-88341-5.
52. Awoke A, Siyum Y, Awoke D, Gebremedhin H, Tadesse A. Ethnobotanical study of medicinal plants and their threats in Yeki district, Southwestern Ethiopia. J Ethnobiol Ethnomed. 2024;20(1):107. doi: 10.1186/s13002-024-00748-y
53. Febriyanti RM, Saefullah K, Susanti RD, Lestari K. Knowledge, attitude, and utilization of traditional medicine within the plural medical system in West Java, Indonesia. BMC Complement Med Ther. 2024;24(1):64. doi: 10.1186/s12906-024-04368-7.
54. Chaachouay N, Zidane L. Plant-derived natural products: A source for drug discovery and development. Drugs Drug Candidates. 2024;3(1):184-207. doi: 10.3390/ddc3010011.

ISSN 2616-0684 (Print)
ISSN 2616-0692 (Electronic)