

Diversity, traditional uses and conservation status of Zingiberaceae in Udon Thani Province, Thailand

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Abstract. Saensouk P, Saensouk S. 2021. Diversity, traditional uses and conservation status of Zingiberaceae in Udon Thani Province, Thailand. *Biodiversitas* 22: 3083-3097. Southeast Asia is recognized as the center of Zingiberaceae distribution with Thailand is among the important regions. Nonetheless, a comprehensive study in a regional context that investigates the biological aspects of the family is lacking. This study aimed to determine the diversity, distribution, ecology, conservation status, and traditional uses of the family Zingiberaceae in Udon Thani Province, northeastern Thailand. In total, three tribes, nine genera, 47 species of Zingiberaceae were identified during a botanical survey between January and December 2020 in Udon Thani. *Curcuma* and *Kempferia* were the most diverse genera with nine and eight species, respectively, followed by *Zingiber* as the third most diverse genus with seven species and *Alpinia* as the fourth most diverse genus with six species. While the genera *Etilingera* and *Hedygium* were the least diverse with each containing just one species. For all Zingiberaceae species, the flowering period was found between March and September, while the fruiting period was found between May and October. Zingiberaceae was found with the greatest frequency in five ecosystem types, namely cultivated areas, deciduous dipterocarp forest, mixed deciduous forest, dry evergreen forest and river basin. Twenty-one species were reported as rare species in research area, i.e. *Boesenbergia baimaii*, *B. isanensis*, *Kaempferia picheansoonthonii*, and *K. udonensis*. It was revealed that the traditional uses of many Zingiberaceae species from villagers in Udon Thani Province were most frequently used for medicine, food, ornamentals, rituals, spices, perfume and cosmetics. Rhizomes, roots, pseudostems, young inflorescences, inflorescences, young leaves, leaves and fruits were the parts of this plant used.

Keywords: conservation of status, diversity, Udon Thani Province, uses, Zingiberaceae

INTRODUCTION

Zingiberaceae (Ginger family) is a large family in monocotyledons under the order Zingiberales with about 50 genera of 1,600 species worldwide (Leong-Škorničková et al. 2019). It is widely distributed in the tropical zone throughout tropical Africa, Asia and the Americas. The center of diversity of the family Zingiberaceae is located in Southeast Asia. The dominant characteristic of Zingiberaceae is the unique smell produced in all parts of the plant, especially in the rhizome. The ginger family is used for a broad range of purposes including for food, spices, medicine, dyes, cosmetics, perfume and ornamental plants. Among the large member of Zingiberaceae family, the popular species include bitter ginger (*Zingiber zerumbet*), galangal (*Alpinia galanga*), ginger (*Zingiber officinale*), patumma or Siam Tulip (*Curcuma alismatifolia*), and turmeric (*Curcuma longa*) (Chumroenphat et al. 2019).

There were several botanists have studied the diversity and utilizations of Zingiberaceae. For example, Saensouk and Jenjittikul (2001) reported the traditional use of this family in Thailand as a vegetable obtained from the young leaves of *Kaempferia grandifolia*. Saensouk and Saensouk (2014) also reported a traditional use as a vegetable from young leaves of *Elettariopsis biphyllo*. Koga et al. (2016)

reported traditional uses of *Zingiber zerumbet* for medicinal plants. Pholhiamhan et al. (2018) found 20 species in family Zingiberaceae were used in the daily life of the Phu Thai ethnic group in Nakhon Phanom Province, Thailand. Furthermore, Saensouk and Saensouk (2019) recognized a new species from Northeastern Thailand (i.e., *Kaempferia mahasarakhamensis*) that has traditional uses. Yob et al. (2011) reported ethnomedicinal, chemical and pharmacological uses of *Zingiber zerumbet* (L.) Smith. Ayati et al. (2019) reported ethnobotany and traditional uses of *Curcuma longa* and *C. zedoaria*. Phumthum and Balslev (2020) reported and identified species from Zingiberaceae family with pharmacological properties using the ICPC-2 Standard. Wahidah et al. (2020) studied the ethnobotany of Zingiberaceae as traditional medicine utilized by the Colo Muria mountain villagers, Central Java, Indonesia. Pham et al. (2021) reported the ethnomedicinal, phytochemistry and pharmacology uses of plant species belonging to *Kaempferia* genus. Chumroenphat et al. (2021) studied changes in curcuminoids and chemical components of turmeric (*Curcuma longa* L.) under freeze-drying and low-temperature drying methods. More recently, Saensouk et al. (2021) published six new species and a new record including traditional uses of *Curcuma* from Thailand.

While there are a large diversity and uses of Zingiberaceae, especially in Southeast Asia, several species are to have conservation concern. IUCN (2021) assigned the conservation status of the family Zingiberaceae, i.e., least concern or LC (seven species-*Amomum schmidtii*, *A. repoense*, *A. villosum* var. *xantoides*, *A. trilobum*, *Boesenbergia rotunda*, *Curcuma alismatifolia* and *Zingiber thorelii*), data deficient or DD (one species-*Amomum uliginosum*) and endangered or E (two species, i.e., *Globba laeta* and *G. siamensis*). Moreover, several botanists have reported many endemic species, such as *Boesenbergia baimaii* (Sensouk and Larsen 2001), *B. isanensis* (Saensouk & Saensouk 2020), *Kaempferia picheansoonthonii* (Phokham et al. 2013), and *K. udonensis* (Phokham et al. 2013).

Many countries are found high diversity of family Zingiberaceae i.e. Thailand is recognized as one of the centers of distribution of Zingiberaceae family with about 26 genera out of 300 species (Saensouk et al. 2016 and Chumroenphat et al. 2019). Udon Thani Province is located in the northeastern part of Thailand and is the biggest province in the region which includes part of the Phu Phan mountain range. Despite the potentially large number of species from Zingiberaceae family that can be found in the province, a comprehensive study that investigates the biological aspects of the family is lacking. Previously study found that only Saensouk and Saensouk (2020) studied seven genera and 18 species of Zingiberaceae (including a new one to science, i.e., *Boesenbergia isanensis*) in Phu Phra Bat Historical Park, Ban Phue District, Udon Thani Province. For this reason, Udon Thani Province has the highest biodiversity in

northeastern Thailand including the large diversity of Zingiberaceae. Therefore, the purpose of this study was to determine the diversity, distribution, ecology, conservation status and traditional uses of the family Zingiberaceae in Udon Thani Province, northeastern Thailand.

MATERIAL AND METHODS

Plant materials

Zingiberaceae specimens were collected from field trips around Udon Thani Province, northeastern Thailand between January and December 2020 (Figure 1). Voucher specimens obtained from fieldwork were deposited in the Mahasarakham University Herbarium, Thailand. The morphological characteristics of the plant materials were studied under stereo microscopy.

Plant diversity study

Plant diversity, vernacular names, distribution data and ecological data were taken from the field, herbarium specimens and available literature. The specimens in this study were compared with herbarium specimens that were kept at overseas herbaria i.e. BK: Bangkok Herbarium, Department of Agriculture, Thailand; BKF: The Forest Herbarium, National Parks, Wildlife and Plant Conservation Department, Thailand; KKU: Khon Kaen University Herbarium Thailand; QBG: Queen Sirikit Botanic Garden Herbarium, Thailand., available taxonomic literature or digital images available online. Keys to the tribes, genera and species are provided based on morphological characters.

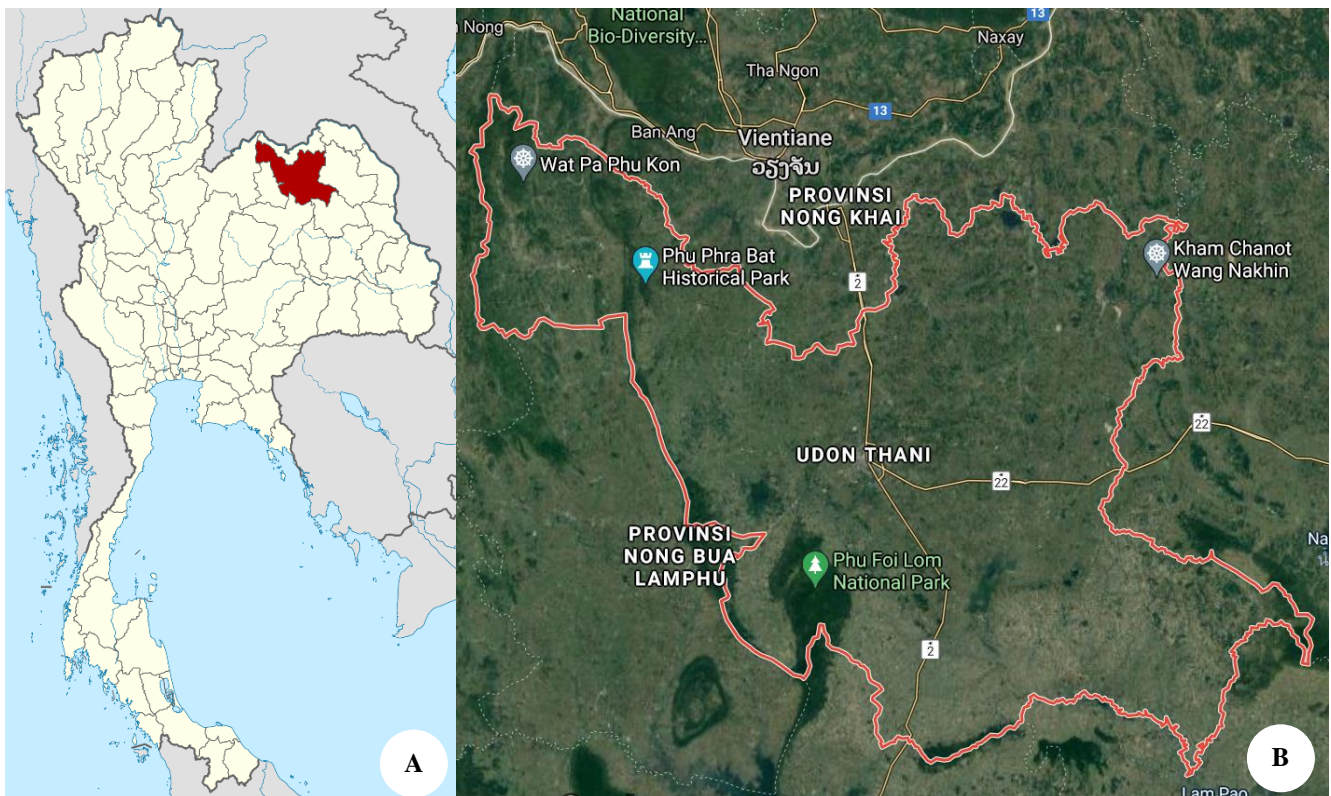


Figure 1. Map of the study location: A. Udon Thani Province in the context of Thailand; B. Udon Thani Province in larger detail.

Traditional utilization study

The traditional data of the Zingiberaceae in Udon Thani Province were obtained through interviewing 5 local villagers especially folk medicine who lived in this province.

Conservation status study

The conservation status of the Zingiberaceae is based on information during observations and from collected specimens. In the context of this study, the conservation status can be divided into two categories, namely common species in the research area, and rare species in the research area.

RESULTS AND DISCUSSION

Zingiberaceae from three tribes, nine genera and 47 species were collected during botanical surveys and collections of specimens from Udon Thani Province between January and December 2020 (Table 1). All specimens of Zingiberaceae collected from the surveys were successfully identified. The detailed information on the ecological data, distributions, specimens examined, distinguishing features, phenological data, traditional uses, conservation status and keys to tribes, genera and species

of Zingiberaceae in Udon Thani Province are provided in Tables 1 and 2.

Diversity of Zingiberaceae in Udon Thani Province

Table 1 shows that the Zingiberaceae recorded in Udon Thani Province are divided into three tribes based on morphology, namely Alpinieae, Globbeae and Zingibereae. The first tribe is Alpinieae with four genera and 14 species, such as *Alpinia* (seven species), *Amomum* (six species) and *Etingera* (one species). This tribe can be divided into two groups based on the initiation of the inflorescence. In the first group the inflorescence is exerted from the pseudostem, only *Alpinia* is recorded in this group. In the second group (*Amomum* and *Etingera*) the inflorescence is exerted from the rhizome. The second tribe is Globbeae, which is comprised of only *Globba* (five species). The third tribe is Zingibereae with six genera and 27 species that is the largest tribe in this study. The members of tribe Zingibereae are *Boesenbergia* (three species), *Curcuma* (nine species), *Hedychium* (one species), *Kaempferia* (eight species) and *Zingiber* (seven species). Keys to the tribes, genera and species are provided based on morphological characteristics and listed below.

Key to tribes of Zingiberaceae in Udon Thani Province

1a. Plane of distichy of leaves parallel to rhizome	2
1b. Plane of distichy of leaves transverse to rhizome	Alpinieae
2a. Appendages at anther	Globbeae
2b. No appendages on anther	Zingibereae

Key to genera of Zingiberaceae in Udon Thani Province

1a. Ovary unilocular with parietal placentation; filament long exerted; Appendaged at anther	<i>Globba</i>
1b. Ovary 3-locular (very rarely unilocular) with central placentation; filament not long exerted; no appendaged at anther	2
2a. Lateral staminodes reduced to small teeth at base of labellum or wanting, plane of distichy of leaves transverse to rhizome	3
2b. Lateral staminodes well developed, free from labellum, plane of distichy of leaves parallel to rhizome	5
3a. Inflorescence terminal on leafy shoot	<i>Alpinia</i>
3b. Inflorescence on separate shoot at base of leafy shoot	4
4a. Labellum and filament connate into distinct tube above insertion of petals; anther crest absent	<i>Etingera</i>
4b. Labellum and filament not connate; anther usually crested	<i>Amomum</i>
5a. Swollen petiole, anther-crest long, enclosing style forming horn-like structure	<i>Zingiber</i>
5b. No swollen petiole, anther-crest variously shaped, but not enclosing style forming horn-like structure	6
6a. Anther-crest prominent	<i>Kaempferia</i>
6b. Anther-crest inconspicuous or absent	7
7a. Corolla tube long exerted; bract compact and indistinct	<i>Boesenbergia</i>
7b. Corolla tube short not exerted; bract not compact and distinct	8
8a. Inflorescence with coma bracts or without coma bract	<i>Curcuma</i>
8b. Inflorescence without coma bract	<i>Hedychium</i> (<i>H. coronarium</i>)

Key to Zingiberaceae species in Udorn Thani Province

Key to *Alpinia* species

- | | |
|--|-----------------------|
| 1a. Bract larger than flower; leaf variegated and bracts green-white | <i>A. vittata</i> |
| 1b. Bract smaller than flower; leaf variegated and bracts green | 2 |
| 2a. Leaf margin denticulate | <i>A. mutica</i> |
| 2b. Leaf margin entire | 3 |
| 3a. Labellum yellow | 4 |
| 3b. Labellum white with red lines | 5 |
| 4a. Flower three on cincinnus | <i>A. zerumbet</i> |
| 4b. Flower one on cincinnus | <i>A. malaccensis</i> |
| 5a. Bracteoles tubular | <i>A. siamensis</i> |
| 5b. Bracteoles not tubular | 6 |
| 6a. Labellum with callus-like at base | <i>A. conchigera</i> |
| 6b. Labellum without callus-like at base | <i>A. galanga</i> |

Key to *Amomum* species

- | | |
|---|--|
| 1a. Bracteoles tubular | 2 |
| 1b. Bracteoles not tubular | 3 |
| 2a. Bract reddish; leaf lower surface reddish | <i>A. wandokthong</i> |
| 2b. Bract greenish; leaf lower surface greenish | <i>A. trilobum</i> |
| 3a. Fruit smooth | 4 |
| 3b. Fruit rough with soft spine | <i>A. villosum</i> var. <i>xantoides</i> |
| 4a. All parts glabrescent; fruit many ridged | <i>A. repoense</i> |
| 4b. All parts pubescence; fruit not above | 5 |
| 5a. Leaf pubescence | <i>A. schmidtii</i> |
| 5b. Leaf glabrous | <i>A. uliginosum</i> |

Key to *Globba* species

- | | |
|--|-----------------------|
| 1a. Inflorescence compact | 2 |
| 1b. Inflorescence not compact | 3 |
| 2a. Bract white | <i>G. laeta</i> |
| 2b. Bract green | <i>G. marantina</i> |
| 3a. Cincinnus exerted from one bract | 4 |
| 3b. Cincinnus not exerted from more than one bract | <i>G. barthei</i> |
| 4a. Bract green | <i>G. schomburgii</i> |
| 4b. Bract white | <i>G. siamensis</i> |

Key to *Boesenbergia* species

- | | |
|--|---------------------|
| 1a. Inside rhizome yellow; labellum orange | <i>B. isanensis</i> |
| 1b. Inside rhizome pale yellow; labellum pink or reddish | 2 |
| 2a. Labellum decurved to ground | <i>B. baimaii</i> |
| 2b. Labellum recurved from ground | <i>B. rotunda</i> |

Key to *Curcuma* species

- | | |
|---|-------------------------|
| 1a. Inflorescence surrounded by cup-shape involucre bracts with two slits | <i>C. campanulata</i> |
| 1b. Inflorescence not surrounded by cup-shape involucre bracts with two slits | 2 |
| 2a. Inflorescence without coma bracts | <i>C. singularis</i> |
| 2b. Inflorescence with coma bract | 3 |
| 3a. Rhizome yellow | <i>C. longa</i> |
| 3b. Rhizome cream or white-cream | 4 |
| 4a. Flower yellow | 5 |
| 4b. Flower white with violet | 7 |
| 5a. Sheath and leaf sheath red or dark red | <i>C. rubescens</i> |
| 5b. Sheath and leaf sheath not as above | 6 |
| 6a. Rhizome branched; blade more than 7 cm wide | <i>C. comosa</i> |
| 6b. Rhizome unbranched; blade less than 6 cm wide | <i>C. angustifolia</i> |
| 7a. Coma bract shorter than bract | <i>C. parviflora</i> |
| 7b. Coma bract longer than bract | 8 |
| 8a. Coma bract pink | <i>C. alismatifolia</i> |
| 8b. Coma bract white | <i>C. thorelii</i> |

Key to *Kaempferia* species

1a. Inflorescence appears before leaves	2
1b. Inflorescence appears between leaves	3
2a. Pseudostem erect from ground	<i>K. rotunda</i>
2b. Pseudostem near ground	<i>K. udonensis</i>
3a. Leaf single	4
3b. Leaf two	5
4a. Lower surface red	<i>K. picheansoonthonii</i>
4b. Lower surface greenish	<i>K. siamensis</i>
5a. Pseudostem erect from ground	6
5b. Pseudostem near ground	7
6a. Leaf variegated; all parts of flower purple	<i>K. pulcha</i>
6b. Leaf not variegated; only labellum purple	<i>K. angustifolia</i>
7a. Leaf margin purple	<i>K. marginata</i>
7b. Leaf margin whitish	<i>K. galanga</i>

Key to *Zingiber* species

1a. Peduncle on separate shoot at base of leafy shoot, arising oblique with ground	2
1b. Peduncle on separate shoot at base of leafy shoot, arising vertically to ground	4
2a. Apex inflorescence tip; labellum cream or pale purple	3
2b. Apex inflorescence rounded; labellum pale yellow mixed red dots	<i>Z. mekongense</i>
3a. Labellum pale purple	<i>Z. rubens</i>
3b. Labellum cream	<i>Z. thorelii</i>
4a. Bract brown-dark red	<i>Z. monatum</i>
4b. Bract yellow, green or pale yellow when young and red when mature	5
5a. Labellum red	<i>Z. officinale</i>
5b. Labellum yellow or cream	6
6a. Rhizome pale purple or pale blue	<i>Z. ottensii</i>
6b. Rhizome cream	<i>Z. zerumbet</i>

Phenology

The phenology, including flowering period and fruiting period of Zingiberaceae in Udon Thani Province, is presented in Table 1. The flowering period was found to be between March and September, while the fruiting period was found to be between May and October. The genus *Alpinia* began flowering at two times: March (*A. malaccensis*, *A. mutica* and *A. zerumbet*) and May (four remaining species). The fruiting period began at two times: June (*A. malaccensis*, *A. mutica*, and *A. zerumbet*) and August (four remaining species). *Amomum* began flowering in May and fruiting in June, but fruiting was not seen in *A. wandokthong*. The phenology of *Etingera elatior* was flowering in March and fruiting in June. Most *Globba* species started flowering in June except May for *G. laeta* and *G. siamensis*. No *Globba* species were seen fruiting. Three *Boesenbergia* species bloomed between June and July and gave fruit in July. Two *Curcuma* species, *C. angustifolia* and *C. singularis*, bloomed from the rhizome before the pseudostem in March-May and the fruits were present after blooming. Other *Curcuma* species, including *C. angustifolia*, bloomed from the pseudostem in May-August and the fruits were present after blooming. Therefore, *C. angustifolia* bloomed in two periods. The flowers of *Hedychium coronarium* were present June-September and the fruits were present after flowering. Two *Kaempferia* species, *K. rotunda* and *K. udonensis*, bloomed from the rhizome before the pseudostem in March-April and the fruits were present after blooming. Other *Kaempferia* species bloomed from the pseudostem in May-

August and the fruits were present after blooming. Inflorescences and flowers of *Curcuma campanulathus* were present in March-May, while the fruits were present in June. All *Zingiber* species bloomed in July-September and fruited in August-October.

Ecology

The ecology of zingiberaceous plants is reported in Table 1. The family was found in five ecosystem types: deciduous dipterocarp forest (containing 19 species), mixed deciduous forest (containing 14 species), dry evergreen forest (containing six species), river basin (only *Alpinia conchigera*) and cultivated in home gardens (containing 20 species). *Boesenbergia baimaii* and *Kaempferia siamensis* were found in new localities. Two endemic species, namely *Kaempferia picheansoonthonii* and *K. udonensis*, were found only in Udon Thani Province.

Conservation status

Table 1 shows the conservation status of family Zingiberaceae in Udon Thani Province. Common species in the research area were 26 species (comprising *Alpinia* five species, *Amomum* one species, *Etingera* one species, *Globba* one species, *Boesenbergia* one species, *Curcuma* seven species, *Hedychium* one species, *Kaempferia* four species and *Zingiber* four species). Rare species in the research area were 21 species (comprising *Alpinia* two species, *Amomum* five species, *Boesenbergia* two species, *Curcuma* two species, *Globba* three species, *Kaempferia* two species and *Zingiber* three species).

Table 1. Notes on Zingiberaceae species in Udon Thani Province, Thailand

Species	Specimen examined	Distinguishing features	Distribution	Phenology	Ecology	Conservation status
<i>Alpinia conchigera</i> Griff.	SS. udorn1	Bracteoles not tubular, labellum callus-like	Srangkorn, Ban Phue and Kudjub and Pen Districts	Fl: May.-Sep. Fr: Aug.-Oct.	RB, Cult.	Common species in research area
<i>A. galanga</i> (L.) Willd.	SS. udorn2	Bracteoles not tubular, labellum not callus-like	All districts	Fl: May-Sept. Fr: Aug.-Oct.	DDF, MDF, Cult.	Common species in research area
<i>A. malaccensis</i> (Burm.f.) Roscoe	SS. udorn3	One flower per cincinnus	Nayoong District	Fl: Mar.-June Fr: June-Oct.	MDF, DEF	Rare species in research area
<i>A. mutica</i> Roxb.	SS. udorn4	Leaf margin denticulate	Ban Phue District	Fl: Mar.-Aug. Fr: June-Oct.	Cult.	Common species in research area
<i>A. siamensis</i> K.Schum.	SS. udorn5	Bracteoles tubular, labellum not callus-like	All districts	Fl: May-Sept. Fr: Aug.-Oct.	Cult.	Common species in research area
<i>A. vittata</i> W. Bull.	SS. udorn6	Leaf variegated and bracts green-white	Ban Phue District	Fl: May-Sept. Fr: Aug.-Oct.	Cult.	Common species in research area
<i>A. zerumbet</i> (Pers.) B.L.Burt & R.M.Sm.	SS. udorn7	Three flowers per cincinnus	Nayoong District	Fl: Mar.-May Fr: June-Oct.	MDF	Rare species in research area
<i>Amomum schmidii</i> (K.Schum.) Gagnep.	SS. udorn8	Fruits smooth, all parts pubescent	Ban Phue and Nayoong Districts	Fl: Mar.-July Fr: June-Oct.	DEF	Rare species in research area
<i>A. repoense</i> Pierre ex Gagnep.	SS. udorn9	Fruits many ridges, all parts glabrescence	Nayoong and Nong Saeng Districts	Fl: May-July Fr: Aug.-Sept.	DEF	Rare species in research area
<i>A. uliginosum</i> J.Koenig	SS. udorn10	Glabrous in all parts including fruit	Nayoong and Nong Saeng Districts	Fl: May-June Fr: June-Oct.	DEF	Rare species in research area
<i>A. villosum</i> var. <i>xantoides</i> (Wall. ex Baker) T.L.Wu&S.J.Chen (Figure 2A)	SS. udorn11	Fruit rough with soft spine	Nayoong District	Fl: May-June Fr: June-Oct.	DEF	Rare species in research area
<i>A. trilobum</i> Gagnep. (Figure 2B)	SS. udorn12	Bract greenish, leaf lower surface greenish	Nayoong and Nong Saeng Districts	Fl: Mar.-Apr. Fr: June-Oct.	MDF	Rare species in research area
<i>A. wandokthong</i> (Picheans. & Yupparach) Skornick. & Hlavatá (Figure 2C)	SS. udorn13	Bract reddish, leaf lower surface reddish	All districts	Fl: Mar.-Apr. Fr: Not seen	Cult.	Common species in research area
<i>Etilingera elatior</i> (Jack) R.M.Sm.	SS. udorn14	Pseudostem upto 4 m tall, bract red	All districts	Fl: Mar-May Fr: June-Sept.	Cult.	Common species in research area
<i>Globba barthei</i> Gagnep.	SS. udorn15	Inflorescence not compact, cincinnus not exerted from more than one bract	Ban Phue District	Fl: June-Aug. Fr: Not seen	MDF	Rare species in research area
<i>G. laeta</i> K. Larsen	SS. udorn16	Inflorescence compact, bract white	Ban Phue and Nayoong Districts	Fl: May-Aug. Fr: Not seen	DDF	Rare species in research area
<i>G. marantina</i> L.	SS. udorn17	Inflorescence not compact, bract green	Ban Phue and Nayoong Districts	Fl: June-July Fr: Not seen	DDF, MDF	Common species in research area

<i>G. schomburgii</i> Hook.f.	SS. udorn18	Inflorescence not compact, cincinnus exerted from one bract, bract green	Ban Phue and Nayoong Districts	Fl: June-Sept. Fr: Not seen	Cult.	Common species in research area
<i>G. siamensis</i> (Hemsl.) Hemsl (Figure 2G)	SS. udorn19	Inflorescence not compact, cincinnus exerted from one bract, bract white	Ban Phue District	Fl: May-Aug. Fr: Not seen	DDF	Rare species in research area
<i>Boesenbergia baimaii</i> S.Saensouk & Larsen (Figure 2D)	SS. udorn20	Labellum pink and apex decurved to ground	Ban Phue District	Fl: June-July Fr: July	DDF, MDF	Rare species in research area
<i>B. rotunda</i> (L.) Mansf.	SS. udorn21	Labellum reddish, apex recurved from ground	All districts	Fl: June-July Fr: July	MDF, Cult.	Common species in research area
<i>B. isanensis</i> Saensouk & P. Saensouk (Figure 2E)	SS. udorn22	Inside rhizome yellow, labellum orange	Ban Phue District	Fl: June-July Fr: July	DDF, MDF	Rare species in research area
<i>Curcuma angustifolia</i> Roxb.	SS. udorn23	Flower yellow, rhizome unbranched, blade less than 6 cm wide	All districts	Fl: Mar-June / July-Sept. Fr: May-July / Aug.-Oct.	DDF	Common species in research area
<i>C. alismatifolia</i> Gagnep.	SS. udorn24	Flower white with violet, coma bract longer than bract, coma bract pink	Ban Phue and Kudjub Districts	Fl: July-Aug. Fr: Aug.-Oct.	DDF, Cult.	Common species in research area
<i>C. campanulata</i> (Kuntze) Škornick. (Figure 2F)	SS. udorn25	Inflorescence surrounded by cup-shape involucre bracts	Ban Phue District	Fl: Mar.-May Fr: June	DDF	Common species in research area
<i>C. comosa</i> Roxb.	SS. udorn26	Flower yellow, rhizome branched, blade more than 7 cm wide	All districts	Fl: Mar.-Aug. Fr: May-July	DDF, Cult.	Common species in research area
<i>C. longa</i> L.	SS. udorn27	Inflorescence with coma bract, rhizome yellow	All districts	Fl: June-Aug. Fr: Aug.-Oct.	MDF, Cult.	Common species in research area
<i>C. parviflora</i> Wall.	SS. udorn28	Flower white with violet, coma bract shorter than bract, coma bract white	Ban Phue, Nayoong and Kudjub Districts	Fl: May-Aug. Fr: Aug.-Oct.	DDF, MDF	Rare species in research area
<i>C. rubescens</i> Roxb.	SS. udorn29	Flower yellow, sheath and leaf sheath red or dark red	Ban Phue, Nayoong and Kudjub Districts	Fl: June-Aug. Fr: Aug.-Oct.	Cult.	Common species in research area
<i>C. singularis</i> Gagnep.	SS. udorn30	Inflorescence from rhizome without coma bracts	All districts	Fl: Mar.-May Fr: May-June	DDF	Common species in research area
<i>C. thorellii</i> Gagnep.	SS. udorn31	Flower white with violet, coma bract longer than bract, coma bract white	Ban Phue Districts	Fl: June-Aug. Fr: Aug.-Oct.	DDF	Rare species in research area
<i>Hedychium coronarium</i> J.Koenig	SS. udorn32	Flower white	All districts	Fl: June-Sept. Fr: Sept.-Oct.	Cult.	Common species in research area
<i>Kaempferia angustifolia</i> Roscoe	SS. udorn33	Pseudostem with two leaves erect from ground, labellum purple	Ban Phue District	Fl: June-July Fr: July	DDF, Cult.	Rare species in research area
<i>K. galanga</i> L.	SS. udorn34	Leaf margin whitish	Ban Phue Districts	Fl: June-July Fr: June-Aug.	DDF	Common species in research area
<i>K. marginata</i> Carey ex Roscoe	SS. udorn35	Leaf margin purple	Ban Phue Districts	Fl: June-Aug. Fr: July-Aug.	DDF	Common species in research area
<i>K. picheansoonthonii</i> Wongsuwan & Phokham. (Figure 2H)	SS. udorn36	Leaf single, lower surface red	NongWua So and Nong Saeng Districts	Fl: May-June Fr: June	DDF	Rare species in research area

<i>K. pulcha</i> Ridl.	SS. udorn37	Pseudostem erect from ground, leaf variegated, all part of flower purple	Ban Phue District	Fl: June-Aug. Fr: Not seen	Cult.	Common species in research area
<i>K. rotunda</i> L.	SS. udorn38	Inflorescence appears before leaves, pseudostem erect from ground	Ban Phue District	Fl: Mar.-Apr. Fr: Mar.-May	DDF, MDF	Common species in research area
<i>K. siamensis</i> P.Sirirugsa (Figure 2I)	SS. udorn39	Leaf single, lower surface greenish	Ban Phue District	Fl: May-June Fr: June	DDF	Rare species in research area
<i>K. udonensis</i> Picheans. & Phokham (Figure 2J)	SS. udorn40	Inflorescence appears before leaves, pseudostem near ground	Nong Wua So and Nong Saeng Districts	Fl: Mar.-Apr. Fr: Mar.-May	DDF	Rare species in research area
<i>Zingiber mekongense</i> Gagnep. (Figure 2K)	SS. udorn41	Apex inflorescence rounded, labellum pale yellow mixed red dots	Ban Phue District	Fl: July-Sept. Fr: Aug.-Oct.	MDF	Rare species in research area
<i>Z. montanum</i> (J.Koenig) Link ex A.Dietr.	SS. udorn42	Apex inflorescence tip, bract brown-dark red	All districts	Fl: July-Sept. Fr: Aug.-Oct.	Cult.	Common species in research area
<i>Z. officinale</i> Roscoe	SS. udorn43	Apex inflorescence tip, bract green, labellum red	All districts	Fl: July-Sept. Fr: Aug.-Oct.	Cult.	Common species in research area
<i>Z. ottensii</i> Valetton	SS. udorn44	Rhizome pale purple or pale blue	All districts	Fl: July-Sept. Fr: Aug.-Oct.	Cult.	Common species in research area
<i>Z. rubens</i> Roxb.	SS. udorn45	Labellum pale purple	Ban Phue District	Fl: July-Sept. Fr: Aug.-Oct.	MDF	Rare species in research area
<i>Z. thorelii</i> Gagnep. (Figure 2L)	SS. udorn46	Apex inflorescence tip, labellum cream	Ban Phue District	Fl: July-Sept. Fr: Aug.-Oct.	DEF	Rare species in research area
<i>Z. zerumbet</i> (L.) Roscoe ex Sm.	SS. udorn47	Rhizome cream, bract green when young and red when mature	All districts	Fl: July-Sept. Fr: Aug.-Oct.	MDF, Cult.	Common species in research area

Note: DDF: deciduous dipterocarp forest, MDF: mixed deciduous forest, DEF: dry evergreen forest, RB: river basin, Cult.: cultivated, LC: least concern, DD: data deficient, Fl: flowering period, Fr: fruiting period

Table 2. Traditional uses of Zingiberaceae in Udon Thani Province, Thailand

Species	Traditional uses						
	Food	Spice	Ornamentals	Cosmetics	Perfume	Rituals	Medicines
<i>Alpinia conchigera</i> Griff.	Local people use rhizomes, young pseudostems and young inflorescences as food and vegetable	Rhizomes used as spice					Rhizomes used for stomachache and skin disease
<i>A. galanga</i> (L.) Willd.	Local people use rhizomes, young pseudostems and young inflorescences as food and vegetable	Rhizomes used as spice					Rhizomes used for stomachache and skin disease
<i>A. malaccensis</i> (Burm.f.) Roscoe	Local people use young inflorescences as vegetable						Rhizomes used for stomachache and skin disease
<i>A. mutica</i> Roxb.			Whole plant is used as ornamental			Whole plant is used as power magic	
<i>A. siamensis</i> K.Schum.	Local people use rhizomes, young pseudostems and young inflorescences as food and vegetable	Rhizomes used as spice					Rhizomes used for stomachache and skin disease
<i>A. vittata</i> W. Bull.			Whole plant used as ornamental				
<i>A. zerumbet</i> (Pers.) B.L.Burt & R.M.Sm.	Local people use young inflorescences as vegetable						Rhizomes used for stomachache and skin disease
<i>Amomum schmidtii</i> (K.Schum.) Gagnep.						Whole plant is used as power magic	Rhizomes used for stomachache and skin disease
<i>A. repoense</i> Pierre ex Gagnep.							Rhizomes and fruits used for stomachache and skin disease
<i>A. uliginosum</i> J.Koenig							Rhizomes and fruits used for stomachache and skin disease
<i>A. villosum</i> var. <i>xantoides</i> (Wall. ex Baker) T.L.Wu & S.J.Chen							Rhizomes and fruits used for stomachache and skin disease
<i>A. trilobum</i> Gagnep.							Rhizomes and fruits used for stomachache and skin disease
<i>A. wandokthong</i> (Picheans. & Yupparach) Skornick. & Hlavatá						Whole plant is used as power magic	Rhizomes used for stomachache and skin disease

<i>Etligeria elatior</i> (Jack) R.M.Sm.	Local people use young inflorescences as food and vegetable		Beautiful inflorescence cultivated as ornamental		Rhizomes used for stomachache and skin disease
<i>Globba barthei</i> Gagnep.			Plants with beautiful inflorescence cultivated as ornamental		Inflorescence used for paying respect to the Buddha
<i>G. laeta</i> K. Larsen			Plants with beautiful inflorescence cultivated as ornamental		Inflorescence used for paying respect to the Buddha
<i>G. marantina</i> L.			Plants with beautiful inflorescence cultivated as ornamental		Inflorescence used for paying respect to the Buddha
<i>G. schomburgii</i> Hook.f.			Plants with beautiful inflorescence cultivated as ornamental		Inflorescence used for paying respect to the Buddha
<i>G. siamensis</i> (Hemsl.) Hemsl			Plants with beautiful inflorescence cultivated as ornamental		Inflorescence used for paying respect to the Buddha
<i>Boesenbergia baimaii</i> S.Saensouk & Larsen	Local people use rhizomes and storage root as food and vegetable				Rhizomes used for stomachache and skin disease
<i>B. rotunda</i> (L.) Mansf.	Local people use rhizomes and storage root as food and vegetable	Storage roots are used as spice			Rhizomes and storage roots used for stomachache and skin disease
<i>B. isanensis</i> Saensouk & P. Saensouk	Local people use rhizomes and storage root as food and vegetable				Rhizomes used for stomachache and skin disease
<i>Curcuma angustifolia</i> Roxb.	Local people use young inflorescences as food and vegetable				Rhizomes used for stomachache
<i>C. alismatifolia</i> Gagnep.	Local people use young inflorescences as food and vegetable				Rhizomes used for stomachache
<i>C. campanulata</i> (Kuntze) Škornick.					Rhizomes used for stomachache and skin disease
<i>C. comosa</i> Roxb.					Rhizome used for stomachache
<i>C. longa</i> L.	Local people use rhizomes and young inflorescences as food and vegetable			Local people make dyes from rhizomes	Rhizomes used for stomachache

<i>C. parviflora</i> Wall.	Local people use young inflorescences as food and vegetable			
<i>C. rubescens</i> Roxb.				Rhizomes used for stomachache
<i>C. singularis</i> Gagnep.	Local people use young inflorescences as food and vegetable			
<i>C. thorellii</i> Gagnep.	Local people use young inflorescences as food and vegetable			
<i>Hedychium coronarium</i> J.Koenig		White flower used for paying respect to the Buddha		
<i>Kaempferia angustifolia</i> Roscoe		Whole plant is used as ornamental		Rhizomes used for stomachache
<i>K. galanga</i> L.		Whole plant is used as ornamental		Rhizomes and leaves used for stomachache
<i>K. marginata</i> Carey ex Roscoe	Local people use young inflorescences as food and vegetable		Rhizomes used to makeperfume	Rhizomes and young leaves used for stomachache
<i>K. picheansoonthonii</i> Wongsuwan & Phokham.	Local people use young inflorescences as food and vegetable			Young leaves used for stomachache
<i>K. pulcha</i> Ridl.		Whole plant and leaves used as ornamental		Rhizomes used for stomachache
<i>K. rotunda</i> L.		Whole plant used as ornamental		Rhizomes used for stomachache
<i>K. siamensis</i> P.Sirirugsa	Local people use young inflorescences as food and vegetable	Whole plant used as ornamental		Rhizomes used for stomachache
<i>K. udonensis</i> Picheans. & Phokham		Whole plant used as ornamental		Rhizomes used for stomachache
<i>Zingiber mekongense</i> Gagnep.	Local people use young inflorescences as food and vegetable	Whole plant used as ornamental		Rhizomes used for stomachache
<i>Z. montanum</i> (J.Koenig) Link ex A.Dietr.	Local people use young inflorescences as food and vegetable	Whole plant used as ornamental		Rhizomes used for stomachache
<i>Z. officinale</i> Roscoe		Whole plant used as ornamental		Rhizomes used for stomachache
<i>Z. ottensii</i> Valetton	Local people use young inflorescences as food and vegetable	Whole plant used as ornamental		Rhizomes used for stomachache
<i>Z. rubens</i> Roxb.		Whole plant used as ornamental		Rhizomes used for stomachache
<i>Z. thorellii</i> Gagnep.	Local people use young inflorescences as food and vegetable	Whole plant used as ornamental		Rhizomes used for stomachache
<i>Z. zerumbet</i> (L.) Roscoe ex Sm.	Local people use young inflorescences as food and vegetable	Whole plant used as ornamental		Rhizomes used for stomachache

Traditional uses of Zingiberaceae in Udon Thani Province

During the surveys, it was found that the villagers from Udon Thani Province used many species of the family Zingiberaceae as food, spice, medicine, in rituals, as cosmetics, for perfume and as ornamentation (Table 2 and Figures 3-4).

Food. As many as 20 ginger family species were used as local food. The parts of the plants were young inflorescences eaten as vegetables (15 species), rhizomes eaten as vegetables (seven species), young leaves eaten as vegetables (three species), young pseudostems eaten as vegetables (three species), leaves eaten as vegetables (two species) and roots (two species) as the most frequently used for food. *Alpinia conchigera*, *A. galanga*, *A. siamensis*, *Boesenbergia rotunda*, *Curcuma angustifolia*, *C. singularis*, and *Zingiber officinale* are famous for being used in local food.

Spice. The rhizomes of *Alpinia conchigera*, *A. galanga* and *A. siamensis* and storage roots of *Boesenbergia rotunda* were used as spices in local food.

Ornamentals. The second most common use found in this study, with 21 zingiberaceous plants, was ornamental plants. The parts used were reported as whole plants, inflorescences and leaves as the most frequently used for ornamental plants. *Hedychium coronarium* was the most cultivated species as an ornamental in home gardens.

Cosmetics. The villagers used the rhizome of *Curcuma longa* as a cosmetic.

Perfume. The rhizomes of *Kaempferia marginata* or “Toob-Moob” (local name) were used as a local perfume that is called “Nam Hom Udon Toob Moob”.

Ritual plants. There were 18 species of Zingiberaceae that were used as ritual plants. The parts of the plant most frequently used were whole plants (seven species), rhizomes (six species) and inflorescences (five species). *Hedychium coronarium* is commonly used.

Medicine. During the survey of specimens and interviews about the uses of Zingiberaceae from villagers, it was found that 33 species were used as medicine. The parts of the plant most frequently used were rhizomes (33 species), fruits (four species), young leaves (two species), roots (one species) and leaves (one species).

In this study, we documented three tribes, nine genera and 46 species of family Zingiberaceae in Udon Thani Province. This finding is higher than the study by Saensouk and Saensouk (2020) who reported 18 species of family Zingiberaceae in Phu Phra Bat Historical Park, Ban Phue District, Udon Thani Province. *Curcuma* and *Kaempferia* were the most diverse genera with nine species and eight species, respectively. *Zingiber* was the third most diverse genus with seven species.

The flowering period was found between March and September, which is similar to a previous study by Saensouk et al. (2016). The fruiting period was found between March and October, which is similar to a previous study by Saensouk et al. (2016). Zingiberaceae in this area

was found frequently in five ecology types: cultivated in home gardens (20 species), deciduous dipterocarp forest (19 species), mixed deciduous forest (14 species), dry evergreen forest (six species) and river basin (one species). The results is in accordance with the report of Saensouk et al. (2016).

Kaempferia udonensis and *Boesenbergia baimaii* were found in a new locality, which differs from previous studies by Phokham et al. (2013) and Saensouk and Larsen (2001). *Kaempferia picheansoonthonii* and *K. udonensis* were found only in Udon Thani Province, which is consistent with Phokham et al. (2013). The data from the review references reported four endemic species (*Boesenbergia baimaii*, *B. isanensis*, *Kaempferia picheansoonthonii* and *K. udonensis*), which agrees with Saensouk and Jenjittikul (2001), Saensouk and Larsen (2001), Phokham et al. (2013), Saensouk and Saensouk (2020), Saensouk et al. (2016) and Wahidah et al. (2020).

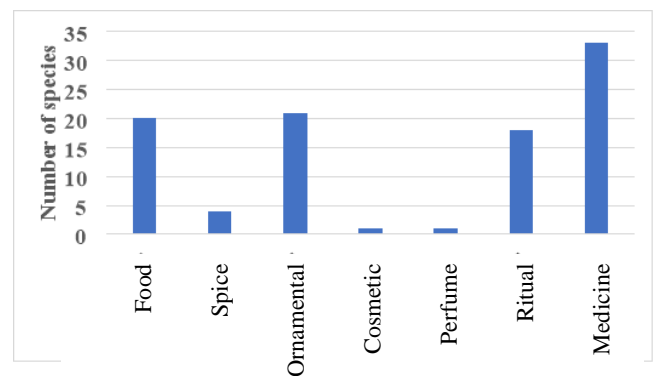


Figure 3. Traditional uses of Zingiberaceae in Udon Thani Province, Indonesia

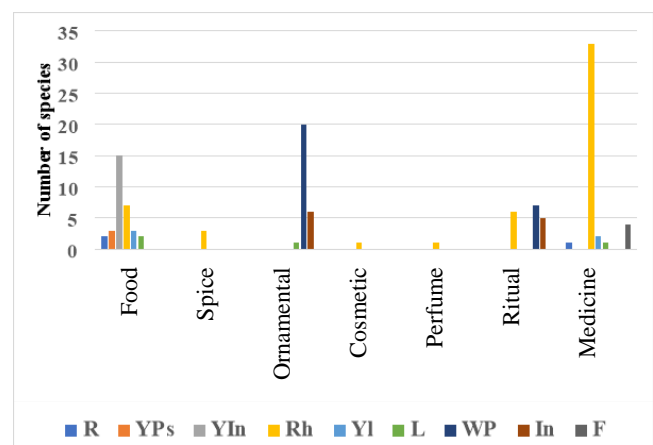


Figure 4. Parts of plant and their main uses for Zingiberaceae in Udon Thani Province, Indonesia. Notes: Rh: rhizome, YPs: young pseudostem, YIn: young inflorescence, Yl: young leaf, WP: whole plant, L: leaf, R: root, In: inflorescence, F: fruit)

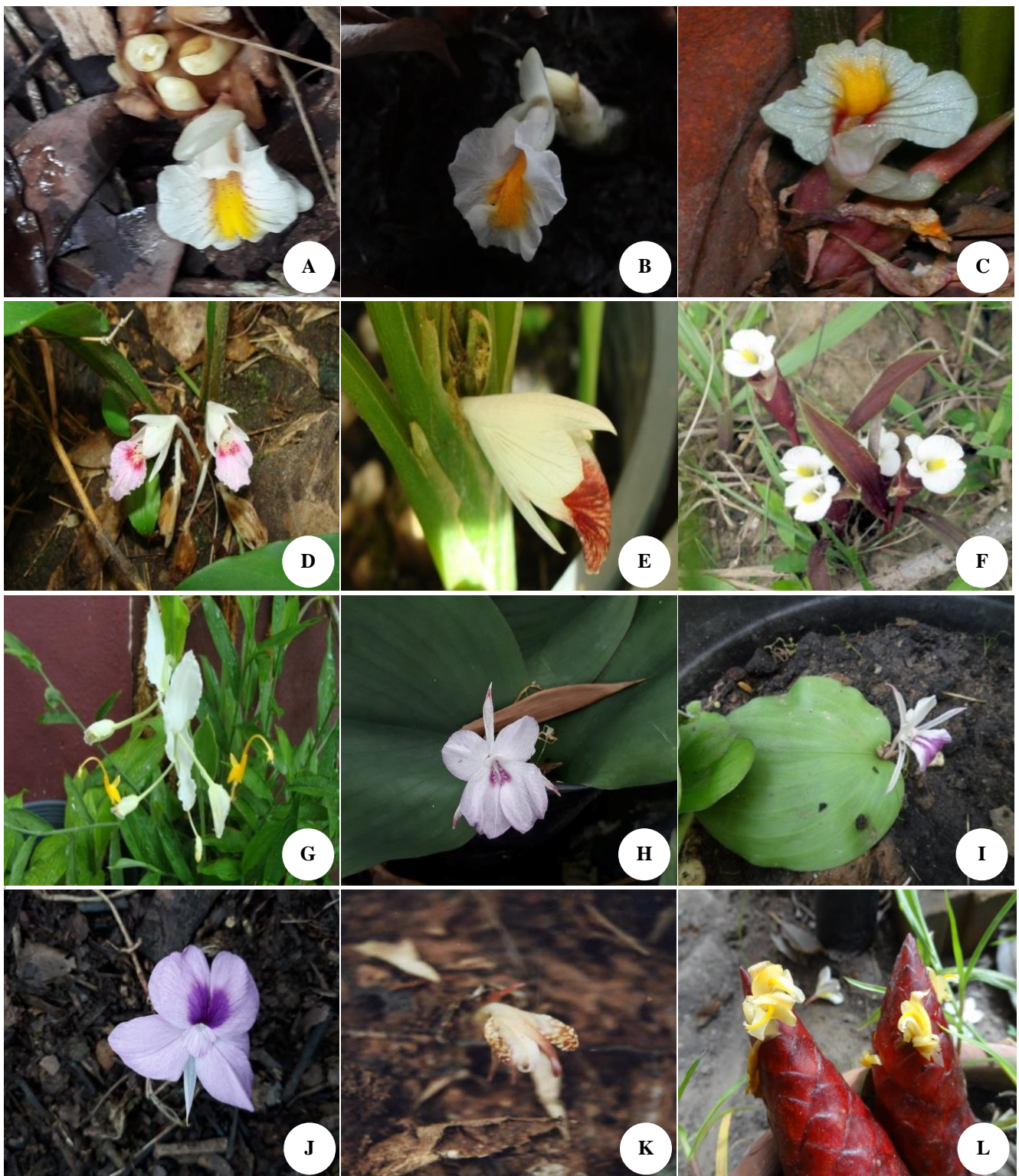


Figure 2. Rare and endemic species of Zingiberaceae in Udon Thani Province, Thailand. A. *Amomum villosum* var. *xantoides*, B. *A. trilobum*, C. *A. wandokthong*, D. *Boesenbergia baimaii*, E. *B. isanensis*, F. *Curcuma campanulatus*, G. *Globba siamensis*, H. *Kaempferia picheansoonthonii*, I. *K. siamensis*, J. *K. udonensis*, K. *Zingiber mekongense* and L. *Z. thorelii*

The conservation status of the family Zingiberaceae in Udon Thani Province (Table 1) is inline with the report of the IUCN (2021), i.e., least concern or LC (*Amomum schmidtii*, *A. repense*, *A. villosum* var. *xantoides*, *A. trilobum*, *Boesenbergia rotunda*, *Curcuma alismatifolia* and *Zingiber thorelii*), data deficient or DD (*Amomum uliginosum*) and endangered or E (*Globba laeta* and *G. siamensis*). Rare species and endemic to Thailand were found, which agrees with several botanists who reported many endemic species, such as *Boesenbergia baimaii* (Sensouk and Larsen 2001), *B. isanensis* (Saensouk & Saensouk 2020), *Kaempferia picheansoonthonii* (Phokham et al. 2013) and *K. udonensis* (Phokham et al. 2013).

It was revealed that the uses of many Zingiberaceae species by villagers in Udon Thani Province were most frequently as medicine, food, ornamentals, in rituals, as spices, perfume and cosmetics, which is consistent with the studies of Sirirugsa (1998), Saensouk et al. (2016), Koga et al. (2016), Pholhiamhan et al. (2018), Saensouk and Saensouk (2019), Phumthum and Balslev (2020), Wahidah et al. (2020) and Pham et al. (2021). The rhizomes, roots, pseudostems, young inflorescences, inflorescences, young leaves, leaves and fruits are the parts of the plant used, which is consistent with the studies of Sirirugsa (1998), Yob et al. (2011), Saensouk et al. (2016), Koga et al. (2016), Pholhiamhan et al. (2018), Saensouk and Saensouk (2019), Phumthum and Balslev (2020), Wahidah et al. (2020) and Pham et al. (2021).

In conclusion, the diversity, phenology data, distribution information, ecology data, conservation status report and traditional uses of the Zingiberaceae in Udon Thani Province, Thailand between January and December 2020 were determined in this study. Three tribes (Alpinieae, Globbeae and Zingibereae), nine genera with 46 species of Zingiberaceae were identified during the botanical survey. *Curcuma*, *Kempferia*, *Zingiber*, *Alpinia*, *Amomum*, *Globba* and *Boesenbergia* were the most diverse genera with nine, eight, seven, seven, six, five and three species, respectively. While the genus *Etilingera* and *Hedychium* were the least diverse genera with one species each. Keys to tribes, genera and species of family Zingiberaceae in this province were constructed based on the morphological characteristics. Phenological data, including flowering period and fruiting period, were presented between May and October. The flowering period was found between March and September, while the fruiting period was found between May and October. Zingiberaceae was found with the greatest frequency for five ecology types: cultivated in home gardens, deciduous dipterocarp forest, mixed deciduous forest, dry evergreen forest and river basin. Four species-*Boesenbergia baimaii*, *B. isanensis*, *Kaempferia picheansoonthonii* and *K. udonensis*, were found to be endemic species. The conservation status during the observation and collection of specimens can be divided into 26 common species in the research area, 12 rare species in the research area, one rare species in Thailand and five rare species in the world. It was revealed that the traditional uses of many Zingiberaceae species from villagers in Udon Thani Province were used for medicine, food, as ornamentals, in

rituals, as spices, for perfume and cosmetics. Rhizomes, roots, pseudostems, young inflorescences, inflorescences, young leaves, leaves and fruits were the parts of the plants used.

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