

Ginger family from Bueng Kan Province, Thailand: Diversity, conservation status, and traditional uses

AREERAT RAGSASILP¹, PIYAPORN SAENSOUK^{2*}, SURAPON SAENSOUK³

¹Diversity of Family Zingiberaceae and Vascular Plant for Its Applications Research Unit, Program of Environmental and Resource Management, Faculty of Environment and Resource Studies, Mahasarakham University, 245 Kham Riang, Kantharawichai District, Maha Sarakham 44150, Thailand

²Diversity of Family Zingiberaceae and Vascular Plant for Its Applications Research Unit, Department of Biology, Faculty of Science, Mahasarakham University, 245 Kham Riang, Kantharawichai District, Maha Sarakham, 44150, Thailand. Tel./Fax. +66-43-754-333,

*email: pcornukaempferia@yahoo.com

³Diversity of Family Zingiberaceae and Vascular Plant for Its Applications Research Unit, Walai Rukhavej Botanical Research Institute, Mahasarakham University, Kantarawichai District, Maha Sarakham, 44150, Thailand

Manuscript received: 25 March 2022. Revision accepted: 29 March 2022.

Abstract. Ragsasilp A, Saensouk P, Saensouk S. 2022. *Ginger family from Bueng Kan Province, Thailand: Diversity, conservation status, and traditional uses. Biodiversitas 23: 2739-2752.* The objective of this study was to determine the diversity, conservation status, and traditional uses of Zingiberaceae in Bueng Kan Province, Thailand. The family Zingiberaceae was collected during field surveys in Bueng Kan Province, northeastern Thailand between January and December 2021. Three tribes, 13 genera, and 67 species of Zingiberaceae were found. The genera with the highest diversity were *Curcuma* (12 species), *Zingiber* (11 species), *Globba* (10 species), *Alpinia* (eight species), *Kaempferia* (seven species), *Amomum* (six species), *Caulokaempferia* (four species), *Boesenbergia* (three species), *Gagnepainia* (two species), *Etilingera* (one species), *Hedychium* (one species), *Meistera* (one species) and *Wurfbainia* (one species). Bung Khla district was found to have the most diverse species in this family with 64 species. The family was discovered in five ecosystem types, deciduous dipterocarp forest (20 species), mixed deciduous forest (21 species), dry evergreen forest (20 species), river basin (two species), and cultivated in home gardens (24 species). There were 41 native species found (62.68%), while 16 species (23.88%) were recognized as being cultivated in home gardens. The highest phenology rate was recorded from March to September. Thirty-eight species were reported to have the conservation status as rare species. Twenty-eight species were recognized as common species. Nine species, namely *Alpinia macrostaminodia*, *Amomum biphyllyum*, *A. wandokthong*, *Globba laeta*, *Boesenbergia baimaii*, *Caulokaempferia jirawongsei*, *Ca. Phutonkensis*, *Ca. phuwoaensis* and *Ca. phulangkaensis* were recorded as endemic species to Thailand. Moreover, *A. macrostaminodia*, *A. biphyllyum*, *A. monophyllum*, *C. jirawongsei*, *Ca. phutonkensis*, *Ca. phuwoaensis* and *Curcuma pygmaea*, were found only in Bueng Kan Province, Thailand. This study reported nine species to be rare plants in Bueng Kan Province. Twenty-nine species of the family Zingiberaceae from Bueng Kan Province were presented in IUCN (2022): CR (1 species), DD (9 species), EN (2 species) LC (16 species), NT (1 species). The Zingiberaceae in Bueng Kan Province had popular uses as food, spice, rituals, and ornamentals. For the medicinal use of Zingiberaceae in this study, they were in relation to flatulence, laxative, diuretic, stomachache, treatment of inguinal hernia, uterine involution, antipruritic, cosmetic, skin disease, carminative, antifatulent, intoxication, and tonic. In Thailand, 42 species of Zingiberaceae are reported for the first time to have traditional uses. Therefore, the information on the diversity, conservation status, and traditional uses are important as biological resources of the Zingiberaceae in Bueng Kan Province, Thailand.

Keywords: Biological resources, Bueng Kan, conservation status, diversity, utilizations, Zingiberaceae

INTRODUCTION

For the Zingiberaceae, or Ginger family, the most important aspects of the plant are well known. Many species are used as spices, for cooking, cosmetics, dyes and as ornamental plants, such as *Alpinia galanga*, *Boesenbergia rotunda*, *Curcuma alismatifolia*, *C. longa*, *Etilingera elatior*, *Hedychium coronarium*, and *Zingiber officinale*, etc. (Larsen and Larsen 2006). The family Zingiberaceae contains herbaceous, perennial plants that grow well in tropical and subtropical areas with high humidity. The center of distribution for the family is in Southeast Asia, from 0-2,000 meters above sea level. The dominant characteristics of the ginger family are essential oil in all parts of the plant, especially in the rhizome. Worldwide, Zingiberaceae contains approximately 57

genera with a total of about 1,600 species (Kew Science 2022). In Thailand, Zingiberaceae contains approximately 26 genera and 300 species (Saensouk and Saensouk 2021a). Many botanists have studied Zingiberaceae in Thailand, such as Boonma and Saensouk (2019), Boonma et al. (2020a, b), Jenjittikul and Ruchisansakun (2020), Maknoi et al. (2021), Naïve et al. (2021), Saensouk and Saensouk (2021a, b, c), Saensouk et al. (2016), Sangvirotjanapat et al. (2020), and Soonthornkalump et al. (2020). Moreover, many researchers have studied ethnomedicinal plants and the traditional uses of Zingiberaceae in Thailand, namely Sirirugsu (1998), who reported the uses of Thai Zingiberaceae, Chuakul and Boonpleng (2003) surveyed the use of 48 medicinal ginger species from 22 provinces in Thailand, Saensouk et al. (2016) recognized traditional uses of Zingiberaceae in Nam

Nao National Park from Thailand and Saensouk and Saensouk (2021b) reported traditional uses of the Zingiberaceae in Udon Thani Province, Thailand. In addition, only Saensouk and Saensouk (2014) have reported the uses of *Elettariopsis biphylla*, a new species from Bueng Kan Province.

Several years ago, many rare or endemic species of Zingiberaceae in Thailand were discovered by several botanists, i.e., *Alpinia latilabris* (Chumroenphat and Saensouk 2022), *A. macrostaminodia* (Chaveerach et al. 2008), *Amomum foetidum* (Boonma et al. 2020b), *Boesenbergia isanensis* (Saensouk and Saensouk 2020a), *B. phengklaii* (Mood et al. 2019), *Curcuma aruna* Maknoi & Saensouk (Maknoi et al. 2021), *C. pitukii* Maknoi (Maknoi et al. 2021), Saensouk, Rakarcha & Thammar, *C. chantaranothaii* (Saensouk et al. 2021a), *C. charanii* (Saensouk et al. 2021a), *C. papilionacea* (Soonthornkalump et al. 2020), *C. saraburiensis* (Boonma and Saensouk 2019), *C. siamensis* (Saensouk et al. 2021c), *C. wanenlueanga* (Saensouk et al. 2021b), *C. woodii* (Chen et al. 2015), *Etingera yunanensis* (Saensouk et al. 2016), *Globba ammicola* (Sangvirotjanapat et al. 2020), *G. amplectens*, (Sangvirotjanapat et al. 2020), *G. chrysantha* (Sangvirotjanapat and Newman 2021), *G. larsenii* (Sangvirotjanapat and Newman 2021), *G. sirirugsae* (Saensouk and Saensouk 2020b), *Kaempferia albiflora* (Jenjittikul and Ruchisansakun 2020), *K. caespitosa* Noppornch. & Jenjitt. (Nopporncharoenkul et al. 2020), *K. jenjittikuliae* (Nopporncharoenkul et al. 2021), *K. kamolwaniae* Picheans., Meechonk. & Wongsuwan (Wongsuwan et al. 2020), *K. koontermii* (Pornpimon et al. 2015), *K. mahasarakhamensis* (Saensouk and Saensouk 2019), *K. minuta* (Jenjittikul and Larsen 2020), *K. pardi* (Jenjittikul and Larsen 2020), *K. pseudoparviflora* (Saensouk and Saensouk 2021c), *K. sripraiana* (Boonma et al. 2022), *K. takensis* Boonma & Saensouk (Boonma et al. 2020), *K. udonensis* Picheans. & Phokham (Phokham et al. 2013), *Zingiber pyroglossum* (Saensouk et al. 2016), *Z. sadakornii* (Saensouk et al. 2016).

Bueng Kan Province is located in northeastern Thailand and it is the boundary between Thailand and Laos PDR. The area has many forests, rich streams, beautiful natural scenery, and a variety of higher plants. Therefore, Zingiberaceae, especially rare or endemic species, will be found in this area. In addition, the Zingiberaceae in Bueng Kan Province have not been determined previously. This study aims to determine the diversity, conservation status, and traditional uses of the Zingiberaceae in Bueng Kan Province, Thailand. This information will be important as a biological resource.

MATERIALS AND METHODS

Plant material

The specimens of the family Zingiberaceae were collected during field trips around Bueng Kan Province, northeastern Thailand, between January and December 2021 (Figure 1). Voucher specimens were deposited in the Mahasarakham University Herbarium, Thailand.

Plant diversity study

Zingiberaceae diversity, vernacular names, distribution data, ecological data, and phenology were recognized in the field. The dominant characteristics, such as color and smell, were also recorded from the field. The specimens in this study were compared with herbarium specimens that were kept at herbaria, i.e., Herbarium of Department of National Parks, Wildlife and Plant Conservation (BKF), Bangkok Herbarium (BK), Queen Sirikit Botanical Gardens Herbarium (QBG) and Khon Kaen University Herbarium (KKU), available taxonomic literature and online images.

Traditional utilization study

The traditional information about the uses of the ginger family from Bueng Kan Province, including food, spice, ornamental plants, and ritual plants, was obtained from interviews with 16 villagers, especially those with knowledge of folk medicine (< 50 years old, 10 male and 6 female).

Conservation status study

Endemic species study

The endemic species of the family Zingiberaceae from Bueng Kan Province was conducted based on Kew Science (2022).

Conservation status in the study area

The evaluation criteria for the conservation status based on data during fieldwork for the collection of specimens in the study area were reported as common or rare species.

Conservation status from global data

The evaluation of global criteria for conservation status of the family Zingiberaceae from Bueng Kan Province was conducted based on IUCN (2022).

RESULTS AND DISCUSSION

Diversity of Zingiberaceae in Bueng Kan Province

A total of three tribes, 13 genera, and 67 species of Zingiberaceae were found in Bueng Kan Province (Table 1, Figure 2). The tribe Alpinieae comprised five genera and 17 species: *Alpinia* (eight species), *Amomum* (six species), *Etingera* (one species), *Meistera* (one species), and *Wurfbainia* (one species). The tribe Globbeae was represented by two genera and five species: *Gagnepainia* (two species) and *Globba* (10 species). The last tribe, Zingibereae, with the highest diversity of Zingiberaceae species had six genera and 23 species: *Boesenbergia* (three species), *Caulokaempferia* (four species), *Curcuma* (12 species), *Hedychium* (one species), *Kaempferia* (seven species) and *Zingiber* (11 species). The distribution, phenology, ecology, endemic species, and conservation status are presented in Table 1. All specimens were deposited in the Mahasarakham University Herbarium, Thailand.

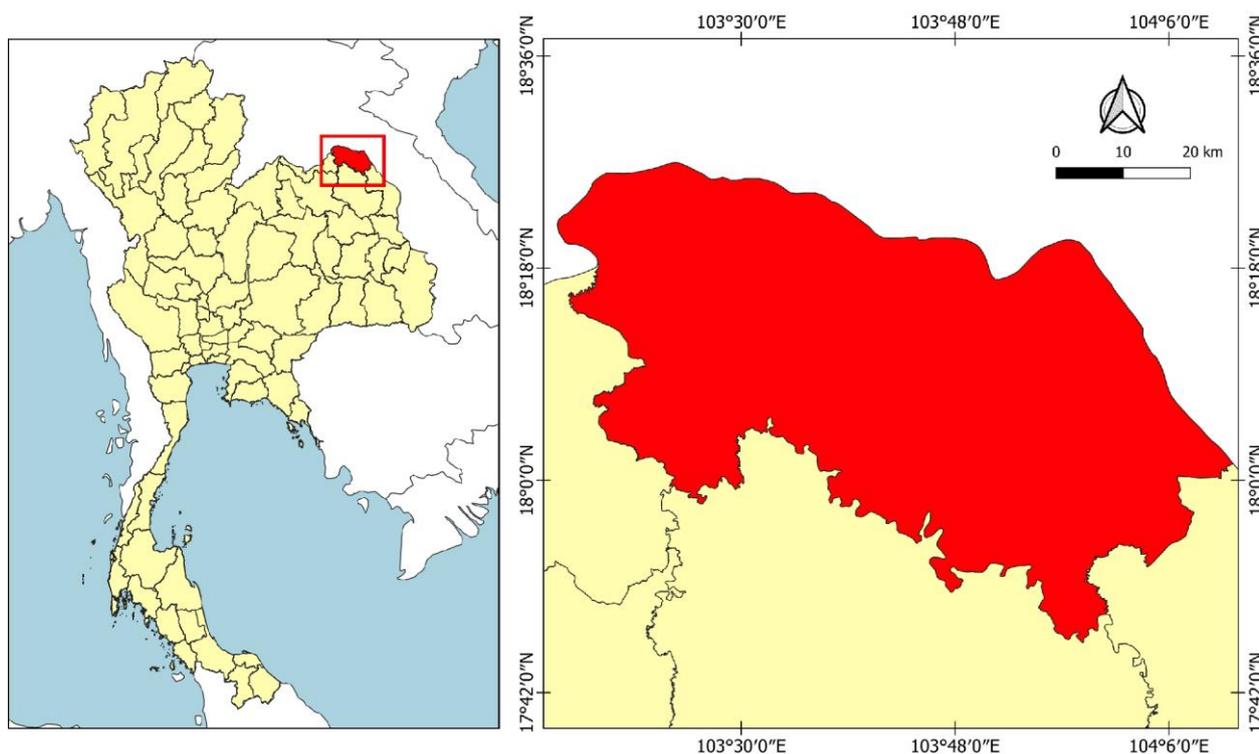


Figure 1. General location and details of Bueng Kan Province, Thailand. (Scale bar =10 km) (Bueng Kan Province. 2021. [https://www.google.com/maps/place/Bueng+Kan/.](https://www.google.com/maps/place/Bueng+Kan/))

Distribution

During surveys and collection of the family Zingiberaceae in Bueng Kan Province, it was found that the most diverse species in this family were discovered in Bung Khla district (containing 64 species), Bueng Kan district (containing 46 species), Seka district (containing 36 species), Bueng Khong Long district (containing 35 species), Pak Khat district (containing 26 species) and other districts (every 25 species).

Ecology

The ecology of all species is recorded in Table 1, which is according to Saensouk and Saensouk (2021). The family was discovered in five ecosystem types: twenty species (comprising *Alpinia* two species, *Caulokaempferia* four species, *Curcuma* nine species, *Kaempferia* four species, and *Zingiber* one species) were collected from deciduous dipterocarp forest. Twenty-seven species (comprising *Alpinia* one species, *Amomum* two species, *Boesenbergia* two species, *Curcuma* three species, *Gagnepainia* two species, *Globba* 10 species, *Kaempferia* two species, and *Zingiber* five species) were discovered in mixed deciduous forest. Twenty species (comprising *Alpinia* two species, *Amomum* five species, *Boesenbergia* one species, *Globba* five species, *Meistera* one species, *Wurfbainia* one species, and *Zingiber* five species) were found in dry evergreen forest. Two species, *Alpinia conchigera*, and *A. mutica*, were found in a river basin but differed from Saensouk and Saensouk (2021b), who reported only *A. conchigera* in a river basin. Twenty-four species (comprising *Alpinia* four species, *Amomum* one species, *Boesenbergia* two species,

Curcuma five species, *Etingera* one species, *Globba* two species, *Hedychium* one species, *Kaempferia* three species, and *Zingiber* six species) were cultivated in home gardens in Bueng Kan Province. Therefore, 41 species (62.68%) were reported to be native plants in Bueng Kan Province. Nine species (13.43%) were found to be both native and cultivated in home gardens. Meanwhile, 16 species (23.88%) were recognized to be cultivated in home gardens.

Phenology

From Table 1, the ginger family in Bueng Kan Province presented the highest flowering rate from March to September. Most of the ginger species had phenology from May to September, except four species that had phenology from February to April, namely *A. latilabris*, *A. zerumbet*, *Curcuma singularis*, and *Kaempferia rotunda*. While, only *Curcuma angustifolia* had phenology in both ranges (March-April and June-August), which follows Saensouk et al. (2016) and Saensouk and Saensouk (2021b).

Conservation status

Endemic species

Table 1 shows that nine endemic species in the family Zingiberaceae from Bueng Kan Province were reported based on Kew Science (2022), namely *Alpinia macrostaminodia*, *Amomum biphylum*, *A. wandokthong*, *Globba laeta*, *Boesenbergia baimaii*, *Caulokaempferia jirawongsei*, *Ca. phutonkensis*, *Ca. phuwoaensis* and *Ca. phulangkaensis*.

Table 1. Diversity notes as a biological resource of Zingiberaceae species in Bueng Kan Province, Thailand

Tribe	Species	Specimen examined	Distribution (district)	Phenology	Ecology	Conservation status			
						Endemic species*	Based on the study area	IUCN (2022)	
Alpinieae	<i>Alpinia conchigera</i>	Saensouk 1000	Bung Khla, Bueng Khong Long, Bueng Kan, Pak Khat, Seka	Fl. & Fr.; Jun-Sep	RB, Cult.		Common species	LC	
	<i>A. galanga</i>	Saensouk 1001	All	Fl. & Fr.; Jun-Sep	DDF, MDF, Cult.		Common species		
	<i>A. latilabris</i>	Saensouk 1066	Bung Khla	Fl. Feb.-April; Fr. April-Jul	DEF		Rare species	LC	
	<i>A. macrostaminodia</i>	Saensouk 1002	Bung Khla	Fl. May-Jun; Fr. Jun-Oct	DDF	✓	Rare species		
	<i>A. mutica</i>	Saensouk 1003	Bung Khla	Fl. May-Jun; Fr. Jun-Oct	RB		Rare species	LC	
	<i>A. purpurata</i>	Saensouk 1004	All	Fl. Jun-Aug; Fr. Not seen	Cult.		Common species		
	<i>A. siamensis</i>	Saensouk 1005	All	Fl. & Fr. Jun-Sep	Cult.		Common species		
	<i>A. zerumbet</i>	Saensouk 1006	Bung Khla	Fl. Feb.-April; Fr. April-Jul	DEF		Rare species	DD	
	<i>Amomum biphyllosum</i>	Saensouk 1011	Bung Khla	Fl. Jun-Aug; Fr. Not seen	DEF	✓	Rare species		
	<i>A. monophyllum</i>	Saensouk 1014	Bung Khla	Fl. May-Jun; Fr. Jun-Sep	DEF		Rare species		
	<i>A. repoeense</i>	Saensouk 1008	Bung Khla	Fl. May-Jun; Fr. Jun-Sep	DEF		Rare species	LC	
	<i>A. trilobum</i>	Saensouk 1013	Bung Khla	Fl. May-Jun; Fr. Jun-Sep	MDF, DEF		Rare species		
	<i>A. wandokthong</i>	Saensouk 1012	All	Fl. May-Jun; Fr. Jun-Sep	Cult.	✓	Common species		
	<i>Etilingera elatior</i>	Saensouk 1015	All	Fl. May-Aug; Fr. Aug-Oct	Cult.		Common species	DD	
	<i>Meistera koenigii</i>	Saensouk 1010	Bung Khla	Fl. May-Jun; Fr. Jun-Sep	DEF		Rare species	LC	
	<i>Wurfbainia schmidtii</i>	Saensouk 1009	Bung Khla	Fl. May-Jun; Fr. Jun-Sep	DEF		Rare species	LC	
	<i>W. villosum</i> var. <i>xantoides</i>	Saensouk 1007	Bung Khla	Fl. March-May; Fr. May-Jun	MDF, DEF		Rare species		
	Globbeae	<i>Gagnepainia godefroyi</i>	Saensouk 1016	Bung Khla	Fl. May-Jun; Fr. Jun-Aug	MDF		Rare species	LC
		<i>G. harmandii</i>	Saensouk 1017	Bung Khla	Fl. May-Jun; Fr. Jun-Aug	MDF		Rare species	
		<i>Globba candida</i>	Saensouk 1018	Bung Khla, Bueng Khong Long, Bueng Kan, Seka	Fl. Jun-Aug; Fr. Aug-Oct	MDF		Rare species	
<i>G. cambodgensis</i>		Saensouk 1019	Bung Khla, Bueng Khong Long, Bueng Kan, Seka	Fl. Jun-Aug; Fr. Aug-Oct	MDF		Rare species		
<i>G. globulifera</i>		Saensouk 1020	Bung Khla	Fl. Jun-Aug; Fr. Aug-Oct	MDF, DEF		Rare species		
<i>G. laeta</i>		Saensouk 1021	Bung Khla	Fl. Jun-Aug; Fr. Aug-Oct	MDF, DEF	✓	Rare species	EN	
<i>G. mogokensis</i>		Saensouk 1022	Bung Khla	Fl. Jun-Aug; Fr. Aug-Oct	MDF, DEF		Rare species		
<i>G. marantina</i>		Saensouk 1023	Bung Khla, Bueng Khong Long, Bueng Kan, Seka	Fl. Jun-Aug; Fr. Aug-Oct	MDF		Common species	LC	
<i>G. pendula</i>		Saensouk 1024	Bung Khla	Fl. Jun-Aug; Fr. Aug-Oct	MDF, DEF		Rare species	LC	
<i>G. patens</i>		Saensouk 1025	Bung Khla	Fl. Jun-Aug; Fr. Aug-Oct	MDF, DEF		Rare species	LC	
<i>G. schomburgkii</i>		Saensouk 1026	Bung Khla, Bueng Khong Long, Bueng Kan, Seka	Fl. Jun-Aug; Fr. Aug-Oct	MDF, Cult.		Common species		
<i>G. winitii</i>		Saensouk 1027	Bung Khla	Fl. Jun-Aug; Fr. Aug-Oct	MDF, Cult.		Rare species	LC	

Zingibereae	<i>Boesenbergia baimaii</i>	Saensouk 1030	All	Fl. Jun-Aug; Fr. Aug-Oct	Cult.	✓	Rare species	
	<i>B. parvula</i>	Saensouk 1029	Bung Khla	Fl. Jun-Aug; Fr. Aug-Oct	MDF, DEF		Rare species	
	<i>B. rotunda</i>	Saensouk 1028	All	Fl. Jun-Aug; Fr. Aug-Oct	MDF, Cult.		Common species	LC
	<i>Caulokaempferia jirawongsei</i>	Saensouk 1049	Bueng Kan	Fl. Jun-Jul; Fr. Jul-Aug	DDF	✓	Rare species	
	<i>Ca.phutonkensis</i>	Saensouk 1050	Bueng Kan	Fl. Jun-Jul; Fr. Jul-Aug	DDF	✓	Rare species	
	<i>Ca.phuwoaensis</i>	Saensouk 1051	Bung Khla	Fl. Jun-Jul; Fr. Jul-Aug	DDF	✓	Rare species	
	<i>Ca. Phulangkaensis</i>	Saensouk 1052	Bueng Kan, Bung Khla	Fl. Jun-Jul; Fr. Jul-Aug	DDF	✓	Rare species	
	<i>Curcuma alismatifolia</i>	Saensouk 1031	All	Fl. Jun-Aug; Fr. Aug-Oct	DDF, Cult.		Common species	NT
	<i>C. angustifolia</i>	Saensouk 1032	All	Fl. Mar-Apr, Jun-Aug; Fr. Jun-Oct	DDF		Common species	
	<i>C. campanulata</i>	Saensouk 1053	Bung Khla, Bueng Khong Long, Bueng Kan, Seka	Fl. May-Jun; Fr. Jun-Aug	DDF		Rare species	
	<i>C. comosa</i>	Saensouk 1033	All	Fl. Jun-Aug; Fr. Aug-Oct	MDF, Cult.		Common species	
	<i>C. gracillima</i>	Saensouk 1034	Bung Khla, Bueng Khong Long, Bueng Kan, Seka	Fl. Jun-Aug; Fr. Aug-Oct	DDF		Rare species	LC
	<i>C. involucrata</i>	Saensouk 1054	Bung Khla, Bueng Khong Long, Bueng Kan, Seka	Fl. May-Jun; Fr. Jun-Aug	DDF		Rare species	
	<i>C. longa</i>	Saensouk 1035	All	Fl. Jun-Aug; Fr. Aug-Oct	MDF, Cult.		Common species	DD
	<i>C. parviflora</i>	Saensouk 1036	All	Fl. Jun-Aug; Fr. Aug-Oct	DDF, MDF, Cult.		Common species	
	<i>C. pygmaea</i>	Saensouk 1037	Bueng Kan	Fl. Jun-Aug; Fr. Aug-Oct	DDF		Rare species	CR
	<i>C. rubescens</i>	Saensouk 1038	All	Fl. Jun-Aug; Fr. Aug-Oct	Cult.		Common species	
	<i>C. singularis</i>	Saensouk 1039	All	Fl. Mar-Apr; Fr. Jun-Jul	DDF,		Common species	
	<i>C. thorelii</i>	Saensouk 1040	All	Fl. Jun-Jul; Fr. Jul-Oct	DDF		Common species	
	<i>Hedychium coronarium</i>	Saensouk 1048	All	Fl. May-Sep; Fr. Aug-Oct	Cult.		Common species	DD
	<i>Kaempferia albomaculata</i> (nom. nud.)	Saensouk 1041	Bung Khla, Bueng Khong Long, Bueng Kan, Seka	Fl. May-Jun; Fr. Jun-Aug	DDF, MDF		Rare species	
	<i>K. angustifolia</i>	Saensouk 1042	All	Fl. Jun-Aug; Fr. Aug-Sep	Cult.		Common species	LC
	<i>K. galanga</i>	Saensouk 1043	All	Fl. Jun-Aug; Fr. Aug-Sep	Cult.		Common species	DD
	<i>K. koratensis</i>	Saensouk 1044	All	Fl. May-Jul; Fr. Jul-Sep	DDF		Common species	
	<i>K. pulchra</i>	Saensouk 1045	All	Fl. Jun-Aug; Fr. Aug-Sep	Cult.		Common species	
	<i>K. rotunda</i>	Saensouk 1046	Bung Khla, Bueng Khong Long, Bueng Kan, Seka	Fl. Mar-Apr; Fr. May-Jun	DDF, MDF		Rare species	
	<i>K. siamensis</i>	Saensouk 1047	Bung Khla, Bueng Khong Long, Bueng Kan	Fl. May-Jun; Fr. Jun-Jul	DDF		Rare species	
	<i>Zingiber chrysostachys</i>	Saensouk 1055	Bueng Kan, Bung Khla	Fl. Jul-Sep; Fr. Sep-Oct	DEF, MDF		Rare species	EN
	<i>Z. junceum</i>	Saensouk 1056	Bueng Kan, Bung Khla	Fl. Jul-Sep; Fr. Sep-Oct	DDF		Rare species	LC
	<i>Z. ligulatum</i>	Saensouk 1057	All	Fl. Jun-Aug; Fr. Aug-Oct	Cult.		Common species	
	<i>Z. mekongense</i>	Saensouk 1058	Bueng Kan, Bung Khla	Fl. Jul-Sep; Fr. Aug-Oct	DEF, MDF		Rare species	
	<i>Z. montanum</i>	Saensouk 1059	All	Fl. Jul-Sep; Fr. Aug-Oct	Cult.		Common species	
	<i>Z. officinale</i>	Saensouk 1060	All	Fl. Jul-Sep; Fr. Aug-Oct	Cult.		Common species	DD
	<i>Z. ottensii</i>	Saensouk 1061	All	Fl. Jul-Sep; Fr. Aug-Oct	Cult.		Common species	DD
	<i>Z. rubens</i>	Saensouk 1062	Bueng Kan, Bung Khla	Fl. Jul-Sep; Fr. Aug-Oct	DEF, MDF		Rare species	
	<i>Z. spectabile</i>	Saensouk 1063	All	Fl. Jul-Sep; Fr. Aug-Oct	Cult.		Common species	DD
	<i>Z. thorelii</i>	Saensouk 1064	Bueng Kan, Bung Khla	Fl. Jul-Sep; Fr. Aug-Oct	DEF, MDF		Rare species	LC
	<i>Z. zerumbet</i>	Saensouk 1065	Bueng Kan, Bung Khla	Fl. Jul-Sep; Fr. Aug-Oct	DEF, MDF, Cult.		Common species	DD

Note: DDF: deciduous dipterocarp forest, MDF: mixed deciduous forest, DEF: dry evergreen forest, RB: river basin, Cult.: cultivated, Fl: flowering period, Fr: fruiting period, CR: Critically Endangered, DD: Data Deficient, EN: Endangered, LC: Least Concern, NT: Near Threatened. *) Endemic species based on Kew Science (2022)



A



B



C



D



E



F



G



H



I



J



K



L



M



N



O



Figure 2. Rare, endemic, and some interesting species of the family Zingiberaceae in Bueng Kan Province, Thailand. A. *Alpinia latilabris*, B-C. *A. macrostaminodia*, D. *A. mutica*, E. *Amomum biphellum*, F. *A. wandokthong*, G. *Boesenbergia baimaii*, H. *B. parvula*, I. *Caulokaempferia jirawongsei*, J. *Ca. phuwoaensis*, K. *Curcuma alismatifolia*, L. *C. angustifolia*, M. *C. involucrata*, N. *C. pygmaea*, O. *C. singularis*, P. *Gagnepainia godefroyi*, Q. *G. harmandii*, R. *Globba globulifera* S. *G. laeta*, T. *G. mokogensis*, U. *G. pendula*, V. *Kaempferia albomaculata* (nom. nud.), W. *K. siamensis*, X. *Zingiber junceum*, Y. *Z. thorelii* and Z. *Z. zerumbet*

Evaluation criteria for the conservation status of Zingiberaceae from the study area

The conservation status of each species was based on data obtained during the survey for the collection of specimens, 38 species (comprising *Alpinia* four species, *Amomum* five species, *Boesenbergia* two species, *Caulokaempferia* four species, *Curcuma* three species, *Gagnepainia* two species, *Globba* seven species,

Kaempferia three species, *Meistera* one species, *Wurfbainia* one species, and *Zingiber* five species) were found to be rare species, and 28 species (comprising *Alpinia* four species, *Amomum* one species, *Boesenbergia* one species, *Curcuma* eight species, *Etligeria* one species, *Globba* two species, *Hedychium* one species, *Kaempferia* four species, and *Zingiber* six species) were reported as common species (Table 1).

Evaluation criteria for the conservation status of Zingiberaceae by IUCN (2022)

Table 1 shows that 29 species of the family Zingiberaceae from Bueng Kan Province were presented in IUCN (2022): CR (1 species), DD (9 species), EN (2 species) LC (16 species), NT (1 species). While, many endemic species (*A. macrostaminodia*, *A. biphillum*, *A. wandokthong*, *B. baimaii*, *C. jirawongsei*, *Ca. phutonkensis*, *Ca. phuwoaensis* and *Ca. phulangkaensi*) were not presented in IUCN (2022). Moreover, many common species in the study area were reported in IUCN (2022), such as *A. conchigera*, *B. rotunda*, *C. alismatifolia*, *C. longa*, *E. elatior*, *Globba marantina*, *H. coronarium*, *Kaempferia angustifolia*, *K. galanga*, *Zingiber zerumbet*, *Z. spectabile*, *Z. ottensii*, and *Z. officinale* (Table 1).

Traditional use of Zingiberaceae in Bueng Kan Province

Three tribes, 13 genera, and 67 species belonging to the family Zingiberaceae had usages for medicine, food, spice, ornamental, rituals, cosmetics, perfume, and dyes (Table 2 and Figures 3-5). Figure 3 shows the number of ginger family species that were traditionally used in Bueng Kan Province. The greatest number of species of the ginger family that were most commonly used is regarded for food, spice, ornamentals, rituals, cosmetics, dyes, and medicines, which is aligned with Sirirugsa (1998) and Saensouk et al. (2016).

Food. The main use of ginger plants (32 species) was as food or as vegetables. The main parts of the plants used for food were the rhizome, pseudostems, young inflorescence, young leaves, inflorescence, and fruits, which is in accordance with Sirirugsa (1998) and Saensouk et al. (2016) (Table 2, Figures 3-5).

Spice. From Table 2 the rhizomes of many species (*A. conchigera*, *A. galanga*, *A. macrostaminodia*, *A. siamensis*, *B. rotunda*, *Curcuma longa*, *K. albomaculata* (nom. nud.), *K. galanga*, *K. koratensis* and *Z. officinale*); roots of *B. rotunda*; and young leaves of *K. albomaculata*, *K. galanga*, *K. koratensis* and *Z. officinale*) were used as spices, which is in accordance with Sirirugsa (1998) and Saensouk et al. (2016) (Figures 3-5).

Ornamentals. The beautiful inflorescences and whole plants, especially the leaves of 34 ginger species, were used as ornamental plants, which is in accordance with Sirirugsa (1998) and Saensouk et al. (2016) (Table 2, Figures 3-5). They can be grown in the garden or home garden.

Ritual. The ginger family in Bueng Kan Province comprises several beliefs or cultural plants known in Thai folk taxonomy as “Wan”. Nineteen species (Table 2, Figures 3-5) were reported from native people as ritual plants, which is in accordance with Sirirugsa (1998) and Saensouk et al. (2016). All *Globba* species were ritual plants.

Cosmetics. Turmeric powder is used as a cosmetic in Bueng Kan Province and also in Thailand, which is in accordance with Sirirugsa (1998) and Saensouk et al. (2016) (Table 2, Figures 3-5).

Dye. The rhizomes of *C. longa* were used as a dye, which is in accordance with Sirirugsa (1998) and Saensouk et al. (2016) (Table 2, Figures 3-5).

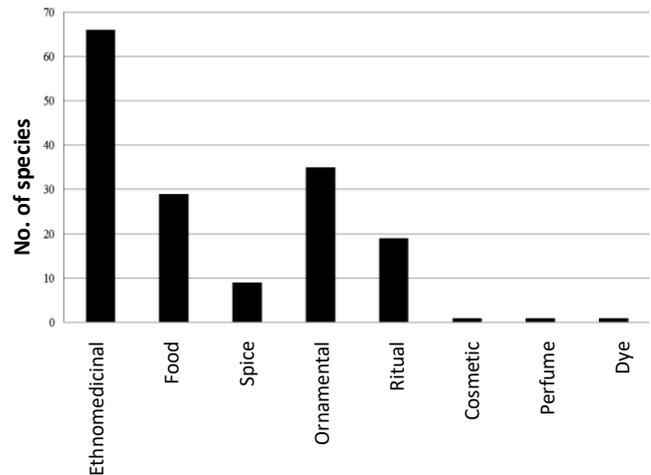


Figure 3 Number of species of Zingiberaceae in Bueng Kan Province, Thailand divided by use

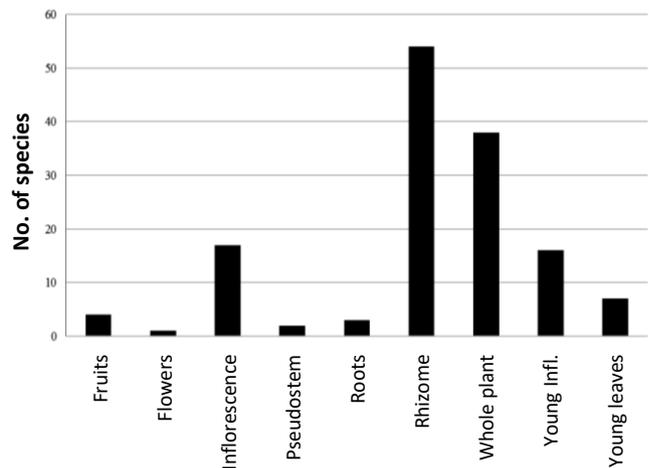


Figure 4 Number of species of the ginger family in Bueng Kan Province, Thailand divided by part of the plant use

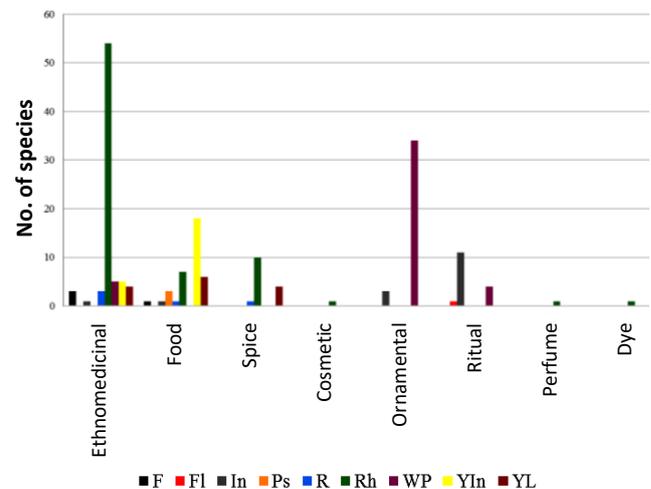


Figure 5. Comparisons of the number of species of Zingiberaceae in Bueng Kan Province, Thailand divided by each use category and part of use. Note: F: Fruits, Fl: Flower, In: Inflorescence, Ps: Pseudostems, R: Roots, Rh: Rhizome, WP: Whole plant, YIn: Young inflorescence, YL: Young leaves

Table 2. Traditional uses of family Zingiberaceae in Bueng Kan Province, Thailand

Tribe	Species	Traditional use						
		Food	Spice	Ornamental	Ritual	Cosmetic	Dye	Medicine
Alpinieae	<i>Alpinia conchigera</i>	Rhizomes, young pseudostems, young inflorescences and young fruits used as food and vegetable	Rhizomes used as a spice					Rhizome used for flatulence, laxative, tonic, stomachache, and skin disease
	<i>A. galanga</i>	Rhizomes, young pseudostems and young inflorescences used as food and vegetable	Rhizomes used as a spice					Rhizome used for flatulence, laxative, tonic, stomachache, and skin disease
	<i>A. macrostaminodia</i>	Rhizomes, young pseudostems and young inflorescences used as food and vegetable	Rhizomes used as a spice					Rhizome used for flatulence, laxative, tonic, stomachache, and skin disease
	<i>A. mutica</i>			Inflorescence and whole plant used as Ornamental	Inflorescence and whole plant used as ritual			Rhizome used for tonic
	<i>A. purpurata</i>			Inflorescence and whole plant used as Ornamental				Rhizome used for tonic
	<i>A. siamensis</i>	Rhizomes, young pseudostems and young inflorescences used as food and vegetable	Rhizomes used as a spice					Rhizome used for flatulence, laxative, tonic, stomachache, skin disease
	<i>A. zerumbet</i>	Young inflorescences used as food and vegetable						Rhizome used for tonic skin disease
	<i>Amomum biphellum</i>	Young leaves used as a food						Whole plant used for stomachache, flatulence
	<i>A. monophyllum</i>	Young leaves used as a food						Whole plant used for stomachache, flatulence
	<i>A. repoeense</i>	Fruits used as a food						Fruits used for carminative, stomachache, antifatulent
	<i>A. trilobum</i>							Whole plants used for stomachache, flatulence
	<i>A. wandokthong</i>			Whole plant used as Ornamental	Whole plants used as ritual			Whole plants used for stomachache, flatulence
	<i>Etingera elatior</i>	Young inflorescences used as a food		Inflorescence and whole plant used as ornamental				Inflorescences used for tonic, flatulence, and stomachache
	<i>Meistera koenigii</i>	Young leaves used as a food						Fruits used for carminative, stomachache, and antifatulent
<i>Wurfbainia schmidtii</i>			Whole plant used as ornamental	Whole plants used in ritual			Whole plants used for carminative, stomachache, and antifatulent	

Globbeae	<i>W. villosum</i> var. <i>xantoides</i>			Fruits used for carminative, stomachache, antifatulent
	<i>Gagnepainia godefroyi</i>	Beautiful inflorescence cultivated as ornamental		Rhizomes used for stomachache, and flatulence
	<i>G. harmandii</i>	Beautiful inflorescence cultivated as ornamental		Rhizomes used for stomachache, and flatulence
	<i>Globba candida</i>	Cultivated as ornamental	Inflorescence used for paying respect to the Buddha	Rhizomes used for stomachache, and flatulence
	<i>G. cambodgensis</i>	Cultivated as ornamental	Inflorescence used for paying respect to the Buddha	Rhizomes used for stomachache, and flatulence
	<i>G. globulifera</i>	Cultivated as ornamental	Inflorescence used for paying respect to the Buddha	Rhizomes used for stomachache, and flatulence
	<i>G. laeta</i>	Cultivated as ornamental	Inflorescence used for paying respect to the Buddha	Rhizomes used for stomachache, and flatulence
	<i>G. mogokensis</i>	Cultivated as ornamental	Inflorescence used for paying respect to the Buddha	Rhizomes used for stomachache, and flatulence
	<i>G. marantina</i>	Cultivated as ornamental	Inflorescence used for paying respect to the Buddha	Rhizomes used for stomachache, and flatulence
	<i>G. pendula</i>	Cultivated as ornamental	Inflorescence used for paying respect to the Buddha	Rhizomes used for stomachache, and flatulence
	<i>G. patens</i>	Cultivated as ornamental	Inflorescence used for paying respect to the Buddha	Rhizomes used for stomachache, and flatulence
<i>G. schomburgkii</i>	Cultivated as ornamental	Inflorescence used for paying respect to the Buddha	Rhizomes used for stomachache, and flatulence	
<i>G. winitii</i>	Cultivated as ornamental	Inflorescence used for paying respect to the Buddha	Rhizomes used for stomachache, and flatulence	
Zingibereae	<i>Boesenbergia baimaii</i>	Cultivated as ornamental		Rhizomes and roots used for flatulence, laxative, tonic, and stomachache
	<i>B. parvula</i>	Cultivated as ornamental		Rhizomes and roots used for stomachache
	<i>B. rotunda</i>	Roots and rhizomes used as a food	Roots and rhizomes used as a spice	Rhizomes and roots used for diuretic, flatulence, laxative, tonic, and stomachache

<i>Caulokaempferia jirawongsei</i>				Inflorescence used in ritual		Rhizomes used for tonic
<i>Ca. phutonkensis</i>				Inflorescence used in ritual		Rhizomes used for tonic
<i>Ca. phuwoaensis</i>				Inflorescence used in ritual		Rhizomes used for tonic
<i>Ca. phulangkaensis</i>				Inflorescence used in ritual		Rhizomes used for tonic
<i>Curcuma alismatifolia</i>	Young inflorescences used as a food		Beautiful whole plant cultivated as ornamental			
<i>C. angustifolia</i>	Young inflorescences used as a food					
<i>C. campanulata</i>			Beautiful whole plant cultivated as ornamental			Rhizomes used for tonic, stomachache, and skin disease
<i>C. comosa</i>			Beautiful whole plant cultivated as ornamental			Rhizomes used for treatment of inguinal hernia, and for uterine involution
<i>C. gracillima</i>			Beautiful whole plant cultivated as ornamental			Rhizomes and young inflorescences used for tonic
<i>C. involucratus</i>			Beautiful whole plant cultivated as ornamental			Rhizomes used for tonic, stomachache, and skin disease
<i>C. longa</i>	Rhizomes used as a food	Rhizomes used as a spice			Rhizomes used as cosmetic	Rhizomes used as dye
<i>C. parviflora</i>	Young inflorescences used as a food		Beautiful whole plant cultivated as ornamental			Rhizomes used for antipruritic, cosmetic, flatulence, laxative, tonic, stomachache, and skin disease
<i>C. pygmaea</i>	Young inflorescences used as a food					Rhizomes and young inflorescences used for stomachache, and tonic
<i>C. rubescens</i>			Beautiful whole plant cultivated as ornamental			Rhizomes and young inflorescences used for tonic
<i>C. singularis</i>	Young inflorescences used as a food					Rhizomes used for flatulence, laxative, stomachache, and tonic
<i>C. thorelii</i>	Young inflorescences used as a food		Beautiful whole plant cultivated as ornamental			Rhizomes and young inflorescences used for stomachache, and tonic
<i>Hedychium coronarium</i>			Beautiful whole plant cultivated as ornamental	Flower used in ritual		Whole plants used for tonic
<i>Kaempferia albomaculata</i> (nom. nud.)	Young leaves used as a food	Rhizomes and young leaves used as a spice				Rhizomes and young leaves used for flatulence, laxative, stomachache, tonic, and intoxication
<i>K. angustifolia</i>			Beautiful whole plant cultivated as ornamental			Rhizomes used for flatulence, laxative, stomachache, and tonic
<i>K. galanga</i>	Young leaves used as a food	Rhizomes and young leaves used as a spice	Beautiful whole plant cultivated as ornamental	Whole plant used in ritual		Rhizomes and young leaves used for flatulence, laxative, stomachache, tonic, and intoxication

<i>K. koratensis</i>	Young leaves used as a food	Rhizomes and young leaves used as a spice		Rhizomes and young leaves used for flatulence, laxative, stomachache, tonic, and intoxication
<i>K. pulchra</i>			Beautiful whole plant cultivated as ornamental	Rhizomes used for tonic
<i>K. rotunda</i>			Beautiful whole plant cultivated as ornamental	Rhizomes used for flatulence, laxative, stomachache, tonic, and intoxication
<i>K. siamensis</i>	Young leaves used as a food			Rhizomes and young leaves used for flatulence, laxative, stomachache, and tonic
<i>Zingiber chrysostachys</i>	Young inflorescences used as a food		Beautiful whole plant cultivated as ornamental	Rhizomes used for tonic, and laxative
<i>Z. junceum</i>	Young inflorescences used as a food			Rhizomes used for tonic, laxative, and stomachache
<i>Z. ligulatum</i>	Young inflorescences used as a food			Rhizomes used for tonic, laxative, stomachache, and headaches
<i>Z. mekongense</i>	Fruits used as a food			Rhizomes used for tonic
<i>Z. montanum</i>	Young inflorescences used as a food			Rhizomes used for tonic, laxative, stomachache, skin disease, pains, and aches
<i>Z. officinale</i>	Young inflorescences, roots and young leaves used as a food	Rhizomes and young leaves used as spice		Rhizomes used for flatulence, laxative, stomachache, tonic, carminative, and antifatulent
<i>Z. ottensii</i>	Young inflorescences used as a food		Rhizome used in ritual	Rhizomes used for flatulence, laxative, stomachache, tonic, and carminative
<i>Z. rubens</i>	Young inflorescences used as a food			Rhizomes used for tonic
<i>Z. spectabile</i>	Young inflorescences used as a food		Beautiful whole plant cultivated as ornamental	Rhizomes used for tonic
<i>Z. thorelii</i>	Young inflorescences used as a food			Rhizomes used for stomachache, and tonic
<i>Z. zerumbet</i>	Young inflorescences used as a food		Beautiful whole plant cultivated as ornamental	Rhizomes used for flatulence, laxative, stomachache, tonic, and carminative

Figure 5 shows a comparison of the number of species of Zingiberaceae in Bueng Kan Province when divided by each use category and part of use. The greatest number of species in the ginger family were most commonly used for ethnomedicinal, ornamental, food, ritual, spice, cosmetic, perfume, and dye.

In conclusion, three tribes, 13 genera, and 67 species of Zingiberaceae were found in Bueng Kan Province (Table 1, Figures 2-4). *Curcuma* was the genus with the greatest number of species at, 12 followed by *Zingiber* (11 species), *Globba* (10 species), *Alpinia* (eight species), *Kaempferia* (seven species), *Amomum* (six species), *Caulokaempferia* (four species), *Boesenbergia* (three species), *Gagnepainia* (two species), *Etilingera* (one species), *Hedychium* (one species), *Meistera* (one species) and *Wurfbainia* (one species). The most diverse species of this family were found in Bung Khla district, with 64 species. The families were discovered in five ecosystem types-deciduous dipterocarp forest (20 species), mixed deciduous forest (21 species), dry evergreen forest (20 species), river basin (two species), and cultivated in home gardens (24 species). The results showed that 41 species (62.68%) were found to be native species and 16 species (23.88%) were recognized as being cultivated in home gardens in Bueng Kan Province. The highest phenology rate was from March to September. During the survey for collection of specimens, it was found that 38 species were reported with the conservation status as rare species. Twenty-eight species were recognized as common species. The family Zingiberaceae from Bueng Kan Province has twenty-nine species in IUCN (2022), including: one species as CR, nine species to be DD, two species as EN, 16 species as LC, one species to be NT.

On the other hand, this study reported *Amomum villosum* var. *xantoides*, *A. repoeense*, *G. laeta*, *G. winitii*, *G. pendula*, *M. koenigii*, *Wurfbainia schmidtii*, *Zingiber junceum* and *Z. thorelii*, except *B. rotunda*, *C. alismatifolia* and *Z. ligulata* that were rare plants in Bueng Kan Province. Nine species—*Alpinia macrostaminodia*, *A. biphyllum*, *A. wandokthong*, *G. laeta*, *B. baimaii*, *C. jirawongsei*, *Ca. phutonkensis*, *Ca. phuwoaensis* and *Ca. phulangkaensis* were recorded as endemic species based on Kew Science (2022). Moreover, *A. macrostaminodia*, *A. biphyllum*, *A. monophyllum*, *C. jirawongsei*, *Ca. phutokensis*, *Ca. phuwoaensis* and *Curcuma pygmaea* were found only in Bueng Kan Province, Thailand. The Zingiberaceae in Bueng Kan Province had popular uses as food, spice, rituals, and ornamentals. For the medicinal use of Zingiberaceae in this study, they were in relation to flatulence, laxative, diuretic, stomachache, treatment of inguinal hernia, uterine involution, antipruritic, cosmetic, skin disease, carminative, antifatulent, intoxication, and tonic. In Thailand, 42 species of Zingiberaceae were reported as having traditional uses for the first time. *Alpinia galanga*, *A. siamensis*, *A. conchigera*, *Amomum wandokthong*, *B. rotunda*, *C. alismatifolia*, *C. longa*, *E. eliator*, *Globba schomburgkii*, *Zingiber montanum*, *Z. officinale* and *Z. zerumbet* were the most popular, which can be cultivated in every home garden. Therefore, the information in this study—the diversity, conservation status,

and traditional uses of Zingiberaceae in Bueng Kan Province, Thailand are important as biological resources.

ACKNOWLEDGEMENTS

We would like to thank Mahasarakham University, Thailand (Faculty of Environment and Resource Studies and Walai Rukhavej Botanical Research Institute) for their facilities during the study. This study was financially supported by Mahasarakham University. In addition, warm thanks to the curators and staff of the BKF and BK herbaria visited. Many thanks to our students for their help in the field. We also thank Dr. Jolyon Dodgson, who is an agriculturist, crop scientist, and plant pathologist from the UK, for language editing and suggestions to improve the manuscript.

REFERENCES

- Boonma T, Saensouk S. 2019. *Curcuma saraburiensis* (Zingiberaceae), a new species from Thailand. *Taiwania* 64 (3): 245-248.
- Boonma T, Saensouk S, Saensouk P. 2020a. Two new species of *Kaempferia* L. (Zingiberaceae) from Thailand. *Taiwania* 65 (3): 371-381.
- Boonma T, Saensouk S, Saensouk P. 2020b. *Amomum foetidum* (Zingiberaceae), a new species from Northeast Thailand. *Taiwania* 65 (3): 364-370.
- Boonma T, Saensouk S, Saensouk P. 2022. *Kaempferia sipraiana* (Zingiberaceae), a new species from Thailand and a new record of *Kaempferia pseudoparviflora* for Myanmar. *Biodiversitas* 23 (4): 2203-2211. DOI: 10.13057/biodiv/d230456.
- Bueng Kan Province. 2021. <https://www.google.com/maps/place/Bueng+Kan/>.
- Chaveerach A, Mookamul P, Sudmoon R, Taneet T. 2008. A New Species of *Alpinia* Roxb. (Zingiberaceae) from Northeastern Thailand. *Taiwania* 53 (1): 1-5.
- Chen J, Lindstrom JA, Xia N. 2015. *Curcuma woodii* (Zingiberaceae), a new species from Thailand. *Phytotaxa* 227 (1): 75-82. DOI: 10.11646/phytotaxa.227.1.8.
- Chuakul W, Boonpleng A. 2003. Ethno-medicinal uses of Thai Zingiberaceae plant. *Thai J Pharm Prac.* 10 (1): 33-39.
- Chumroenphat T and Saensouk S. 2022. Taxonomy, phytochemical and bioactive compounds and potential use as material with different drying methods of *Alpinia latilabris* Ridl. new record from Thailand. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca* 50 (1): 12619. DOI: 10.15835/nbha50112619.
- IUCN. 2022. The IUCN Red List of Threatened Species. Version 2022.1. <http://www.iucnredlist.org/>, 22 January 2022.
- Jenjittikul T, Larsen K. 2020. Two New Species of *Kaempferia* (Zingiberaceae) from Thailand. *Nat Hist Bull Siam Soc* 64 (1): 17-23.
- Jenjittikul T, Ruchisansakun S. 2020. *Kaempferia albiflora* (Zingiberaceae), a new species from Thailand. *Kew Bulletin* 75 (1): 13. DOI: 10.1007/s12225-020-9868-4.
- Kew Science. 2022. World Checklist of Selected Plant Families (WCSP), 2022.
- Larsen K, Larsen S. S. 2006. *Gingers of Thailand*. Queen Sirikit Botanic Garden, Chiang Mai, Thailand.
- Maknoi C, Saensouk S, Saensouk P, Rakarcha S, Thammarong W. 2021. Two new species of *Curcuma* L. (Zingiberaceae) from Thailand. *Biodiversitas* 22 (9): 3910-3921 DOI: 10.13057/biodiv/d220937.
- Mood JD, Veldkamp JF, Mandáková T, Prince LM, de Boer HJ. 2019. Three new species of *Boesenbergia* (Zingiberaceae) from Thailand and Lao P.D.R. *Gardens' Bulletin Singapore* 71 (2): 477-498. DOI: 10.26492/gbs71(2).2019-15.
- Naive MAK, Demayo CG, Alejandro GJD. 2021. Short Communication: New insights into the morphology and distribution of the Philippine endemic *Etilingera pilosa* (Zingiberaceae). *Biodiversitas* 22 (8): 3175-3179. DOI: 10.13057/biodiv/d220811.

- Nopporncharoenkul N, Laongsri W, Jenjittikul T. 2020. Two new species of *Kaempferia* subgenus *Protanthium* (Zingiberaceae) from northern Thailand. *Nord J Bot* 38 (2): e02633. DOI: 10.1111/njb.02633.
- Nopporncharoenkul N, Somnoo T, Tanming W, Maknoi C. 2021. *Kaempferia jenjittikuliae* (*Kaempferia* Subg. *Protanthium*: Zingiberaceae), a new, endangered species endemic to Thailand. *Edin J Bot* 78 (350): 1-13. DOI: 10.24823/EJB.2021.350.
- Pholhiamhan R, Saensouk S, Saensouk P. 2018. Ethnobotany of Phu Thai ethnic group in Nakhon Phanom Province, Thailand. *Walailak J Sci Technol* 15 (10): 679-699. DOI: 10.48048/wjst.2018.3737.
- Phumthum M, Balslev H. 2020. Using ICPC-2 standard to identify Thai Zingiberaceae of pharmacological interest. *Plants* 9 (7): 906. DOI: 10.3390/plants9070906.
- Phokham B, Wongsuwan P, Picheansoonthon C. 2013. Three new species of *Kaempferia* (Zingiberaceae) from Thailand and Laos. *J Jap Bot* 88 (5): 297-308.
- Pornpimon W, Sitthichok P, Picheansoonthon C. 2015. *Kaempferia koontermii* (Zingiberaceae)-a new species from Thailand. *J Jap Bot* 90: 29-33.
- Saensouk S, Saensouk P. 2014. *Elettariopsis biphylla*, a new species of Zingiberaceae from Thailand. *Phytotaxa* 159 (1): 23-25. DOI: 10.11646/phytotaxa.159.1.4.
- Saensouk S, Saensouk P. 2019. *Kaempferia mahasarakhamensis* sp. nov. (Zingiberaceae), a new species from Northeastern Thailand. *Taiwania* 64 (1): 39-42. DOI: 10.1007/s13237-020-00318-z.
- Saensouk S, Saensouk P. 2020a. *Boesenbergia isanensis* (Zingiberaceae), a New Species from Thailand. *J Jpn Bot* 95 (2): 65-68.
- Saensouk S, Saensouk P. 2020b. *Globba sirirugsae*, a New Species of Zingiberaceae from Thailand. *J Jpn Bot* 95 (6): 328-333.
- Saensouk P, Saensouk S. 2021a. Diversity and cytological studies on the genus *Amomum* Roxb. former *Elettariopsis* Baker (Zingiberaceae) in Thailand. *Biodiversitas* 22 (6): 3209-3218. DOI: 10.13057/biodiv/d220624.
- Saensouk P, Saensouk S. 2021b. Diversity, traditional uses and conservation status of Zingiberaceae in Udon Thani Province, Thailand. *Biodiversitas* 22 (8): 3083-3097. DOI: 10.13057/biodiv/d220801.
- Saensouk P, Saensouk S. 2021c. Taxonomy, cytology and palynology of *Kaempferia pseudoparviflora* (Zingiberaceae), a new and rare species from northern Thailand. *Asian J Plant Sci* 20: 414-420. DOI: 10.3923/ajps.2021.414.420.
- Saensouk P, Boonma T, Saensouk S. 2021. *Curcuma siamensis* (Zingiberaceae, Zingibereae), a new species of *Curcuma* subgen. *Ecomatae* from Southeastern Thailand. *Biodiversitas* 22 (12): 5239-5246. DOI: 10.13057/biodiv/d221201.
- Saensouk S, Boonma T, Saensouk P. 2021a. Six new species and a new record of *Curcuma* L. (Zingiberaceae) from Thailand. *Biodiversitas* 22 (4): 1658-1685. DOI: 10.13057/biodiv/d220410.
- Saensouk S, Boonma T, Thomudtha A, Thomudtha P, Saensouk P. 2021b. *Curcuma wanenlueanga* (Zingiberaceae), a new species of subgenus *Curcuma* from Thailand. *Biodiversitas* 22 (7): 2988-2994. DOI: 10.13057/biodiv/d220752.
- Saensouk S, Boonma T, Saensouk P. 2021c. A new species and a new record of *Curcuma* subgen. *Curcuma* (Zingiberaceae) from Northern Thailand. *Biodiversitas* 22 (9): 3661-3670. DOI: 10.13057/biodiv/d220904.
- Saensouk S, Saensouk P, Pasorn P, Chantaranothai P. 2016. Diversity and uses of Zingiberaceae in Nam Nao National Park, Chaiyaphum and Phetchabun Provinces, Thailand, with a new record for Thailand. *Agric Nat Resour* 50: 445-453. DOI: 10.1016/j.anres.2016.08.002.
- Sangvirojjanapat S, Newman M. 2021. Eight new species of *Globba* (Zingiberaceae) from Thailand and Lao PDR. *Phytotaxa* 505 (2): 139-156. DOI: 10.11646/phytotaxa.505.2.2.
- Sangvirojjanapat S, Hũu Đãng T, Newman M. 2020. Ten new species of *Globba* section *Globba* from continental South-East Asia. *Thai For Bull Bot* 48 (2): 212-233. DOI: 10.20531/tfb.2020.48.2.15.
- Sirirugs P. 1998. Thai Zingiberaceae: Species diversity and their uses. International Conference on Biodiversity and Bioresources: Conservation and Utilization, 23-27 November 1997, Phuket, Thailand.
- Soonthornkalump S, Ongsakul A, Dolaji A, Leong-Škorničková J. 2020. *Curcuma papilionacea* (Zingiberaceae), An unusual new species from Southern Thailand. *Phytotaxa* 432 (1): 11-16. DOI: 10.11646/phytotaxa.432.1.2.
- Wongsuwan P, Meechonkit P, Phokham B, Sangnark S, Yupparach P, Picheansoonthon C. 2020. A new species of *Kaempferia* (Zingiberaceae) from Northern Thailand. *J Jap Bot* 95 (1): 34-38.