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Diversity, Traditional Uses, Economic Values, and Conservation Status of Zingiberaceae in Kalasin Province, Northeastern Thailand

Tammanoon Jitpromma [1], Surapon Saensouk [1,*], Piyaporn Saensouk [2] and Thawatphong Boonma [1]

[1] Diversity of Family Zingiberaceae and Vascular Plant for Its Applications Research Unit, Walai Rukhavej Botanical Research Institute, Mahasarakham University, Kantarawichai District, Maha Sarakham 44150, Thailand; jitpromma.t@gmail.com (T.J.); boonma.thawat@gmail.com (T.B.)

[2] Diversity of Family Zingiberaceae and Vascular Plant for Its Applications Research Unit, Department of Biology, Faculty of Science, Mahasarakham University, Kantarawichai District, Maha Sarakham 44150, Thailand; pcornukaempferia@yahoo.com

* Correspondence: surapon.s@msu.ac.th; Tel.: +66-088-029-3958

Abstract: The Zingiberaceae family is widely recognized for its diversity, ecological significance, and economic value, playing a crucial role in both natural ecosystems and local livelihoods. This study investigates the species diversity, traditional uses, and economic importance of Zingiberaceae in Kalasin Province, northeastern Thailand, while also assessing the conservation status of species found in natural habitats. A total of 69 Zingiberaceae taxa were identified across the province, with 7 taxa found occurring only in natural habitats and 36 taxa found only in cultivation, while 26 taxa were found in both situations. Of these, twenty-five wild taxa represent new records for the province, and six are endemic. Traditional uses include food, spices, medicine, ornamental plants, commercial cultivation, rituals and socio-religious activities, and cosmetics, with rhizomes being the most utilized plant part. *Boesenbergia rotunda* (L.) Mansf. displayed the highest economic value. Based on conservation assessments according to IUCN red list criteria, *Globba conferta* M.F.Newman is proposed as critically endangered (CR), 5 species as endangered, 10 taxa as vulnerable, and 17 taxa as least concern. These findings emphasize the ecological, horticultural, and economic importance of Zingiberaceae in Kalasin, where the trade of herbal products and commercial cultivation significantly contribute to local livelihoods. To ensure long-term sustainability, conservation strategies should be prioritized, balancing biodiversity preservation with economic and horticultural benefits.

Keywords: conservation; diversity; ginger; taxonomy; traditional uses; Zingiberaceae

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1. Introduction

Zingiberaceae plants have been used for centuries in traditional medicine, Ayurvedic practices, and as a common spice [1–3]. They continue to be widely valued for their potential health benefits and remain an essential component in various global cuisines [4–7]. Some parts of Zingiberaceae plants are utilized as a source of natural dyes [7,8]. The flowers and inflorescences of most Zingiberaceae species are aesthetically pleasing, and many of them are cultivated as ornamental plants [9–11]. Furthermore, these plants are also utilized in various rituals [11,12].

Numerous research studies have explored the biodiversity and traditional uses of Zingiberaceae plants in Thailand [1,8,12]. They demonstrate that Thailand is a natural habitat for the ginger family, with Thai people continuing to utilize these plants in various

ways, including as food and spices, cosmetic applications, medicinal herbs, ornamental plants, and in ceremonial practices [1,8,12–14]. They highlight that the Zingiberaceae species are essential to daily life, play a significant role in the local economy, and are closely tied to cultural beliefs and religious practices [11,13].

Ethnobotanical studies in Kalasin Province have documented the rich local plant biodiversity and the diverse ways in which plants, including species from the Zingiberaceae family, are utilized [15–18]. These studies provide valuable insights into traditional knowledge and the cultural significance of these plants within the community. For example, a study of food plants in the rice fields of Kalasin Province identified two species of Zingiberaceae [15]. This research emphasizes the importance of anthropogenic areas in supporting wild food plants, which contribute to the food and nutritional security of rice farmers in northeast Thailand. Similarly, a study in Don Chao Poo Forest identified 10 species across five genera, highlighting the cultural and spiritual significance of the Zingiberaceae family to local communities [16]. In Muang District, seven species of ginger plants were identified; these plants are not only used as food but also valued for their medicinal properties [17]. Furthermore, an ethnobotanical study in Khong Chai District discovered 12 species of Zingiberaceae, which are utilized for various purposes [18], underscoring the integral role of Zingiberaceae species in daily life, serving as food and spice sources, traditional remedies, ornamental purposes, and cosmetic applications, reflecting the rich cultural knowledge embedded in the community's use of local plant species.

Kalasin Province is rich in traditions and cultures, with a diverse ethnic composition that includes Lao, Khmer, Chinese, Vietnamese, Phu Thai, Kalerng, Tai Kha, Tai Dam, and Nyo communities. The province is divided into 18 districts and features a variety of ecosystems, including wetlands, riverbanks, forests, and agricultural lands, all of which provide suitable habitats for Zingiberaceae plants. However, only a limited number of areas have been surveyed for the traditional uses of these plants, particularly within the Zingiberaceae family. Only eight species were recorded as wild species that are distributed in this province [19].

This article aims to document the diversity and distribution of Zingiberaceae plants across Kalasin Province, incorporating ecological, botanical, and traditional uses data. The goal is to create a comprehensive database that can track changes in plant populations and distributions over time, which is vital for conservation efforts. Additionally, this study lays the groundwork for integrating traditional plant knowledge with sustainable practices, contributing to both the preservation of cultural heritage and the future development of horticulture and commercial cultivation.

2. Materials and Methods

2.1. Study Area

Kalasin is located in the northeastern region of Thailand (Figure 1), covering an area of 6946.746 km^2. About 27% of the province is forested. It is divided into 18 districts and borders several neighboring provinces: Udon Thani and Sakon Nakhon to the north, Mukdahan to the east, Roi Et and Maha Sarakham to the south, and Maha Sarakham and Khon Kaen to the west. The province contains two national parks: Phu Phan National Park, which spans approximately 665 km^2, and Phu Pha Lek National Park, covering about 404 km^2. The region's landscape features riverine lowlands along the Chi, Pao, and Phan Rivers.



Figure 1. The study area, Kalasin Province (the red part), shows its position on the map of Thailand (the geographic system used: WGS84), administratively divided into 18 districts, graphics designed using the Pixelmator Pro Program (Version 3.6.15 (Archipelago), 2025, Pixelmator Team, Vilnius, Lithuania.

2.2. Diversity Study and Plant Resources

Field surveys were carried out from October 2023 to September 2024 to gather specimens and document Zingiberaceae species across Kalasin Province. These surveys took place two to four times per month in a variety of habitats, such as forests, urban areas, and other accessible sites. In national parks and protected areas, efforts were made to minimize ecological disturbance, with only photographic records and field notes being collected, and no specimens were gathered. Spirit specimens preserved in 70% ethanol were stored at the Mahasarakham University Herbarium (MSU) in Thailand.

The morphological characteristics of the collected Zingiberaceae specimens were examined using a stereoscopic microscope (Stemi 2000-C, Zeiss, Oberkochen, Germany) and measured with rulers and vernier calipers for precise documentation. Species identification was verified by comparing specimens with protologue descriptions and established references, e.g., *Flora of Thailand Volume 16, Part two* [19] and POWO [20]. A comprehensive review of the primary taxonomic literature and major research databases (Scopus, Web of Science, and Google Scholar) was conducted, alongside comparisons with digital images from Kew's Herbarium, the Kew Science website, and the Zingiberaceae Resource Center (https://padme.rbge.org.uk/ZRC) (accessed on 11 November 2024). Additional verification was made using herbarium collections from Aarhus University (AU), The Forest Herbarium (BKF), Royal Botanic Garden Edinburgh (E), Faculty of Forestry Herbarium (FOF), Royal Botanic Gardens (K), National Museum of Natural History (P), Queen Sirikit Botanical Garden (QBG), and Singapore Botanic Gardens (SING). Specimens' distribution in Thailand and neighboring countries was also considered to ensure accurate species identification. The nomenclature of the taxa followed the plant names from POWO [20].

2.3. Distribution Study of Zingiberaceae in Kalasin Province

The process of data collection involved cataloging species on a district-by-district basis, as depicted in Figure 1, in alignment with the diversity study. These data were crucial for distinguishing between plants that thrived in their natural environments, those cultivated in controlled conditions, and species observed in both settings. Additionally, the distribution status of each species was evaluated to determine whether it was native or introduced. Information was gathered from the POWO database [20], and distribution data were sourced from both printed and online research materials. To ensure data accuracy, references emphasizing specimens stored in various herbarium collections were given priority.

2.4. Ecology

Ecological data were recorded during field surveys on Zingiberaceae diversity and traditional uses in Kalasin Province. The surveys focused on identifying the forest types where species were observed. Plants occurring in natural habitats were classified based on their presence in deciduous dipterocarp forest (DDF), dry evergreen forest (DEF), deciduous forest (DCF), evergreen forest (EGF), or mixed deciduous forest (MDF), as detailed in Table 1. Species found in cultivated settings, such as home gardens, were categorized as 'Cultivated'.

2.5. Phenology

The phenological study of Zingiberaceae in Kalasin Province focused on documenting the flowering and fruiting patterns. Each month was assigned a numerical value from one to twelve, representing January to December. The emphasis on flowering and fruiting stages was essential for understanding the reproductive success, distribution, and economic importance of these plants. A comprehensive assessment of the full growth cycle was not feasible within the one-year study period and would have required longer-term monitoring. Moreover, since many Zingiberaceae species grew year-round without a dormant phase, the flowering and fruiting stages were the most significant. This focus also provided valuable insights into how climate change influences these plants, as these stages are highly responsive to environmental changes, highlighting potential shifts in reproductive timing and conservation requirements.

2.6. Utilization

Data on the use of Zingiberaceae plants in Kalasin Province were gathered through interviews with 360 residents, with an equal distribution of 10 male and 10 female participants from each district. This resulted in a total of 180 male and 180 female participants, all residing in their own homes within the province (excluding those living in rented accommodations). Prior to conducting the interviews, informed consent was obtained from all participants, who were fully briefed on the study's objectives to ensure voluntary participation. The interview questions focused solely on the identification of plant species, the plant parts utilized, and their purposes of use. No personal information was solicited or collected during the survey, which exempted the study from requiring formal ethics approval.

2.7. Conservation Status

The Zingiberaceae species in Kalasin Province were systematically evaluated following the criteria set out by the IUCN Red List [21] to assess their conservation status.

Table 1. Diversity of Zingiberaceae species in Kalasin Province, along with their vernacular name, conservation status, distribution, ecology, utilization, phenology, and voucher number.

No.	Scientific Name	Vernacular Name	Conservation Status	Conservation Status for Wild Species Proposed by Authors with IUCN Red List Criteria 2024	Distribution Status for Thailand	Districts of Kalasin Province																	Ecology	Purposes	Used Parts	Phenology		Voucher Number
						Mueang Kalasin	Na Mon	Kamalasai	Rong Kham	Kuchinarai	Khao Wong	Yang Talat	Huai Mek	Sahatsakhan	Kham Muang	Tha Khantho	Nong Kung Si	Somdet	Huai Phueng	Sam Chai	Na Khu	Don Chan	Khong Chai				Flowering	Fruiting	
1.	* *Alpinia galanga* (L.) Willd.	Kha	NE	LC	Native	CT	CT	CT	CT	CT	BT	CT	CT	CT	CT	CT	CT	BT	CT	CT	BT	CT	CT	CT, DEF, MDF	CC, FD, MD, SP	RT, RZ, PS, LV, IF, FS	4–9	7–10	KS0001
2.	* *Alpinia malaccensis* (Burm.f.) Roscoe	Kha Pa	DD	VU B2ab(ii,iv,v)	Native	-	-	-	-	-	BT	-	-	-	-	-	-	BT	-	-	-	-	-	CT, EGF	MD, OT	RZ, WP	2–6	4–8	KS0002
3.	*Alpinia purpurata* (Vieill.) K.Schum.	Khing Dang	NE		Introduced	CT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CT	CC, MD, OT	RZ, WP	1–12	Not seen	KS0003
4.	* *Alpinia siamensis* K.Schum.	Kha Ta Dang	NE	LC	Native	CT	CT	CT	CT	CT	BT	CT	CT	CT	CT	CT	CT	BT	CT	CT	BT	CT	CT	CT	CC, FD, MD, SP	RZ, PS, LV, IF	5–8	7–10	KS0004
5.	*Alpinia vittata* W.Bull	Kha Daang	NE		Introduced	CT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CT	OT	WP	6–8	Not seen	KS0005
6.	*Alpinia zerumbet* (Pers.) B.L.Burtt & R.M.Sm.	Kha Kom	DD		Native	-	-	-	-	CT	CT	-	-	-	-	-	-	CT	-	-	-	-	-	CT	MD, OT	RZ, PS, LV, WP	3–5	Not seen	KS0006
7.	*Amomum foetidum* Boonma & Saensouk	Ton Mang Kang	NE		Native	CT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CT	SP	WP	1–3	Not seen	KS0007
8.	*Amomum repoeense* Pierre ex Gagnep.	Reo Pa	LC	LC	Native	-	-	-	-	BT	BT	-	-	-	-	-	-	BT	-	-	-	-	-	CT, DEF	FD	RZ, PS, IF	5–7	Not seen	KS0008
9.	* *Amomum trilobum* Gagnep.	Wan Dok Thong	NE	LC	Native	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	WD	CT	CT	CT	CT	CT	CT, DEF, MDF	RB	WP	7–9	Not Seen	KS0009
10.	* *Boesenbergia isanensis* Saensouk & P.Saensouk	Kra Chai Isan	NE	EN B2ab(ii,iv,v)	Native	-	-	-	-	-	-	-	-	-	-	-	-	WD	-	-	-	-	-	DEF, DCF	FD	RZ	7–9	Not seen	KS0010
11.	* *Boesenbergia rotunda* (L.) Mansf.	Kra Chai	LC	LC	Native	CT	CT	CT	CT	CT	BT	CT	CT	CT	BT	CT	CT	BT	CT	CT	CT	CT	CT	CT, MDF	CC, FD, MD, SP	RT, RZ	7–9	9–10	KS0011
12.	* *Boesenbergia thorelii* (Gagnep.) Loes.	Wan Phet Klab	NE	VU B2ab(ii,iv,v)	Native	-	-	-	-	CT	BT	-	-	-	-	-	-	BT	-	-	-	-	-	CT, DEF	MD, RB	RZ, WP	7–9	Not seen	KS0012
13.	* *Boesenbergia xiphostachya* (Gagnep.) Loes.	Ngon Nark	LC	VU B2ab(ii,iv,v)	Native	-	-	-	-	WD	WD	-	-	-	-	-	-	WD	-	-	-	-	-	DCF	FD, MD	RZ, WP	5–8	8–10	KS0013
14.	*Curcuma angustifolia* Roxb.	Kra Chiao Dang	NE	LC	Native	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	BT	CT	CT	CT	CT	CT	CT, DCF	CC, FD, MD	RZ, IF	4–9	6–10	KS0014
15.	*Curcuma borealis* Saensouk, P.Saensouk & Boonma	Thep Apsorn	NE		Native	CT	-	CT	-	-	-	CT	-	-	-	-	-	-	-	-	-	-	-	CT	OT	WP	4–7	6–8	KS0015
16.	* *Curcuma campanulata* (Kuntze) Škorničk.	Wan Duk Dae	NE	LC	Native	CT	-	-	-	CT	CT	CT	CT	CT	CT	CT	-	-	BT	-	-	-	-	-	CT, DCF	MD	RZ	3–5	Not seen	KS0016
17.	*Curcuma comosa* Roxb.	Wan Chuk Modlook	NE		Native	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CC, CO, MD	RZ	3–5	Not seen	KS0017
18.	*Curcuma eburnea* Škorničk., Suksathan & Soonthornk.	Thepprasit	NE		Native	CT	-	-	-	-	-	-	-	-	-	-	-	CT	-	-	-	-	-	CT	SP	IF	6–8	Not seen	KS0018
19.	*Curcuma longa* L.	Khamin Chun	DD		Introduced	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CC, CO, FD, MD, SP	RZ, LV, IF	6–9	8–10	KS0019
20.	*Curcuma mangga* Valeton & Zijp	Khamin Khaow	DD		Introduced	CT	-	CT	-	CT	-	CT	CT	-	-	CT	-	CT	-	-	-	-	-	CT	FD	RZ, PS	3–6	Not seen	KS0020
21.	*Curcuma nakhonphanomensis* Boonma, Saensouk & P.Saensouk	Khamin Nakhon-phanom	NE		Native	CT	-	-	-	-	-	CT	CT	-	-	-	-	-	-	-	-	-	-	CT	FD, OT, RB	WP	6–9	Not seen	KS0021
22.	* *Curcuma parviflora* Wall.	Wan Thep Rum Luek	NE	LC	Native	CT	-	CT	-	CT	-	-	CT	CT	BT	CT	-	BT	-	-	-	-	-	CT, DEF	FD, MD	RT, RZ, IF	6–9	Not seen	KS0022
23.	*Curcuma peninsularis* Saensouk, P.Saensouk, Maknoi & Boonma	Ploy Andaman	NE		Native	CT	-	-	-	CT	-	-	-	-	-	-	-	CT	-	-	-	-	-	CT	OT	WP	6–9	Not seen	KS0023
24.	*Curcuma peramoena* Souvann. & Maknoi	Wan Houa Noi	NE		Native	-	-	-	-	CT	CT	-	-	CT	CT	-	-	CT	-	-	-	-	-	CT	OT	WP	5–7	Not seen	KS0024
25.	*Curcuma petiolata* Roxb.	Bua Chan	DD		Native	-	-	-	-	CT	CT	-	-	-	-	-	-	CT	-	-	-	-	-	CT	OT, RB	WP	7–9	8–10	KS0025
26.	*Curcuma phrayawan* Boonma & Saensouk	Phraya Wan	NE		Native	CT	-	-	-	CT	CT	CT	-	CT	CT	-	-	CT	-	-	-	-	-	CT	CC, MD, RB	RZ, WP	7–9	Not seen	KS0026
27.	*Curcuma rangjued* Saensouk & Boonma	Wan Rang-Jued	NE		Native	CT	-	CT	-	CT	CT	CT	-	-	-	-	-	CT	-	-	-	-	-	CT	MD	RZ	8–10	Not seen	KS0027

Table 1. *Cont.*

No.	Scientific Name	Vernacular Name	Conservation Status	Conservation Status for Wild Species Proposed by Authors with IUCN Red List Criteria 2024	Distribution Status for Thailand	Districts of Kalasin Province																	Ecology	Purposes	Used Parts	Phenology		Voucher Number
						Mueang Kalasin	Na Mon	Kamalasai	Rong Kham	Kuchinarai	Khao Wong	Yang Talat	Huai Mek	Sahatsakhan	Kham Muang	Tha Khantho	Nong Kung Si	Somdet	Huai Phueng	Sam Chai	Na Khu	Don Chan	Khong Chai				Flowering	Fruiting	
28.	*Curcuma rhabdota* Sirirugsa & M.F.Newman	Bua Komain	VU		Native	CT	-	CT	-	-	-	CT	-	-	-	-	-	-	-	-	-	-	-	CT	OT	WP	7–9	8–10	KS0028
29.	*Curcuma rosea* P.Saensouk, Saensouk & Boonma	Chor Chom Phu	NE		Native	CT	-	CT	-	-	-	CT	-	-	-	-	-	-	-	-	-	-	-	CT	OT	WP	6–9	8–10	KS0029
30.	*Curcuma roseobracteata* Saensouk, P.Saensouk, Maknoi & Boonma	Ngu-Hao Chomphoo	NE		Native	CT	-	CT	-	-	-	CT	-	-	-	-	-	-	-	-	-	-	-	CT	OT	WP	6–9	Not seen	KS0030
31.	*Curcuma rubescens* Roxb.	Wan Maha Prab	NE		Introduced	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	OT	WP	5–7	7–9	KS0031
32.	* *Curcuma rubroaurantiaca* Škorničk. & Soonthornk.	Wan Phet Ma Isan	NE	EN B2ab(ii,iv)	Native	CT	-	CT	-	-	-	CT	-	-	-	-	-	WD	-	-	-	-	-	CT, DEF	OT	WP	5–7	7–9	KS0032
33.	*Curcuma rubrobracteata* Škorničk., M.Sabu & Prasanthk.	Wan Ngoo Hao	NE		Native	CT	-	CT	-	CT	CT	CT	-	-	-	-	-	CT	-	-	-	-	-	CT	OT	WP	7–9	Not seen	KS0033
34.	*Curcuma singularis* Gagnep.	Kra Chiao Khaow	NE	LC	Native	CT	BT	CT	CT	CT	BT	CT	CT	CT	CT	CT	CT	BT	CT	CT	CT	CT	CT	CT, DDF	CC, FD	IF	4–6	Not seen	KS0034
35.	*Curcuma suphanensis* P.Saensouk, Boonma, Rakarcha, Maknoi, Wongnak & Saensouk	Kra Chiao Suphan	NE		Native	CT	-	CT	-	-	-	CT	-	-	-	-	-	-	-	-	-	-	-	CT	OT	WP	7–9	8–10	KS0035
36.	*Curcuma thorelii* Gagnep.	Kra Chiao Khaow	NE	VU B2ab(ii,iv)	Native	CT	CT	CT	CT	CT	CT	BT	CT	CT	CT	CT	CT	BT	CT	CT	CT	CT	CT	CT, MDF	OT	WP	7–9	Not seen	KS0036
37.	*Curcuma wanenlueanga* Saensouk, Thomudtha & Boonma	Wan En Lueang	NE		Native	CT	-	CT	-	CT	CT	CT	-	-	-	-	-	CT	-	-	-	-	-	CT	MD	RZ	7–9	Not seen	KS0037
38.	*Etlingera elatior* (Jack) R.M.Sm.	Da La	NE		Native	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	OT	WP	6–12	Not seen	KS0038
39.	* *Globba conferta* M.F.Newman	Daeng Phuphan	NE	CR B2ab(ii,iv,v)	Native	CT	-	CT	-	CT	BT	CT	-	-	-	-	-	BT	WD	-	WD	-	-	CT, DCF	MD, OT, RB	RZ, IF, WP	5–8	8–10	KS0039
40.	*Globba hilaris* Sangvir.	Khao Phan Sa Chor Khaow	NE		Native	CT	-	CT	-	CT	CT	CT	-	-	-	-	-	CT	-	-	-	-	-	CT, EGF	MD, OT, RB	RZ, IF, WP	5–9	9–11	KS0040
41.	* *Globba rosea* Gagnep.	Hong Hern Chor Tabtim	NE	VU B2ab(ii,iv,v)	Native	WD	-	WD	-	WD	WD	WD	-	-	-	-	-	WD	-	-	-	-	-	EGF	NA	-	7–9	8–10	KS0041
42.	* *Globba schomburgkii* Hook.f.	Kha Ling	NE	LC	Native	CT	-	CT	-	CT	CT	CT	-	CT	CT	-	-	BT	-	-	-	-	-	CT, DCF, MDF	OT	WP	6–9	8–10	KS0042
43.	* *Globba siamensis* (Hemsl.) Hemsl.	Whan Tabtim Siam	LC	VU B2ab(ii,iv,v)	Native	-	-	-	-	CT	CT	-	-	-	-	-	-	BT	-	-	-	-	-	CT, DCF	OT, RB	IF, WP	5–8	8–10	KS0043
44.	*Globba thorelii* Gagnep.	Hong Hern, Khao Phan Sa	LC	LC	Native	-	-	-	-	CT	CT	-	-	-	-	-	-	BT	-	-	-	-	-	CT, DEF	OT	WP	7–9	8–10	KS0044
45.	*Globba williamsiana* M.F.Newman & Sangvir.	Dok Khao Phan Sa	NE		Native	CT	-	CT	-	CT	CT	CT	-	CT	CT	-	-	CT	-	-	-	-	-	CT	OT	WP	6–9	Not seen	KS0045
46.	*Hedychium coronarium* J.Koenig	Maha Hong Khaow, Salata	DD		Native	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CC, MD, OT, RB	RZ, IF, WP	6–12	Not seen	KS0046
47.	*Kaempferia elegans* Wall.	Pro Yai	NE		Native	CT	-	CT	-	-	-	CT	-	-	-	-	-	CT	-	-	-	-	--	CT	MD, OT, RB	RZ, WP	6–10	Not seen	KS0047
48.	*Kaempferia galanga* L.	Wan Pro Hom	DD		Native	CT	-	CT	-	CT	CT	CT	-	-	-	-	-	CT	-	-	-	-	-	CT	FD, MD, RB	RZ, PS, LV, IF, WP	6–9	Not seen	KS0048
49.	* *Kaempferia marginata* Carey ex Roscoe	Wan E-moop	NE	LC	Native	BT	WD	WD	WD	WD	BT	WD	WD	WD	BT	WD	WD	BT	WD	WD	BT	WD	WD	CT, DDF	FD, MD	RZ, LV	5–7	Not seen	KS0049
50.	*Kaempferia parviflora* Wall. ex Baker	Kra Chai Dam	DD		Native	CT	-	CT	-	CT	CT	CT	-	-	-	-	-	CT	-	-	-	-	-	CT	MD	RZ	6–9	Not seen	KS0050
51.	*Kaempferia pulchra* Ridl.	Wan Toop Moop	NE		Native	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	FD, MD, OT	RZ, LV, WP	6–9	Not seen	KS0051
52.	*Kaempferia rotunda* L.	Wan How Non	NE	VU B2ab(ii,iv,v)	Native	CT	-	CT	-	CT	BT	CT	-	-	-	-	-	BT	-	-	-	-	-	CT, MDF	FD, MD, RB	RZ, LV, WP	3–5	Not seen	KS0052
53.	* *Kaempferia sakolchaii* P.Saensouk, Saensouk & Boonma	Pro Ajarn Sumon	NE	EN B2ab(ii,iv,v)	Native	-	-	-	-	-	-	-	-	-	-	-	-	WD	-	-	-	-	-	DCF, MDF	NA	-	5–7	Not seen	KS0053

Table 1. *Cont.*

No.	Scientific Name	Vernacular Name	Conservation Status	Conservation Status for Wild Species Proposed by Authors with IUCN Red List Criteria 2024	Distribution Status for Thailand	Districts of Kalasin Province																	Ecology	Purposes	Used Parts	Phenology		Voucher Number
						Mueang Kalasin	Na Mon	Kamalasai	Rong Kham	Kuchinarai	Khao Wong	Yang Talat	Huai Mek	Sahatsakhan	Kham Muang	Tha Khantho	Nong Kung Si	Somdet	Huai Phueng	Sam Chai	Na Khu	Don Chan	Khong Chai				Flowering	Fruiting	
54.	* *Kaempferia sakonensis* Saensouk, P.Saensouk & Boonma	Pro Sakon	NE	EN B2ab(ii,iv,v)	Native	-	-	-	-	-	-	-	-	-	WD	-	-	WD	-	-	-	-	-	DCF	NA	-	6–8	Not seen	KS0054
55.	* *Kaempferia siamensis* Sirirugsa	Wan Nok Khoom	NE	VU B2ab(ii,iv,v)	Native	-	-	-	-	BT	BT	-	-	-	-	-	-	-	-	-	-	-	-	CT, DCF, EGF	MD, OT	RZ, WP	5–8	8–10	KS0055
56.	*Meistera chinensis* (Chun ex T.L.Wu) Škorničk. & M.F.Newman	Naeng yai	LC	LC	Native	-	-	-	-	WD	WD	-	-	-	-	-	-	WD	-	-	-	-	-	DCF, DEF	NA	-	5–8	8–10	KS0056
57.	* *Wurfbainia uliginosa* (J.Koenig) Giseke	Kra Wan Pa	LC	LC	Native	-	-	-	-	-	BT	-	-	-	-	-	-	BT	-	-	-	-	-	CT, DEF, MDF	MD	RZ, LV, IF, FS	4–7	Not seen	KS0057
58.	*Wurfbainia vera* (Blackw.) Škorničk. & A.D.Poulsen	Kra Wan	NE		Native	-	-	-	-	CT	CT	-	-	-	-	-	-	CT	-	-	-	-	-	CT	MD, SP	FS	4–7	6–9	KS0058
59.	* *Wurfbainia villosa* (Lour.) Škorničk. & A.D.Poulsen	Reo Dong	DD	LC	Native	-	-	-	-	-	WD	-	-	-	-	-	-	WD	-	-	-	-	-	EGF	FD, MD	RZ, PS, FS	5–9	7–10	KS0059
60.	*Zingiber corallinum* Hance	Khing Krabong	NE		Native	-	-	-	-	-	-	-	-	-	-	-	-	CT	-	-	-	-	-	CT	OT	WP	7–9	Not seen	KS0060
61.	* *Zingiber junceum* Gagnep.	Wan Yok Isan	LC	LC	Native	-	-	-	-	-	BT	-	-	-	-	-	-	BT	-	-	-	-	-	CT, DEF	FD	IF	7–9	Not seen	KS0061
62.	* *Zingiber mekongense* Gagnep.	Khing Hang	NE	VU B2ab(ii,iv,v)	Native	-	-	-	-	-	CT	-	-	-	-	-	-	BT	-	-	-	-	-	CT, DDF	MD	RZ	4–6	Not seen	KS0062
63.	*Zingiber montanum* (J.Koenig) Link ex A.Dietr.	Wan Fai	NE		Native	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	FD, MD, RB	RT, RZ, PS, LV, IF, WP	3–5	Not seen	KS0063
64.	*Zingiber officinale* Roscoe	Khing Noy	DD		Introduced	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CC, FD, MD, SP	RT, RZ, PS, LV, IF	7–10	Not seen	KS0064
65.	*Zingiber ottensii* Valeton	Plai Dum	DD		Introduced	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	FD, MD	RZ, IF	7–10	Not seen	KS0065
66.	* *Zingiber parishii* subsp. *phuphanense* Triboun & K.Larsen	Wan Hom	NE	VU B2ab(ii,iv,v)	Native	-	-	-	-	WD	BT	-	-	-	-	-	-	BT	-	-	-	-	-	CT, MDF	OT	WP	6–7	Not seen	KS0066
67.	*Zingiber purpureum* Roscoe	Plai Lueang	DD		Introduced	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	MD	RZ	6–9	Not seen	KS0067
68.	*Zingiber pyroglossum* Triboun & K.Larsen	Khing Kratai Yai	LC	EN B2ab(ii,iv,v)	Native	-	-	-	-	CT	BT	-	-	-	-	-	-	BT	-	-	-	-	-	CT, DEF	FD, MD	RT, RZ, IF	7–9	Not seen	KS0068
69	* *Zingiber zerumbet* (L.) Roscoe ex Sm.	Kra Tue	DD	LC	Native	CT	CT	CT	CT	CT	BT	CT	CT	CT	BT	CT	CT	BT	BT	CT	BT	CT	CT	CT, MDF	FD, MD	RT, RZ, PS, LV, IF	6–10	Not seen	KS0069

Abbreviations: conservation status: data deficient (DD), least concern (LC), not evaluated (NE), and vulnerable (VU); distribution: both cultivated and wild (BT), cultivated (CT), and wild (WD); forest type: deciduous dipterocarp forest (DDF), dry evergreen forest (DEF), deciduous forest (DCF), evergreen forest (EGF), and mixed deciduous forest (MDF); utilization: food (FD), spice (SP), medicine (MD), commercial cultivation (CC), rituals and socio-religious activities (RB), ornamental (OT), cosmetics (CO), and no use (NA); used parts: roots (RT), rhizomes (RZ), pseudostems (PS), leaves (LV), inflorescences (IF), fruits/seeds (FS), and whole plants (WP). Notes: Newly recorded taxa in Kalasin Province are marked with an asterisk (*) preceding their scientific names, while the gray background color of the cell indicates that the species is not found in the wild in Kalasin Province.

2.8. Statistical Analysis

2.8.1. Jaccard's Similarity Index (JI)

Jaccard's Similarity Index (JI) [22] was used to assess species composition similarity across eighteen districts, calculated as follows:

$$JI = \frac{a}{a + b + c} \quad (1)$$

where "a" represents the number of species common to both districts, "b" refers to species found only in the first district, and "c" represents species found solely in the second district [23]. By applying this index, we quantified species diversity, enabling an objective comparison of ecological compositions across the districts. This metric provided valuable insights into the level of similarity or differences in species presence, thereby enhancing our understanding of biodiversity patterns in the study area.

Additionally, the unweighted pair group method with arithmetic mean (UPGMA) was employed to analyze species diversity similarity between the districts. The Jaccard Similarity Index was used to quantify the shared species between each district pair, and the resulting similarity matrix served as the input for the UPGMA algorithm. Clustering and dendrogram construction were performed using the Past4 software. The dendrogram generated through this method visually illustrates the hierarchical clustering of districts based on their species compositions, offering insights into their ecological relationships and identifying clusters with similar biodiversity profiles.

2.8.2. Economic Value of Zingiberaceae in Kalasin Province

The economic value of Zingiberaceae (EVZ) evaluation was designed with a focus on the local economy, aiming to explore the relationship between vendors of Zingiberaceae and their customers within the study area. This approach allowed the incorporation of quantitative research methods, supported by botanical expertise, to accurately identify the scientific names of commonly traded commercial plants in Kalasin Province.

The study participants included both plant sellers and consumers (or buyers). The research targeted a selection of plants that were actively exchanged in the market. Data on the prices of these plants were collected every four months over the course of one year (October 2023 to September 2024). The EVZ assessment involved calculating the average price that consumers were willing to pay for each plant species, which was determined by averaging the highest and lowest prices. The following formula was used:

$$EVZ = AP \times SM \times SP \quad (2)$$

AP: average price of the commercial plant in Thai baht per kilograms (THB/kg); SM: total quantity of commercial plants sold per month by traders (in kilograms); SP: total number of months the plants are sold throughout the year.

Thus, the EVZ quantifies the total annual value of commercial plants traded. In essence, the EVZ reflects the annual income earned by traders from selling each species of commercial plant [24]. For plants sold for ornamental purposes, the economic value of the whole plant was calculated according to Saensouk et al. [25], using the following formula:

$$\text{Annual Economic Value} = Np \times Pp \quad (3)$$

Np = number of pots sold per year, and Pp = average price per pot.

3. Results

3.1. Diversity of Zingiberaceae in Kalasin Province

The Zingiberaceae family in Kalasin Province exhibits remarkable species diversity, with a total of sixty-nine taxa (Table 1) classified into two subfamilies: Alpinioideae and Zingiberoideae. These subfamilies are divided into three tribes (Figure 2), which together encompass eleven genera. The tribe Alpinieae includes fourteen species across five genera, with the genus *Alpinia* exhibiting the greatest diversity, containing six species. This is followed by *Amomum* and *Wurfbainia*, each with three species, while *Etlingera and Meistera* each have one species. In the tribe Globbeae, there is only one genus, *Globba*, which includes seven species. The Zingibereae tribe shows the highest diversity in the genus *Curcuma* with 24 species, followed by *Zingiber* with 10 taxa, *Kaempferia* with nine species, *Boesenbergia* with four species, and *Hedychium* with one species (Figure 2). The keys to the genera and species are available in Tables S1 and S2, respectively.

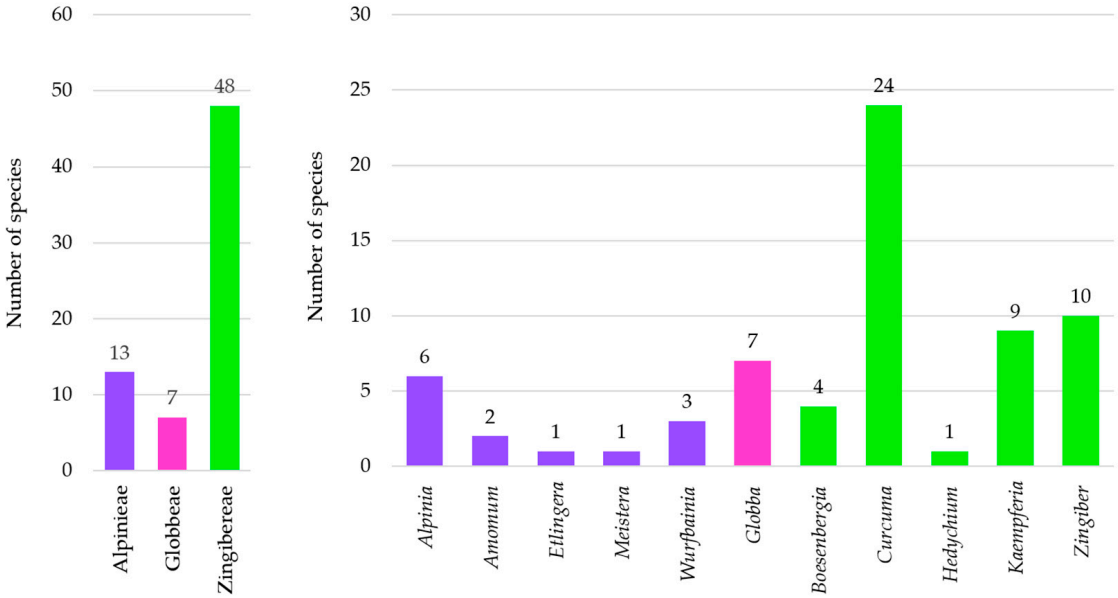

Figure 2. The Zingiberaceae plants in Kalasin Province, number of species grouped by tribe and genus, each represented by their respective colors.

Genera from the Zingiberaceae family in Kalasin Province exhibit varying numbers of taxa found in the wild: *Curcuma* has the highest representation (with six species); *Globba*, *Kaempferia*, and *Zingiber* (five taxa each); *Boesenbergia* (four species); *Alpinia* (three species); *Amomum* and *Wurfbainia* (two species each); and *Meistera* has one species in the wild. Notably, *Etlingera* and *Hedychium* do not have any species found in the wild (Figure 3).

The cultivation of species within the Zingiberaceae family in Kalasin Province varies significantly across genera. *Curcuma* is still the most widely cultivated genus, with 24 species; followed by *Zingiber* (10 taxa); *Kaempferia* (seven species); *Alpinia* and *Globba* (six species each); *Amomum* (three species); *Boesenbergia* and *Wurfbainia* (two species each); *Etlingera* and *Hedychium* (one species each); while *Meistera* has no species in cultivation (Figure 3).

The number of taxa found both in the wild and in cultivation varies across genera. *Curcuma* has the highest number of taxa (with six species found in both habitats), followed by *Zingiber* (five), *Globba* (four), *Alpinia* and *Kaempferia* (three species each), *Amomum* and *Boesenbergia* (two species each), and *Wurfbainia* with one species, while *Etlingera*, *Hedychium*, and *Meistera* are not found in either situation (Figure 3).

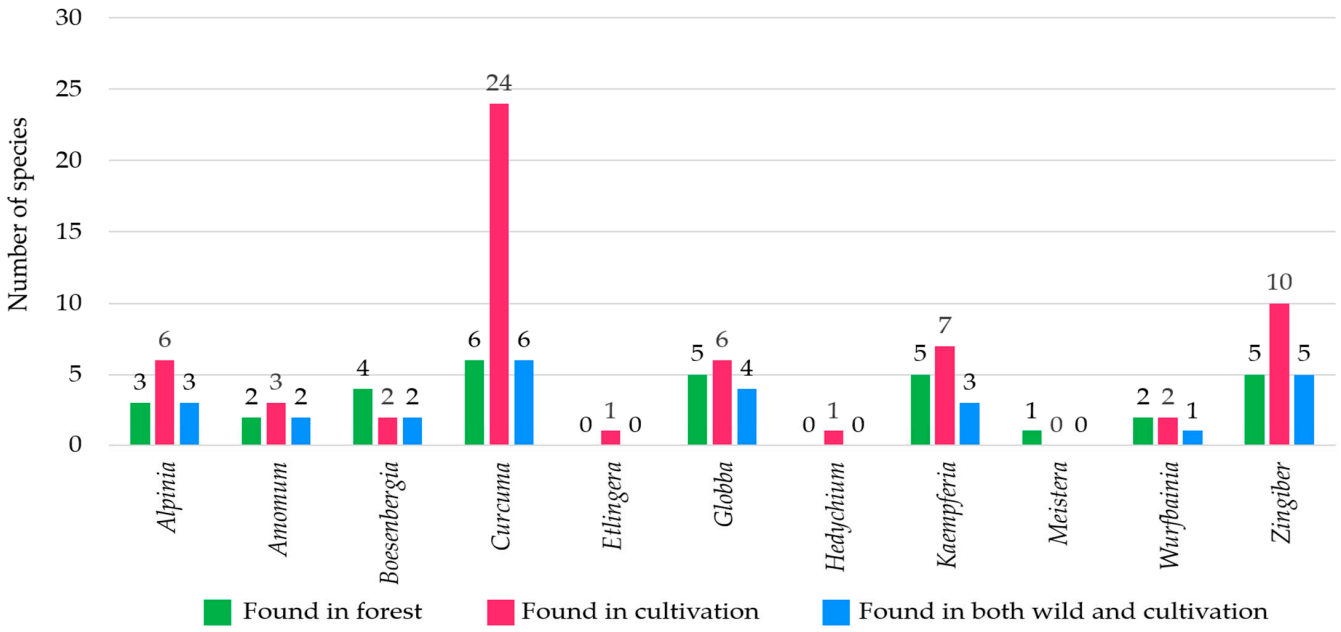

Figure 3. Diversity of Zingiberaceae species in Kalasin Province, with number of taxa found in the forest (green bars), found in cultivation (pink bars), and taxa found in both wild and cultivation (blue bars), categorized by genus.

3.2. Distribution of Zingiberaceae in Kalasin Province

In a comprehensive survey of Kalasin Province, a total of 69 taxa were recorded. (Table 1). Of these, 7 taxa were found only in natural habitats, while 36 taxa were identified only in cultivated areas. Additionally, 26 taxa were found in both types of habitats. Notably, seven species were exclusively found in the wild and not in cultivation, including *Boesenbergia isanensis*, *B. xiphostachya*, *Globba rosea*, *Kaempferia sakolchaii*, *K. sakonensis*, *Meistera chinensis*, and *Wurfbainia villosa* (Table 1). Twenty-five wild taxa are newly recorded in Kalasin Province and are marked with an asterisk before their scientific names in Table 1, Among these, six wild species are endemic to Thailand: *Boesenbergia isanensis, Curcuma rubroaurantiaca, Globba conferta, Kaempferia sakolchaii, K. sakonensis,* and *Zingiber pyroglossum*.

Somdet district has the highest species diversity, recording 59 taxa in total (Table 2). This includes 9 wild taxa, 27 cultivated taxa, and 23 taxa found in both wild and cultivated settings. Khao Wong follows with 50 taxa, comprising 4 wild taxa, 30 cultivated taxa, and 16 taxa shared between the two environments. Kuchinarai has a high taxa diversity, with forty-eight taxa: five wild, forty-one cultivated, and two in both habitats.

3.3. Ecological Habitats of Zingiberaceae Plants in Kalasin Province

Wild Zingiberaceae plants in Kalasin Province are found across different forest types. Dry evergreen forest (DEF) contains 12 taxa; deciduous forest (DCF) has 11 taxa; mixed deciduous forest (MDF) has 10 taxa; evergreen forest (EGF) has 5 taxa; and deciduous dipterocarp forest (DDF) has 3 taxa, while 62 taxa are found in cultivation (Table 1).

The dendrogram (Figure 4) illustrates the similarity patterns among Zingiberaceae species across different forest types in Kalasin Province. The first major branch corresponds to the deciduous dipterocarp forest, which is characterized by a unique species composition, clearly distinguishing it from the other forest types. Following this, the evergreen forest forms a separate branch, highlighting its distinct ecological traits that set it apart from the remaining forest types. This pattern of clustering emphasizes the variation in species distribution linked to the ecological characteristics of each forest type in the region. The deciduous forest forms a distinct cluster, indicating a unique species composition that

separates it from both the deciduous dipterocarp and evergreen forests. Interestingly, the mixed deciduous and dry evergreen forests are grouped together in a close cluster, suggesting a high degree of similarity in their species diversity. This clustering pattern highlights the ecological affinities between these two forest types, reflecting their shared environmental characteristics and similar Zingiberaceae species distributions.

Table 2. Species diversity in each district of Kalasin Province, grouped by taxa found only in the wild, only in cultivation, both in the wild and in cultivation, total wild taxa, total cultivated taxa, and total taxa diversity.

Districts	Only in the Wild Taxa	Only in Cultivation Taxa	Both Wild and Cultivation Taxa	Total Wild Taxa	Total Cultivation Taxa	Total Taxa Diversity
Somdet	9	27	23	32	50	59
Khao Wong	4	30	16	20	46	50
Kuchinarai	5	41	2	7	43	48
Mueang Kalasin	1	45	1	2	46	47
Kham Muang	1	21	4	5	25	26
Na Khu	1	15	4	5	19	20
Huai Phueng	2	17	1	3	18	20
Yang Talat	2	38	1	3	39	41
Kamalasai	2	37	0	2	37	39
Sahatsakhan	1	24	0	1	24	25
Huai Mek	1	22	0	1	22	23
Tha Khantho	1	20	0	1	20	21
Na Mon	1	17	1	2	18	19
Don Chan	1	18	0	1	18	19
Khong Chai	1	18	0	1	18	19
Nong Kung Si	1	18	0	1	18	19
Rong Kham	1	18	0	1	18	19
Sam Chai	1	18	0	1	18	19

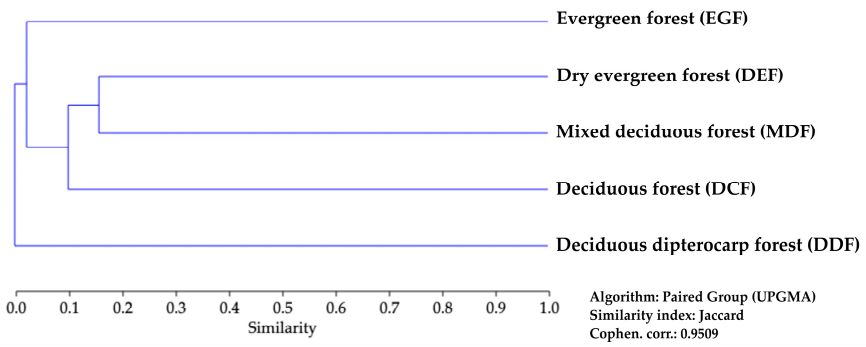

Figure 4. A dendrogram from UPGMA cluster analysis showing the distribution of Zingiberaceae species across different forest types in Kalasin Province.

This clustering pattern suggests a shared ecological context or environmental factors that promote the growth of similar species in both mixed deciduous and dry evergreen forests. The Zingiberaceae plants in these forests may have adapted to similar microenvironments, contributing to a common set of species that are suited well for comparable ecological conditions. Biogeographical factors, such as geographical proximity or historical influences, may also play a role in shaping the observed Zingiberaceae species diversity among these forest types. It is possible that plants with similar adaptations have dispersed or evolved over time, leading to their presence in these areas.

Additionally, if plants from the Zingiberaceae family in these forests utilize similar seed dispersal methods, this could help explain the convergence of species across various forest types. Beyond their natural habitats, a notable number of Zingiberaceae taxa—62 in total—are not found in the wild but are cultivated instead. These cultivated species are commonly grown and maintained in home gardens, residential areas, temples, and shops for various uses. This cultivation contributes to their distribution in the region. Species like *Alpinia galanga*, *A. siamensis*, *Boesenbergia rotunda*, *Curcuma longa*, *C. singularis*, and *Zingiber officinale* are also grown on a larger scale for commercial purposes.

3.4. Phenology of Zingiberaceae Plants in Kalasin Province

The Zingiberaceae species identified in Kalasin Province exhibited their peak flowering period from June to August. In most cases across the three tribes, it was observed that the plants typically flowered after the maturation of their pseudostems. Another group of species flowered between February and May, often producing flowers before the emergence of their pseudostems. In the Zingiberaceae tribe, several taxa were noted to generate lateral inflorescences directly from the rhizome prior to the emergence of new shoots after the dormancy period. Examples include *Curcuma comosa*, *C. mangga*, *C. singularis*, and *Kaempferia rotunda*. Additionally, some species, such as *C. angustifolia*, produced both lateral and terminal inflorescences before and after the production of new pseudostems.

Furthermore, certain species from the Alpinieae tribe, which typically do not undergo dormancy during the dry season, were observed to produce inflorescences during this period. Species such as *Alpinia malaccensis*, *A. zerumbet*, and *Amomum foetidum* were among those observed. Additionally, species like *A. purpurata* were found to produce inflorescences and flowers year-round.

The survey identified 24 taxa from the Zingiberaceae family in Kalasin Province that produced fruits. Most of these taxa fruited between August and October, coinciding with the flowering period from May to August. Furthermore, fruiting was observed from April to June, corresponding with taxa that generally flowered from February to May (Figure 5).

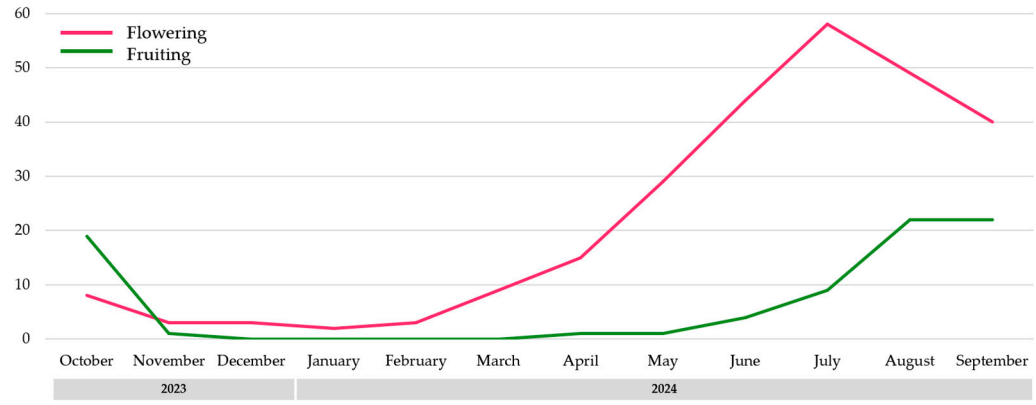

Figure 5. Phenological patterns of Zingiberaceae species in Kalasin Province.

3.5. Utilization of Zingiberaceae in Kalasin Province

A study in Kalasin Province recorded 69 taxa from 11 genera and 3 tribes within the Zingiberaceae family. Among these, 65 taxa had reported uses, categorized into seven groups: food, spices, ornamental purposes, commercial cultivation, cosmetic applications, ritual and socio-religious activities, and herbal medicine (Table 1). Meanwhile, four taxa (3.15%) from three genera had no reported uses: *Globba rosea*, *Kaempferia sakolchaii*, *K. sakonensis*, and *Meistera chinensis*.

The most prevalent uses were for herbal medicine, accounting for 36 taxa (28.35%), followed by ornamental purposes (30 taxa, 23.62%), food (23 taxa, 18.11%), rituals and socio-religious activities (13 taxa, 10.24%), commercial cultivation (11 taxa, 8.66%), spices (eight taxa, 6.30%), and cosmetic applications (two taxa, 1.57%).

The rhizomes and the whole plant were the most used plant parts, each representing 29.46% of the total, followed by the inflorescences that represented 15.50%, while leaves made up 9.30%. Pseudostems were utilized in 7.75% of cases, and roots were used in 5.43%. Fruit and seeds were the least commonly used, comprising only 3.10% (Figure 6).

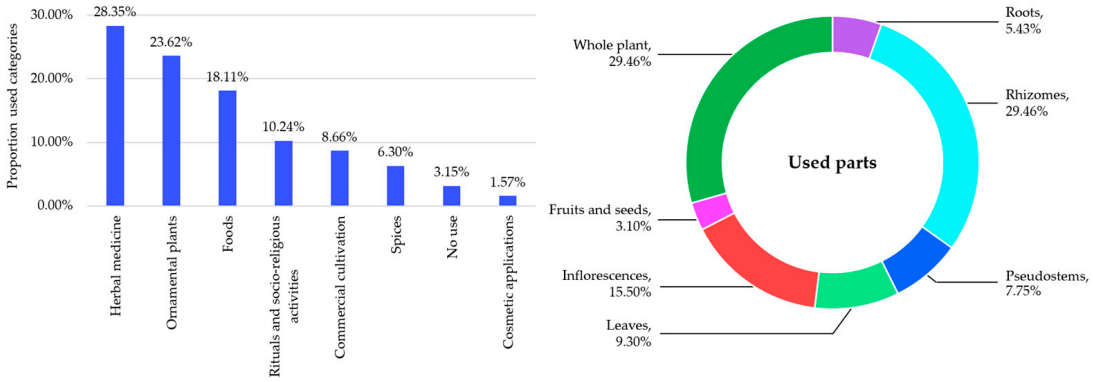

Figure 6. Proportion of utilization categories and used parts of Zingiberaceae taxa in Kalasin Province.

3.5.1. Utilized as Food

This study found 23 Zingiberaceae taxa used for culinary purposes (Figure 7). These belong to two tribes: Alpinieae (four taxa, three genera) and Zingibereae (19 taxa, four genera). No Globbeae species are used as food.

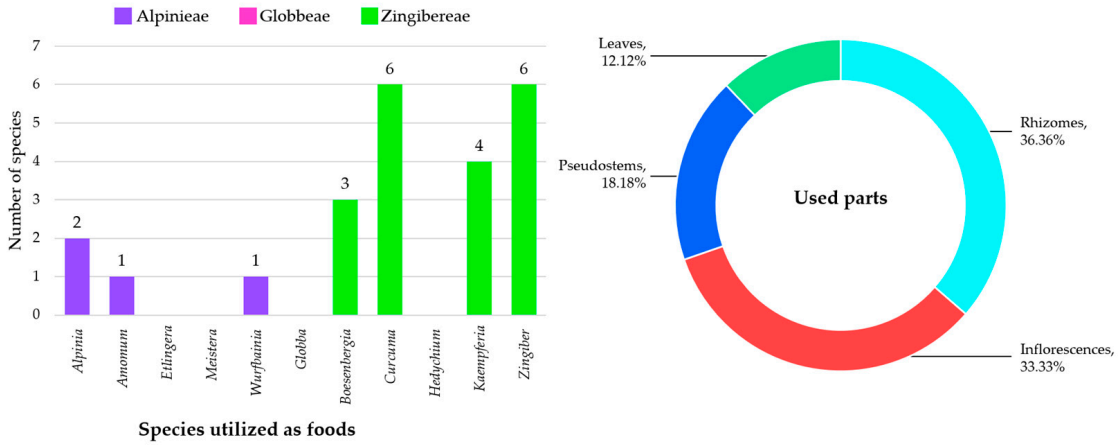

Figure 7. Species diversity grouped by genus, each represented by respective colors: purple = plants in Alpinieae tribe, pink = Globbeae tribe, and green = Zingibereae tribe, and the used parts of Zingiberaceae plants utilized as food in Kalasin Province.

In the tribe Alpinieae, *Alpinia* has two food-utilized taxa (*A. galanga* and *A. siamensis*), followed by *Amomum* (*A. repoeense*) and *Wurfbainia* (*W. villosa*). Within the tribe Zingibereae, food-use taxa include *Boesenbergia* (three taxa: *B. isanensis*, *B. rotunda*, *B. xiphostachya*), *Curcuma* (six taxa: *C. angustifolia*, *C. longa*, *C. mangga*, *C. nakhonphanomensis*, *C. parviflora*, *C. singularis*), *Kaempferia* (four taxa: *K. galanga*, *K. marginata*, *K. pulchra*, *K. rotunda*), and *Zingiber* (six taxa: *Z. junceum*, *Z. montanum*, *Z. officinale*, *Z. ottensii*, *Z. pyroglossum*, *Z. zerumbet*).

The primary parts utilized are the young rhizomes, which make up 36.36%, followed by the inflorescences at 33.33%. Young pseudostems are used at a rate of 18.18%, while the leaves contribute 12.12%. No reports indicate the use of roots, fruits, or seeds as food (Figure 7). For more detailed information on the use of each plant species, refer to Table S3.

In Kalasin Province, local people commonly cook the young leaves of *Kaempferia galanga*, *K. marginata*, *K. pulchra*, and *K. rotunda* in a variety of traditional dishes. These plants are often incorporated into foods, such as fried fish cakes, spicy salads, "Kaeng Om" (a type of Isaan spicy herbal soup), or eaten fresh with chili paste. Despite the differences in plant species, the method of preparation and consumption remains similar for all four taxa, with the young leaves typically being chopped and used to add flavor and aroma to these dishes. This shared approach highlights the importance of these plants in the local culinary practices. The rhizome of *Zingiber officinale*, commonly known as ginger, is widely used in Isaan cuisine, particularly in its pickled form. Pickled ginger is often served alongside Isaan sausage or pickled sausage. Additionally, ginger is commonly prepared as a refreshing beverage, often brewed into a tea or mixed with sugar and other ingredients to create a sweet and spicy drink. In the villages of Kalasin Province, residents often grow a variety of aromatic plants in their kitchen gardens, such as *Alpinia galanga*, *A. siamensis*, *Boesenbergia rotunda*, *Curcuma longa*, *C. mangga*, *Zingiber montanum*, *Z. officinale*, *Z. ottensii*, and *Z. zerumbet*.

3.5.2. Utilized as Spices

The analysis of species usage across tribes and genera identified eight taxa from two tribes and six genera. In the tribe Alpinieae, *Alpinia* (*A. galanga* and *A. siamensis*), *Amomum* (*A. foetidum*), and *Wurfbainia* (*W. vera*) were utilized. The tribe Zingibereae contributed four taxa: *Curcuma* (*C. eburnea* and *C. longa*), *Boesenbergia* (*B. rotunda*), and *Zingiber* (*Z. officinale*). No species from the tribe Globbeae were used as spices (Figure 8).

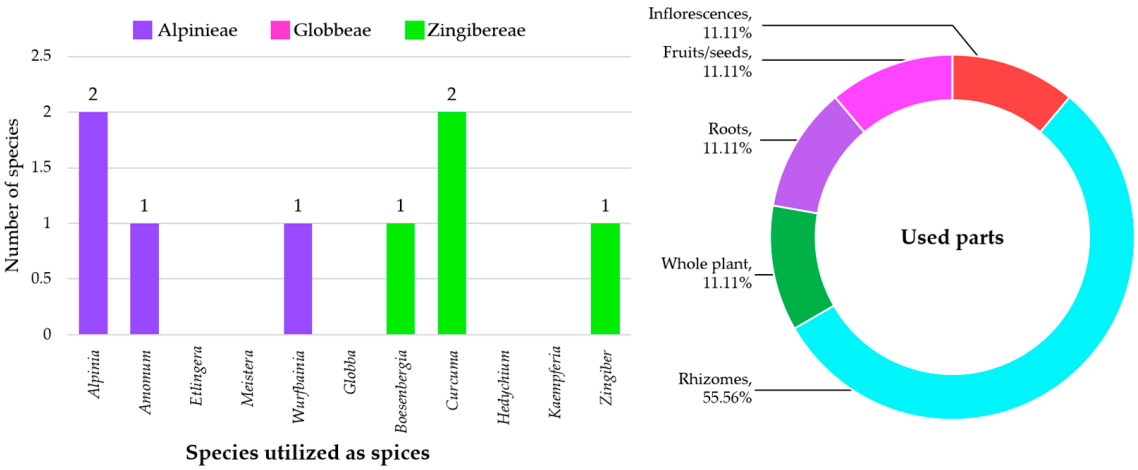

Figure 8. Species diversity grouped by genus, each represented by respective colors: purple = plants in Alpinieae tribe, pink = Globbeae tribe, and green = Zingibereae tribe, and used parts of Zingiberaceae plants utilized as spices in Kalasin Province.

In Kalasin Province, the rhizomes of Zingiberaceae plants are the most frequently used part for spicing, comprising 55.56% of the total usage. Inflorescences, roots, seeds, and whole plants each account for 11.11% (Table S4, Figure 8). There is no reported use of pseudostems, leaves, or flowers. These plants are commonly grown in local gardens due to their popularity in cooking, especially as spices, and are also sold in nearby markets.

3.5.3. Utilized for Ornamental Purposes

The Zingiberaceae family of plants is renowned for its striking appearance, which adds to the allure of tropical landscapes and gardens throughout Kalasin Province. Their vivid colors, distinct leaf patterns, and unique floral arrangements play a major role in enhancing the beauty of their surroundings. These plants are commonly displayed in pots and can be found in home gardens, temples, resorts, hotels, educational institutions, and popular tourist spots, especially during the rainy season, drawing the attention of both locals and visitors. A total of 30 taxa from three tribes are utilized as ornamental plants. This includes five species from the Alpinieae tribe, represented by four species of *Alpinia*: *A. malaccensis*, *A. purpurata*, *A. vittata*, and *A. zerumbet*, as well as one species of *Etlingera* (*E. elatior*). Furthermore, six species from the Globbeae tribe are included: *Globba conferta*, *G. hilaris*, *G. schomburgkii*, *G. siamensis*, *G. thorelii*, and *G. williamsiana*.

The remaining 19 taxa are classified under the Zingibereae tribe, consisting of 13 species of *Curcuma*, namely *C. borealis*, *C. nakhonphanomensis*, *C. peninsularis*, *C. peramoena*, *C. petiolata*, *C. rhabdota*, *C. rosea*, *C. roseobracteata*, *C. rubescens*, *C. rubroaurantiaca*, *C. rubrobracteata*, *C. suphanensis*, and *C. thorelii*; three species of *Kaempferia*: *K. elegans*, *K. pulchra*, and *K. siamensis*; two taxa of *Zingiber*: *Z. corallinum* and *Z. parishii* subsp. *phuphanense*; and one taxon of *Hedychium* (*H. coronarium*). All of these plants are cultivated for ornamental purposes, meaning that 100% of the whole plant is used (Figure 9).

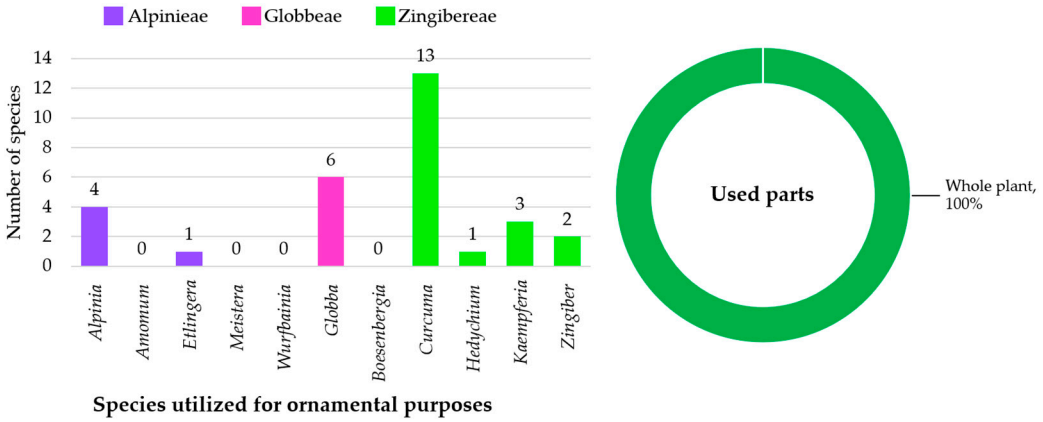

Figure 9. Species diversity grouped by genus, each represented by respective colors: purple = plants in Alpinieae tribe, pink = Globbeae tribe, and green = Zingibereae tribe, and used parts of Zingiberaceae plants utilized for ornamental purposes in Kalasin Province.

3.5.4. Utilized for Commercial Cultivation

In Kalasin Province, it was found that local villagers grow various species of Zingiberaceae, primarily for commercial purposes alongside personal use. These plants belong to two tribes: Alpinieae and Zingibereae. The Alpinieae tribe consists of three species, all of which belong to the genus *Alpinia*, including *A. galanga*, *A. purpurata*, and *A. siamensis*. Meanwhile, the Zingibereae tribe includes eight taxa, with five species from *Curcuma*, and each of *Boesenbergia*, *Hedychium*, and *Zingiber* with one taxon (Figure 10).

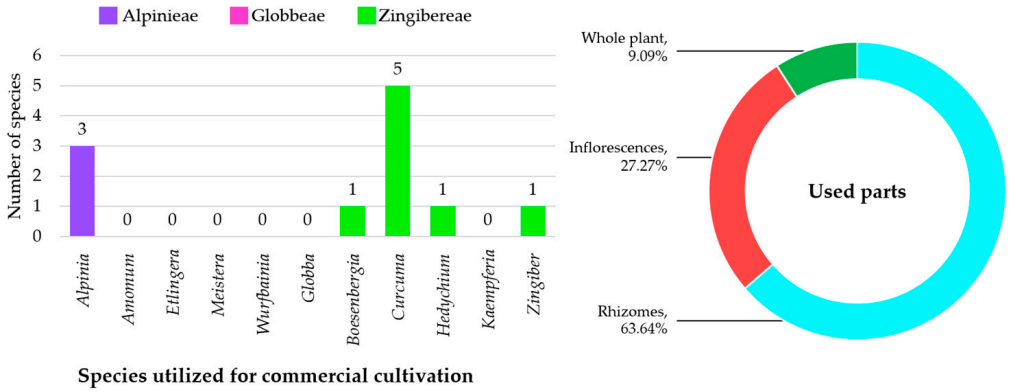

Figure 10. Species diversity grouped by genus, each represented by respective colors: purple = plants in Alpinieae tribe, pink = Globbeae tribe, and green = Zingibereae tribe, and used parts of trades of Zingiberaceae plants utilized for commercial cultivation in Kalasin Province.

The rhizome is the most commonly sold part, representing 63.64% of total sales, while the inflorescences account for 27.27%, and whole plants make up 9.09% (Figure 10). The plants cultivated for their rhizomes include *Alpinia galanga*, *A. siamensis*, *Boesenbergia rotunda*, *Curcuma comosa*, *C. longa*, *C. phrayawan*, and *Zingiber officinale*, while those grown for their inflorescences include *Curcuma angustifolia*, *C. singularis*, and *Hedychium coronarium*. Whole plants are primarily sold for ornamental purposes or whole plant use and are mostly limited to species like *Alpinia purpurata*.

3.5.5. Utilized as Cosmetics

Only two species from the genus *Curcuma* (tribe Zingibereae), *Curcuma comosa* and *C. longa*, were found to be utilized for cosmetic purposes, while no species from the tribes Alpinieae and Globbeae were reported for such use. For the taxa listed, only the rhizomes are employed in cosmetic applications, accounting for the entire 100% of the plant material used (Figure 11). The extracts derived from the rhizomes of both plants are utilized as key ingredients in various cosmetic products, such as liquid soaps, body lotions, and skincare formulations. *Curcuma longa* is widely recognized for its skin-nourishing properties, its ability to delay signs of aging, and its effectiveness in reducing wrinkles. To use, fresh rhizome is peeled, finely ground, and mixed with *Tamarindus indica* L., creating a scrub that can be applied to the skin.

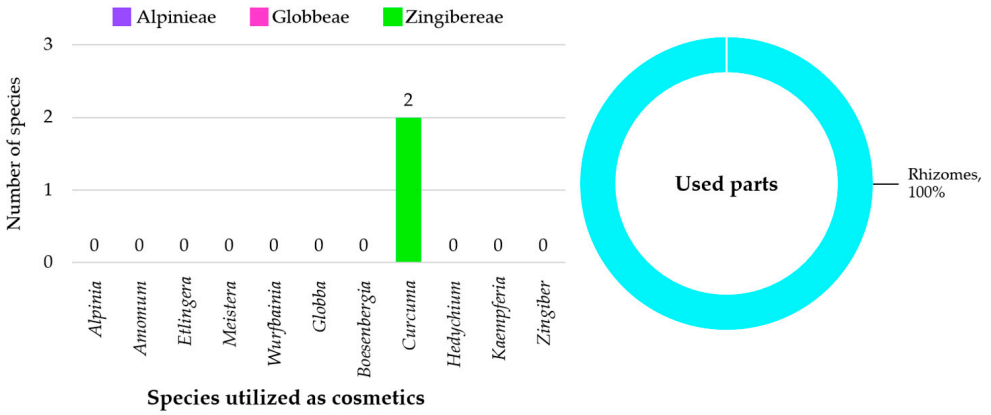

Figure 11. Species diversity grouped by genus, each represented by respective colors: purple = plants in Alpinieae tribe, pink = Globbeae tribe, and green = Zingibereae tribe, and used parts of Zingiberaceae plants utilized as cosmetics in Kalasin Province.

3.5.6. Utilized in Rituals and Socio-Religious Activities

In addition to their practical uses, several Zingiberaceae taxa play an important role in rituals and socio-religious activities, with 13 species from six genera across three tribes: Alpinieae, Globbeae, and Zingibereae.

The study recorded one *Amomum* species (Alpinieae), three *Globba* species (Globbeae), and nine Zingibereae species, including *Boesenbergia* (one), *Curcuma* (three), *Hedychium* (one), and *Kaempferia* (three). The entire plant is the most frequently used part, comprising 76.92% of the total, while the inflorescences are utilized in 23.71% of cases (Figure 12).

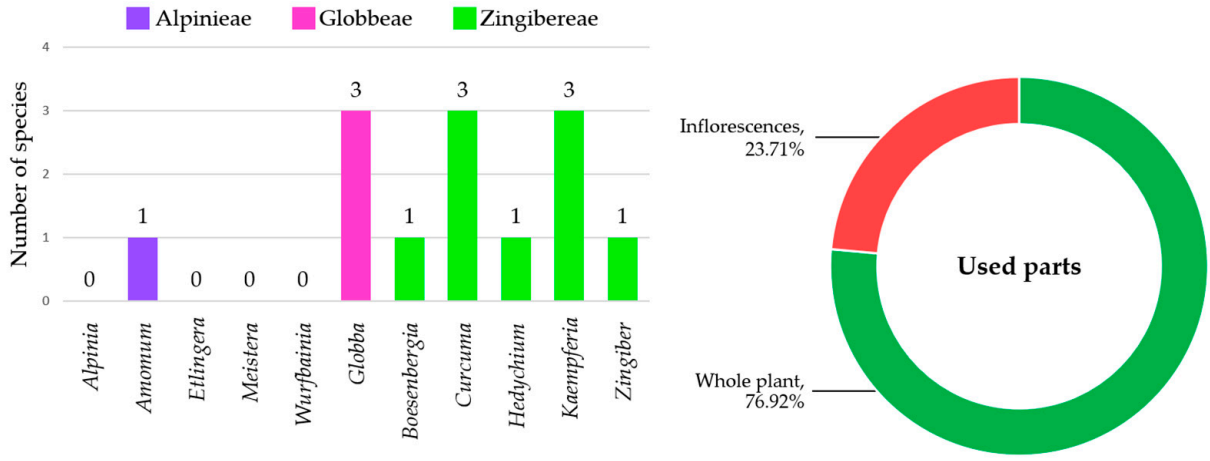

Figure 12. Species diversity grouped by genus, each represented by respective colors: purple = plants in Alpinieae tribe, pink = Globbeae tribe, and green = Zingibereae tribe, and used parts of Zingiberaceae plants utilized in rituals and socio-religious activities in Kalasin Province.

The villagers hold the belief that *Boesenbergia thorelii*, *Curcuma phrayawan*, *Kaempferia elegans*, and *Zingiber montanum* considered sacred herbs, possess protective powers. When planted in the home, these plants are said to guard against black magic. If an individual with malicious intentions enters the house, their mind will be changed. These plants are believed to have the ability to dispel evil spirits, prevent accidents, and protect against violent deaths. *Boesenbergia thorelii* is locally known as "Wan Phet Klab," which signifies that carrying it will ensure a safe return home, no matter where one goes.

Some plants are believed to be cultivated to enhance kindness and popularity for their grower, bringing good fortune and protection from harm. These plants include *Curcuma nakhonphanomensis*, *C. petiolata*, *Kaempferia galanga*, and *K. rotunda*. *Hedychium coronarium* is regarded as a captivating plant, often used to attract the attention of those we admire. It is also planted for religious purposes, such as honoring the Buddha and the gods, and is believed to bring good fortune. When grown in the home, it is considered highly auspicious. In ancient traditions of the northeast, there were customs prohibiting the planting of the flower near a daughter's bedroom or forbidding young girls from wearing the flower, as it was thought to provoke sexual attraction. Plants frequently used in Buddhist religious ceremonies include *Globba conferta*, *G. hilaris*, and *G. siamensis*.

3.5.7. Utilized as Herbal Medicine

In Kalasin Province, a total of 36 taxa from the Zingiberaceae family are utilized in traditional herbal medicine to address a variety of ailments. Of these, eight species belong to the Alpinieae tribe, including five species of *Alpinia* and three species of *Wurfbainia*. The Globbeae tribe contributes two species from the *Globba* genus. Most of the taxa, twenty-six in total, are found in the Zingibereae tribe, comprising three taxa of *Boesenbergia*,

eight taxa of *Curcuma*, and one taxon of *Hedychium*, while *Kaempferia* and *Zingiber* each comprise seven taxa. These species are an integral part of the local pharmacopoeia, highlighting the extensive use of Zingiberaceae plants in regional medicinal practices. Rhizomes are the most commonly used plant part in medicinal applications, accounting for 49.28% of the total reported usage. Leaves follow, making up 14.49%, while flowers represent 11.59%, pseudostems 10.14%, roots 8.70%, and fruits 5.80%. Notably, there are no reports on the use of whole plants in herbal medicine (Figure 13).

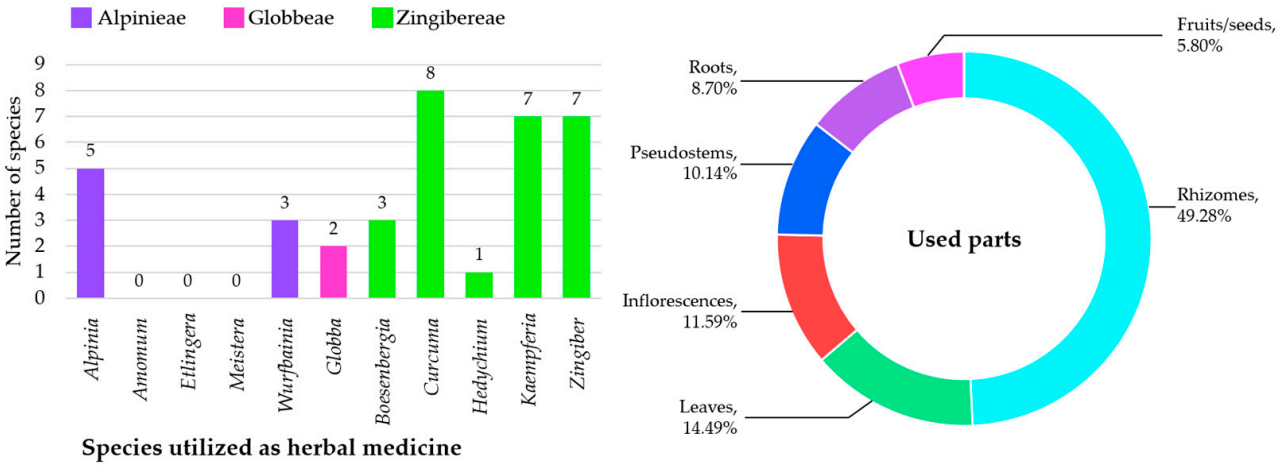

Figure 13. Species diversity grouped by genus, each represented by respective colors: purple = plants in Alpinieae tribe, pink = Globbeae tribe, and green = Zingibereae tribe, and used parts of Zingiberaceae plants utilized as herbal medicine in Kalasin Province.

In Kalasin Province, Zingiberaceae plants are widely used as herbal remedies to treat various symptoms. Out of the 36 taxa used for medicinal purposes, 83.33% are utilized for gastrointestinal conditions, followed by 47.22% for skin conditions and 38.89% for nutrition and blood health. Obstetric, gynecological, and urinary disorders are treated with 36.11%, while musculoskeletal and joint diseases, along with respiratory ailments, each account for 33.33%. Infections, parasites, and immune system issues involve 30.56%, and 27.78% of taxa are used for antipyretic treatments and poisoning. Cardiovascular and eye conditions each account for 11.11%, while reproductive and lymphatic system issues are treated with 5.56%. Finally, cancer treatment involves 2.78% of the medicinal taxa.

These plants are predominantly utilized for the treatment of various health conditions, with gastrointestinal disorders being the most common, accounting for 21.13% of their applications. Other frequent uses include addressing skin issues (11.97%), enhancing nutrition and supporting blood health (9.86%), as well as treating obstetric, gynecological, and urinary concerns (9.15%). Musculoskeletal and joint disorders, along with respiratory problems, represent 8.45% each, while conditions related to infections, parasites, and immune system disorders make up 7.75%. A similar proportion (7.04%) is dedicated to the management of antipyretics and poisoning or toxicological issues. Cardiovascular and eye-related conditions each comprise 2.82%, while reproductive and lymphatic system ailments are treated in 1.41% of cases. Cancer is the least represented condition, accounting for 0.70% (Figure 14, Table S5).

3.6. Economic Value of Zingiberaceae in Kalasin Province

The study identified 11 plant taxa (Table 3), primarily harvested for their rhizomes, inflorescences, or whole plant, with the rhizome being the most commonly traded part. Among the Zingiberaceae plants examined, *Boesenbergia rotunda* resulted in the highest average annual income, with traders earning 69,000 Thai Baht (THB) per year. This was

largely due to its higher price range of 100 to 150 THB per kilogram and a year-round trading period. *Curcuma comosa* followed with an average income of 44,400 THB per trader, benefiting from a similar trading period. *Zingiber officinale* also showed strong earnings, with traders making 36,000 THB annually, supported by its year-round availability.

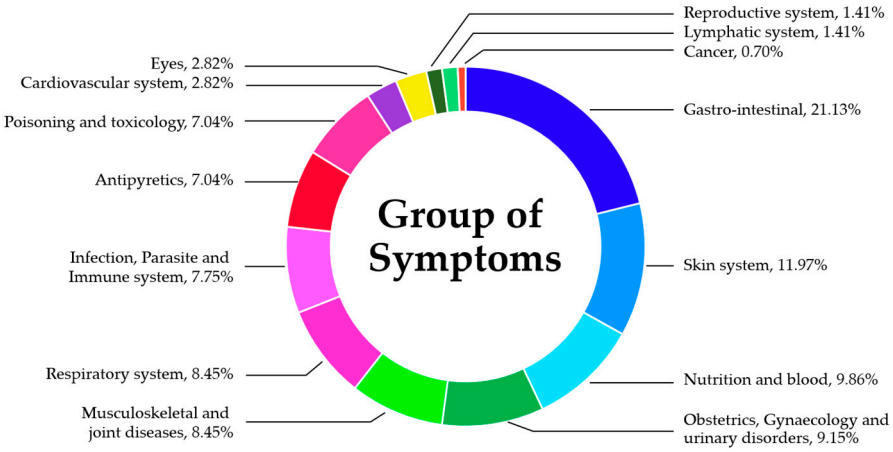

Figure 14. Percentages of symptom categories treated with Zingiberaceae plants as herbal remedies in Kalasin Province.

Table 3. List of Zingiberaceae plants used for commercial cultivation along with their price ranges, trading periods, and average annual income in Kalasin Province, Thailand.

Scientific Name	Used Parts for Trade	Price (THB/kg)		Trading Periods (Months)	Average Annual Income (THB/a Trader)
		Max	Min		
Alpinia galanga (L.) Willd.	Rhizomes	40	35	1–12	24,750
Alpinia purpurata (Vieill.) K.Schum.	Whole plants	150 *	100 *	1–12	37,500
Alpinia siamensis K.Schum.	Rhizomes	40	35	1–12	24,300
Boesenbergia rotunda (L.) Mansf.	Rhizomes	150	100	1–12	69,000
Curcuma angustifolia Roxb.	Inflorescences	100	60	6–10	14,400
Curcuma comosa Roxb.	Rhizomes	190	180	1–12	44,400
Curcuma longa L.	Rhizomes	60	50	1–12	34,320
Curcuma phrayawan Boonma & Saensouk	Rhizomes	150	140	1–12	26,100
Curcuma singularis Gagnep.	Inflorescences	200	100	4–6	22,500
Hedychium coronarium J.Koenig	Inflorescences	70	50	6–12	12,600
Zingiber officinale Roscoe	Rhizomes	70	50	1–12	36,000

* The whole plant price is the price per pot.

Plants such as *Alpinia purpurata* (37,500 THB), *Curcuma longa* (34,320 THB), and *Alpinia siamensis* (24,300 THB) earned somewhat lower, but still significant, incomes. *Alpinia galanga* came in at 24,750 THB, while *Curcuma phrayawan* generated an income of 26,100 THB annually. On the lower end, *C. angustifolia* earned 14,400 THB, *C. singularis* brought in 22,500 THB, and *Hedychium coronarium* yielded 12,600 THB per trader each year (Table 3).

These results show that plants with higher price ranges and longer trading periods tend to bring in higher incomes. This insight can guide traders in focusing on more profitable taxa to maximize their earnings.

3.7. Conservation Status of Wild Zingiberaceae Taxa in Kalasin Province

The conservation status of 69 studied taxa of Zingiberaceae in Kalasin Province, based on the IUCN Red List website, reveals a diverse range of concerns. Thirteen taxa are classified as data deficient (DD), indicating insufficient information to assess their extinction

risk. Nine taxa are categorized as least concern (LC), suggesting they are widespread and not currently threatened. Forty-four species remain not evaluated (NE), highlighting the need for further research and assessment. Notably, one taxon is classified as vulnerable (VU), facing a high risk of extinction due to habitat loss, overharvesting, or climate change.

In addition, the conservation status of wild Zingiberaceae taxa found in natural habitats within Kalasin Province was assessed by the authors following the Guidelines for Using the IUCN Red List Categories and Criteria, Version 16 (March 2024) [20]. One taxon, *Globba conferta*, is proposed to be treated as critically endangered (CR) under criterion B2ab(ii,iv,v) Five species are proposed as endangered (EN); four species (*Boesenbergia isanensis*, *Kaempferia sakolchaii*, *K. sakonensis*, and *Zingiber pyroglossum*) are under criterion B2ab(ii,iv,v), while *Curcuma rubroaurantiaca* is proposed under criterion B2ab(ii,iv). Ten taxa are proposed as vulnerable (VU) under criterion B2ab(ii,iv,v): *Alpinia malaccensis*, *Boesenbergia thorelii*, *B. xiphostachya*, *Curcuma thorelii*, *Globba rosea*, *G. siamensis*, *Kaempferia rotunda*, *K. siamensis*, *Zingiber mekongense*, and *Z. parishii* subsp. *phuphanense*. Seventeen species are proposed as least concern (LC): *Alpinia galanga*, *A. siamensis*, *Amomum repoeense*, *A. trilobum*, *Boesenbergia rotunda*, *Curcuma angustifolia*, *C. campanulata*, *C. parviflora*, *C. singularis*, *Globba schomburgkii*, *G. thorelii*, *Kaempferia marginata*, *Meistera chinensis*, *Wurfbainia uliginosa*, *W. villosa*, *Zingiber junceum*, and *Z. zerumbet* (Table 1). These findings highlight the importance of continued research to address knowledge gaps and ensure that conservation efforts are effectively directed, particularly for taxa with insufficient data or critical conservation needs.

4. Discussion

The findings of this study underscore the remarkable diversity of the Zingiberaceae family in Kalasin Province, northeastern Thailand, emphasizing both its ecological significance and cultural relevance. The recorded presence of 69 taxa across 11 genera, distributed within the subfamilies Alpinioideae and Zingiberoideae and spanning the tribes Alpinieae, Globbeae, and Zingibereae, highlights the region as a key area for Zingiberaceae biodiversity. Notably, this study documents 25 wild taxa as newly recorded in Kalasin Province (marked with an asterisk preceding their scientific names in Table 1), a substantial increase from the eight species previously reported in the *Flora of Thailand* for this province [19]. This expansion of known distribution suggests that the Zingiberaceae flora in Kalasin has been historically under-documented, warranting further botanical surveys to assess the full extent of its diversity. The prominence of genera such as *Alpinia*, *Curcuma*, *Globba*, *Kaempferia*, and *Zingiber*, which hold significant economic and cultural value for local communities, further underscores the importance of continued research and conservation efforts in this area.

At the district level, significant variation in species richness was observed. Somdet District stands out with the highest diversity of Zingiberaceae taxa, hosting both wild and cultivated plants, indicating its ecological and agricultural importance. Khao Wong, Kuchinarai, and Mueang Kalasin Districts also reported high taxa counts, reflecting their favorable environmental conditions for Zingiberaceae plant growth. In contrast, districts such as Na Mon, Don Chan, Khong Chai, Nong Kung Si, Rong Kham, and Sam Chai exhibited lower taxa richness, suggesting less suitable conditions for either wild or cultivated plant diversity. This district-level species diversity underscores the influence of local environmental factors, such as soil, climate, and human activity, on the distribution of Zingiberaceae taxa. The findings provide a valuable basis for targeted conservation efforts and sustainable cultivation practices across different districts in Kalasin Province.

In the wild, *Curcuma* and *Zingiber* dominate, with several taxa found in natural forest environments. Notably, some genera, such as *Etlingera* and *Hedychium*, have highly specialized habitat preferences, with no species recorded in the wild of Kalasin Province. While

in cultivated environments, *Curcuma* continues to show the highest diversity, suggesting its broader horticultural appeal. Some genera, such as *Zingiber*, *Kaempferia*, and *Globba*, are well represented in both natural and cultivated habitats, illustrating their adaptability. The overlap of taxa across both habitats in districts like Somdet and Khao Wong further emphasizes the potential for cultivating wild species, which may offer insights into future conservation and agricultural practices in the region.

The ecological characteristics of different forest types in Kalasin Province play a crucial role in shaping the diversity and distribution of Zingiberaceae taxa. The distinct clustering patterns observed in the dendrogram (Figure 4) indicate that taxa composition is influenced by specific environmental conditions, such as soil moisture, light availability, and seasonal variability. The separation of deciduous dipterocarp and evergreen forests suggests that their unique ecological traits create selective pressures that favor different species assemblages. The close clustering of mixed deciduous and dry evergreen forests highlights their shared ecological conditions, which are likely to promote the growth of similar Zingiberaceae species. Additionally, biogeographical factors, such as historical species dispersal and habitat connectivity, contribute to the observed distribution patterns. Adaptations to microenvironments, along with similar seed dispersal strategies, may further influence species convergence across forest types. Beyond natural habitats, extensive cultivation of Zingiberaceae species in home gardens and commercial settings enhances their presence in the region, reflecting human influence on their distribution and accessibility.

Zingiberaceae taxa in Kalasin Province exhibited distinct flowering and fruiting patterns influenced by seasonal changes. Most taxa flowered from June to August after pseudostem maturation, while others, including *Curcuma* taxa, bloomed between February and May, often before pseudostem emergence. Some *Curcuma* and *Kaempferia* taxa produced lateral inflorescences from the rhizome post-dormancy. In contrast, Alpinieae species like *Alpinia malaccensis* and *A. zerumbet* flowered during the dry season, with *A. purpurata* blooming year-round. Fruiting occurred mainly from August to October, aligning with flowering peaks, while early flowering taxa fruited from April to June, in accordance with the previous studies in Thailand [26–28].

The Zingiberaceae family plays a crucial role in the lives of people in Kalasin Province, providing a diverse array of benefits. Our findings on utilization align with previous studies in Thailand [8,15–18,26–28], which emphasized the significant role of Zingiberaceae plants in herbal medicine, culinary applications (including spices), ornamental uses, commercial cultivation, cosmetics, and religious ceremonies. This research highlights the deep connection between local communities and their plant resources. Zingiberaceae species are not only vital to the region's economy but also central to its cultural and religious identity. To ensure the continued availability and significance of these plants, it is essential to promote sustainable cultivation and usage practices that protect their cultural and ecological value.

In contrast to findings from numerous other studies [5,29–33], our investigation in Kalasin Province identified no use of Zingiberaceae plants for fabric dyeing. Despite these differences, our study is consistent with the general trends observed in previous research on the diversity and utilization of Zingiberaceae plants [26–28]. It highlights the importance of advocating for sustainable practices, advancing conservation initiatives, and safeguarding local traditions and knowledge in each specific study region.

The conservation status derived from the IUCN Red List website and the assessment proposed by the authors exhibit notable differences, primarily due to data availability and localized field studies. The IUCN Red List includes a high number of not evaluated (NE) and data deficient (DD) taxa, reflecting gaps in global assessments, whereas the authors' evaluation, based on direct field observations and recent guidelines [21], provides a more comprehensive regional perspective. The proposal of several taxa as critically endangered

(CR), endangered (EN), and vulnerable (VU) underscores the urgency of conservation actions that may not yet be reflected in global assessments. This discrepancy highlights the need for regional evaluations to supplement global conservation frameworks, ensuring that overlooked taxa receive appropriate conservation attention based on their actual threats and habitat conditions.

The high economic value of certain Zingiberaceae species, such as *Boesenbergia rotunda*, *Curcuma comosa*, and *Zingiber officinale*, reflects their significant horticultural potential, driven by their desirable traits like year-round availability, consistent market demand, and versatile uses in culinary, medicinal, and ornamental sectors. Species that generate higher annual incomes tend to have prolonged trading periods, making them suitable for large-scale commercial cultivation and offering stability in income for traders. This economic success highlights the possibility of cultivating these species in controlled environments or through advanced horticultural techniques like tissue culture, providing opportunities for sustainable farming and contributing to the expansion of horticultural practices while meeting consumer needs.

The ecological and cultural importance of Zingiberaceae species in Kalasin Province goes far beyond their direct uses by local communities, as they play a critical role in supporting biodiversity and ecosystem health. These plants, which grow in the wild, are essential for the stability and proper functioning of their ecosystems, contributing to processes like nutrient cycling, soil preservation, and providing sustenance and shelter for other plant and animal species. Their presence in diverse habitats also strengthens the resilience of forest ecosystems, helping to mitigate the effects of environmental fluctuations [34–37]. Gaining a deeper understanding of the ecological contributions of Zingiberaceae taxa in Kalasin is crucial for developing effective conservation strategies, as safeguarding these plants involves not only protecting individual taxa but also preserving the broader ecosystems in which they thrive.

Beyond ecological factors, conserving Zingiberaceae taxa requires tackling the various threats from human activities, such as deforestation, habitat loss, and unsustainable harvesting practices [38–40]. Given that many taxa are commercially cultivated, the intensification of agricultural activities and land-use changes can threaten their wild counterparts and disturb their natural ecosystems [41–43].

This study and that one of Pisani et al. [44] highlight the importance of conservation, though from different perspectives. Pisani et al. focus on the economic valuation of protected areas. This study emphasizes the need for conservation beyond these regions through sustainable land use and community involvement. Incorporating other effective area-based conservation measures (OECMs), such as community-managed forests and sustainable agricultural landscapes, can enhance biodiversity protection in non-protected areas. Integrating these approaches will ensure that both protected and non-protected areas contribute to long-term sustainability.

5. Conclusions

This present study provides a comprehensive assessment of the species diversity, traditional uses, and economic importance of Zingiberaceae in Kalasin Province, northeastern Thailand. A total of 69 taxa across 11 genera were identified, with *Curcuma* showing the greatest diversity. These species occur in a variety of ecosystems, including deciduous dipterocarp forest, dry evergreen forest, deciduous forest, evergreen forest, mixed deciduous forest, and in cultivation. A total of 33 taxa were found in natural habitats, 62 taxa were found in cultivated habitats, and 26 taxa were found in both situations. Notably, twenty-five wild taxa represent new records for the province, and six taxa are endemic.

The study also highlights the traditional uses of Zingiberaceae, which encompass food, spices, medicine, ornamental plants, rituals, socio-religious activities, and cosmetics. Rhizomes are the most frequently utilized part of the plants. Economic contributions of Zingiberaceae are significant, with species such as *Boesenbergia rotunda* and *Curcuma comosa* being valuable commodities, actively traded for their rhizomes and other plant parts. The trade of these plants and their incorporation into local livelihoods emphasize their horticultural and economic importance.

Conservation assessments revealed that some taxa face significant threats, with *Globba conferta* proposed as critically endangered and several others categorized as endangered (five taxa), vulnerable (10 taxa), and least concern (17 taxa). These findings underscore the necessity for effective conservation strategies, focusing on balancing biodiversity preservation with the economic benefits derived from Zingiberaceae taxa.

This research highlights the exceptional species diversity and ecological value of Zingiberaceae in Kalasin, providing valuable insights into their distribution, traditional uses, and economic significance. The findings emphasize the need for sustainable cultivation practices, conservation efforts, and the preservation of cultural heritage to ensure the long-term sustainability of Zingiberaceae in the region. Targeted research and conservation strategies are crucial, particularly for under-researched and vulnerable taxa, to safeguard the future of these plants and their contributions to both ecological and economic well-being in Kalasin Province.

Supplementary Materials: The following supporting information can be downloaded at https://www.mdpi.com/article/10.3390/horticulturae11030247/s1: Table S1: Key to genera of Zingiberaceae plants in Kalasin Province.; Table S2: Key to species of Zingiberaceae plants in Kalasin Province.; Table S3: Species diversity and methods of utilizing Zingiberaceae plants as food in Kalasin Province.; Table S4: Diversity of Zingiberaceae species in Kalasin Province used as spices.; Table S5: Diversity of Zingiberaceae species in Kalasin Province used in cultural herbal medicine.

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