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Original Article

Diversity and uses of Zingiberaceae in Nam Nao National Park, Chaiyaphum and Phetchabun provinces, Thailand, with a new record for Thailand

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ABSTRACT

Three tribes, 12 genera and 38 species of the ginger family (Zingiberaceae) along five routes in Nam Nao National Park were surveyed between January 2012 and December 2013 to determine their diversity, ecological data, phenology, uses and conservation status. The highest diversity was found in the tribe Zingibereae (6 genera and 21 species), of which the genera *Curcuma* and *Zingiber* comprised the highest number species (eight species each). A species key was constructed based on morphology. The ginger family was found in four forest-types—deciduous dipterocarp forest, mixed deciduous forest, dry evergreen forest and pine forest. The most flowering bloom of the ginger family in Nam Nao National Park was during March to August and the most fruiting bloom was during June to September. The popular uses of Zingiberaceae were as a food, spice, in medicine, as ornamentation and in rituals. Eight species have been evaluated as of least concern and are presented in the IUCN Red List, while two rare species were reported in Thailand Red Data: Plants, while six rare Zingiberaceae species were identified based on the evaluation criteria of Saensouk (2011). Four species were endemic to Thailand. Moreover, *Etlingera yunnanensis* (T. L. Wu & S. J. Chen) R. M. Smith was a new record for Thailand.

Introduction

Species in the ginger family (Zingiberaceae) are well known in everyday life. Many species are used as spices, in food, cosmetics and dyes, and as ornamental plants. The Zingiberaceae family consists of herbaceous perennial plants that grow well in humid tropical and subtropical areas. The family is centrally distributed in Southeast Asia, from 0 to 2000 m above sea level. The dominant characteristic of the ginger family is the presence of essential oils in all parts of the plant, especially in the rhizomes and leaves. The family Zingiberaceae contains approximately 50 genera and 1500 species world wide. In Thailand, the Zingiberaceae contains approximately 30 genera and 300 species (Larsen and Larsen, 2006). Several Thai genera of the Zingiberaceae have been studied, namely *Kaempferia* (Sirirugsa, 1992), *Zingiber* (Triboun, 2006), *Amomum* (Kaewsri, 2006), *Curcuma* (Maknoi, 2006), *Alpinia* (Saensouk, 2006) and *Cornukaempferia* (Saensouk, 2008). In Thailand, a number of localities have been studied focusing on the Zingiberaceae, such as in Phu Phan National Park, Sakon Nakhon province (Saensouk and Chantaranothai, 2003), Thong Pha Phum Forest, Kanchanaburi province (Suvandech and Sookchaloem, 2007), Phu Phra Bat Historical Park, Udon Thani province (Saensouk et al., 2014) and Phu Laen Kha National Park, Chaiyaphum province (Khamtang et al., 2014). Nam Nao National Park is located in Lom Sak district, Nam Nao district, Phetchabun province and Chaiyaphum province and acts as a boundary between northeastern and northern Thailand. The National Park area is approximately 966 km^2, contains generally high mountains (about 700 m above sea level) and many forest types, streams and a variety of plants (http://www.dnp.go.th). However, there are no published reports of studies in the National Park on the ginger family. Therefore, this research aimed to study the diversity, conservation

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status and uses of the Zingiberaceae in Nam Nao National Park and to construct an identification key.

Materials and methods

Study site

Ginger specimens were collected from Nam Nao National Park, in Chaiyaphum and Phetchabun provinces, monthly during the two-year study from January 2012 to December 2013, along five separate routes (Fig. 1).

Route 1 consisted of a nature trail (approximately 5.8 km) behind the headquarters of the park comprising forest types such as dry evergreen forest, mixed deciduous forest and pine forest.

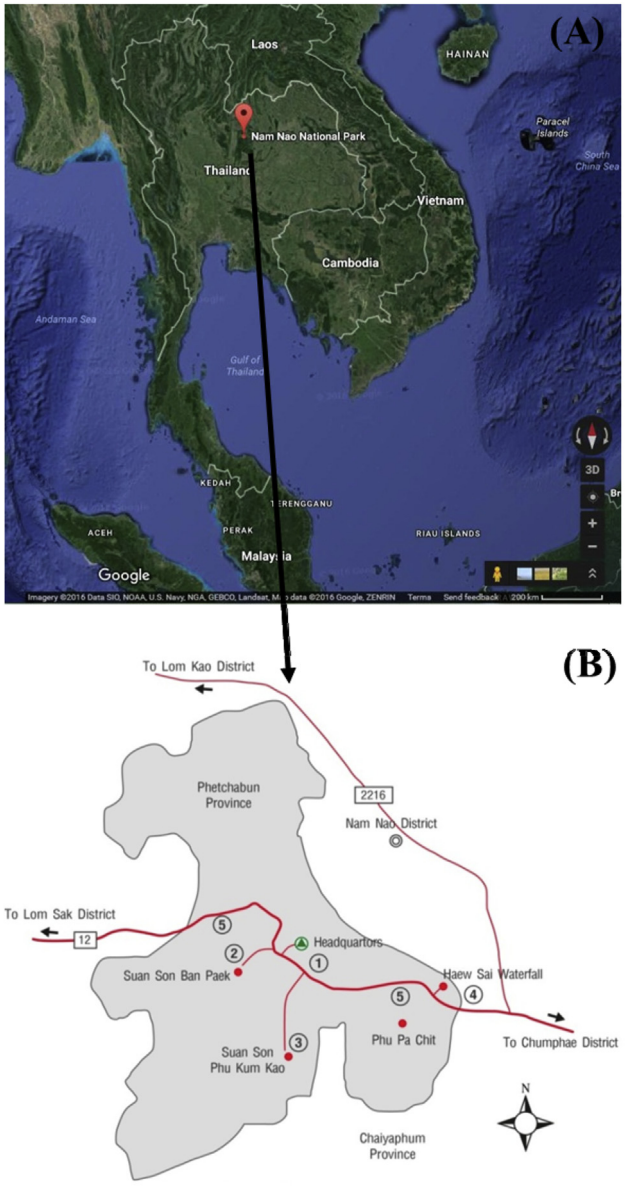

Fig. 1. General location and (A) and detail (B) of Nam Nao National Park with circled numbers showing the sampling routes.
(A) sourced: https://www.google.co.th/maps/place/, 27 October 2016 (Nam Nao National Park, 2016); **(B)** sourced: http://www.dnp.go.th/, 20 December 2015 (Nam Nao National Park, 2015).

Route 2 (Suan Son Ban Park) was approximately 5 km long comprising three forest types—deciduous dipterocarp forest, mixed deciduous forest and pine forest.
Route 3 went along the road to Suan Son Phu Kum Kao (approximately 14 km) comprising three forest types—deciduous dipterocarp forest, mixed deciduous forest and pine forest.
Route 4 (length approximately 700 m) at the Heaw Sai waterfalls comprised two forest types—deciduous dipterocarp forest and mixed deciduous forest.
Route 5 was along the roadside of highway No. 12 (approximately 30 km) and comprised three forest types—deciduous dipterocarp forest, mixed deciduous forest and pine forest.

Morphology and taxonomy

The dried plant specimens from many herbaria, including the Herbarium of the Department of National Parks, Wildlife and Plant Conservation (BKF), Bangkok Herbarium (BK), Chiang Mai University Herbarium (CMU), Queen Sirikit Botanical Gardens Herbarium (QBG), Prince of Songkla University Herbarium (PSU) and Khon Kaen University Herbarium (KKU) were checked for basic information such as correct species identification, ecological data, phenological data and notes on the dominant characters.

Important characteristics, such as the color of all the organs, ecological information and distribution data, were recorded. Specimens were collected as 3–5 pieces per specimen and then dried in an oven at 60 °C until completely dried. Flowers or other organs of some species were preserved in 70% alcohol. The specimens were collected and deposited as reference specimens in the Mahasarakham University Herbarium, Thailand. The morphology of the specimens was studied using a stereo microscope and the roots, rhizomes, pseudostems, leaves, inflorescence, flowers, fruit and seeds were described to verify taxonomy. Identification was based on morphological data and on references on the flora of Indo-China, British India, China and the Malay Peninsula monocotyledons and from scientific publications. A key to tribes, genera and species was constructed based on morphology. Utilization data of the Zingiberaceae was obtained through interviewing local villagers who were living in the Nam Nao National Park.

Conservation status evaluation

The conservation status of plants was based on the evaluation criteria of the IUCN Red List (IUCN Red List of Threatened Species, 2014), the Thailand Red Data: Plants (Santisuk et al., 2006) and the evaluation criteria of Saensouk (2011).

Results

Diversity of Zingiberaceae in Nam Nao National Park

Three tribes, 12 genera and 38 species of Zingiberaceae were collected from the five routes in Nam Nao National Park (Table 1 and Fig. 2). The tribe Alpinieae was comprised of four genera and 10 species—*Alpinia* (4 species), *Amomum* (4 species), *Elettariopsis* (1 species) and *Etlingera* (1 species). The tribe Zingibereae, with the highest diversity of Zingiberaceae species had 6 genera and 23 species—*Boesenbergia* (3 species), *Cornukaempferia* (2 species), *Curcuma* (8 species), *Kaempferia* (2 species), *Stahlianthus* (1 species) and *Zingiber* (7 species). The tribe Globbeae was represented by two genera and five species—*Gagnepainia* (2 species) and *Globba* (3 species) (Fig. 2).

Table 1
Diversity, ecological data, phenological data, uses and conservation status of Zingiberaceae in Nam Nao National Park.

Species (Collection number)	Vernacular name	Ecological data	Species status‡	Route	Phenology		Uses
					Flowering	Fruiting	
1. Tribe Alpinieae	Kha Kom	Dry evergreen forest	***	1	Mar–Apr	Jun–Jul	Young inflorescence as food
Alpinia blepharocalyx K. Schum. (Saensouk 600; MSU†)							
A. conchigera Griff. (Saensouk 601; MSU†)	Kha Ling	Dry evergreen forest		1,2	Jun–Jul	Jul–Sep	Young pseudostem, young inflorescence, rhizome as food; rhizome as spice
A. galanga (L.) Willd. (Saensouk 602; MSU†)	Kha Pha	Deciduous dipterocarp forest + mixed deciduous forest		2,3	Jun–Jul	Jul–Sep	Young pseudostem, young inflorescence, rhizome as food; rhizome as spice
A. malaccensis (Burm. f.) Rosc. (Saensouk 603; MSU)	Kha Kom	Dry evergreen forest		2,5	Mar–Apr	Jun–Jul	Young inflorescence as food
Amomum koenigii J.F. Gmel. (Saensouk 604; MSU†)	Reo Poung A-Ngoon	Dry evergreen forest	*	1	Mar–Apr	Jun–Jul	Fruit as a medicinal plant
A. schmidtii (K. Schum.) Gagnep. (Saensouk 605; MSU†)	Wan Sane Sao Long	Mixed deciduous forest + dry evergreen forest	*	1	Mar–Apr	Jun–Jul	All parts as powerful magic plant
A. cf. *villosum* var. *xanthioides* (Wall. ex Baker) T.L. Wu & S.J. Chen (Saensouk 606; MSU†)	Mak Naeng	Mixed deciduous forest + dry evergreen forest	*	1	Mar–Apr	Jun–Jul	Fruit as a medicinal plant
A. uliginosum J. Koenig (Saensouk 607; MSU†)	Mak Naeng	Dry evergreen forest	*	1	Mar–Apr	Jun–Jul	Fruit as a medicinal plant
Elettariopsis triloba (Gagnep.) Loes. (Saensouk 608; MSU†)	Reo Noo	Mixed deciduous forest	**	1,2	Mar–Apr	Jun–Jul	Not recorded
Etlingera yunnanensis (T.L. Wu & S.J. Chen) R.M. Sm. (Saensouk 609; MSU†)	Reo Yunan	Dry evergreen forest	****	1	Mar–Apr	Jun–Jul	Not recorded
2. Tribe Globbeae	Pet Na Tung	Mixed deciduous forest	***	1	May	Jun–Jul	Ornamental plant
Gagnepainia godefroyi (Baill) K. Schum (Saensouk 610; MSU†)							
G. thoreliana (Baill) K. Schum (Saensouk 611; MSU†)	Pet Na Tung	Mixed deciduous forest	***	4	May	Jun–Jul	Ornamental plant
Globba albiflora var. *albiflora* Ridl. (Saensouk 612; MSU†)	E-Tua	Mixed deciduous forest	*	4	May–Jun	Jun–Aug	Ornamental plant
G. laeta K. Larsen (Saensouk 613; MSU†)	Khing Kaeng/E-Tua	Mixed deciduous forest + dry evergreen forest	*/***	1,4	Jun–Jul	Jul–Sep	Ornamental plant
G. cf. *sherwoodiana* W.J. Kress & V. Gowda (Saensouk 614; MSU†)	Mung Korn Kao	Mixed deciduous forest		3	Jun–Jul	Jul–Sep	Ornamental plant
Tribe Zingibereae	Krachai Pha	Mixed deciduous forest		4	Jun–Jul	Jul–Sep	Not recorded
Boesenbergia collinsii J. Mood & L.M. Prince (Saensouk 615; MSU†)							
B. maxwellii J. Mood., L.M. Prince & Triboun (Saensouk 616; MSU†)	Krachai Pha	Mixed deciduous forest		2,4	Jun–Jul	Jul–Sep	Not recorded
B. rotunda (L.) Mansf. (Saensouk 617; MSU†)	Krachai Pha	Mixed deciduous forest	*	1,4,5	Jun–Jul	Jul–Sep	Rhizomes and roots as food and spice
Cornukaempferia aurantiflora J. Mood & K. Larsen (Saensouk 618; MSU†)	Wan Proa Tong	Mixed deciduous forest + dry evergreen forest	**/***/*****	1	May–Jun	Jun–Jul	Rhizomes as medicinal plant; leaf as ornamental plant
C. longipetiolata J. Mood & K. Larsen (Saensouk 619; MSU†)	Proa Kao Kan Bai Yao	Mixed deciduous forest + dry evergreen forest	***/*****	1	May–Jun	Jun–Jul	Rhizomes as medicinal plant; leaf as ornamental plant
Curcuma angustifolia Roxb. (Saensouk 620; MSU†)	Krajiew Daeng	Deciduous dipterocarp forest + pine forest		2,3,5	Mar–May and Jun–Jul	Apr–Jan and Jul–Aug	Young inflorescence as food
C. alismatifolia Gagnep. (Saensouk 621; MSU†)	Krajiew	Deciduous dipterocarp forest	*	3	Jun–Jul	Jul–Aug	Ornamental plant
C. cf. *comosa* Roxb. (Saensouk 622; MSU†)	Wan Chuk Mod Look	Dry evergreen forest		3	Jul	Not seen	Rhizomes as medicinal plant
C. gracillima Gagnep. (Saensouk 623; MSU†)	Krajiew Lek	Mixed deciduous forest	***	4	Jun–Jul	Not seen	Ornamental plant
C. longa L. (Saensouk 624; MSU†)	Kha Mint Pha	Dry evergreen forest		3	Jul	Not seen	Rhizomes as medicinal plant, cosmetic and spice
C. parviflora Wall. (Saensouk 625; MSU†)	Kra Jiew Kao	Mixed deciduous forest		1,2	Jun–Jul	Jul–Aug	Ornamental plant
C. singularis Gagnep. (Saensouk 626; MSU†)	Kra Jiew Kao			2,3	Mar–May	Apr–Jun	Young inflorescence as food

(*continued on next page*)

Table 1 (*continued*)

Species (Collection number)	Vernacular name	Ecological data	Species status[‡]	Route	Phenology		Uses
					Flowering	Fruiting	
		Deciduous dipterocarp forest + pine forest					
C. thorelii Gagnep. (Saensouk 627; MSU[†])	Krajiew Bua	Deciduous dipterocarp forest		2,3	Jun–Jul	Jul–Aug	Ornamental plant
Kaempferia rotunda L. (Saensouk 627; MSU[†])	Wan How Non	Mixed deciduous forest		4	Mar–May	May–Jun	Ornamental plant; rhizomes as medicinal plant
K. albomaculata (Saensouk 628; MSU[†])	Proa Pha	Mixed deciduous forest	*****	1,4	May–Jun	Jul–Aug	Ornamental plant; young leaves as a food
Stahlianthus involucratus (King ex Baker) Craib ex Loes. (Saensouk 629; MSU[†])	Wan Pet Noi	Deciduous dipterocarp forest		2	Apr–May	Jun–Aug	Rhizomes as medicinal plant
Zingiber chrysostachys Ridl. (Saensouk 630; MSU[†])	Khing Pha	Deciduous dipterocarp forest + pine forest		3	Jul–Aug	Aug–Sep	Not recorded
Z. mekongense Gagnep. (Saensouk 631; MSU[†])	Khing Pha	Deciduous dipterocarp forest + pine forest		3,5	Jul–Aug	Aug–Sep	Young fruit as a food
Z. montanum (J. König) Link ex A. Dietr. (Saensouk 632; MSU[†])	Plai	Deciduous dipterocarp forest + pine forest		3	Jul–Aug	Aug–Sep	Young inflorescence as a food
Z. pyroglassum Triboun & K. Larsen (Saensouk 635; MSU[†])	Khing Pha	Deciduous dipterocarp forest + pine forest		3	Jul–Aug	Aug–Sep	Young inflorescence as food
Z. rubens Roxb. (Saensouk 633; MSU[†])	Khing Pha	Deciduous dipterocarp forest + pine forest		3,5	Jul–Aug	Aug–Sep	Not recorded
Z. sadakornii Triboun & K. Larsen (Saensouk 636; MSU[†])	Khing Pha	Mixed deciduous forest	*****	5	Jul–Aug	Aug–Sep	Young inflorescence as food
Z. zerumbet (L.) Smith (Saensouk 634; MSU[†])	E-Tua	Mixed deciduous forest		4	Jul–Aug	Aug–Sep	Young inflorescence as a food

[†]MSU = Mahasarakham University Herbarium; [‡]* = least concern species, IUCN, ** = Thailand Red Data: Plants, *** = Saensouk (2011), **** = new record for Thailand, ***** = endemic to Thailand.

Species diversity

The Zingiberaceae in Nam Nao National Park collected from the five routes had the highest species diversity on Routes 1, 3 and 2, respectively (Fig. 2).

Route 1: had 15 species—*Alpinia blepharocalyx*, *Alpinia conchigera*, *Amomum schmidtii*, *Amomum* cf. *villosum* var. *xanthioides*, *Amomum uliginosum*, *Amomum koenigii*, *Elettariopsis triloba*, *Etlingera yunnanensis*, *Gagnepainia godefroyi*, *Gagnepainia thoreliana*, *Globba laeta*, *Boesenbergia rotunda*, *Cornukaempferia aurantiflora*, *Cornukaempferia longipetiolata*, *Curcuma parviflora* and *Kaempferia albomaculata* (Table 1).
Route 2: had 10 species—*A. conchigera*, *Alpinia galanga*, *Alpinia malaccensis*, *E. triloba*, *Boesenbergia maxwellii*, *Curcuma angustifolia*, *C. parviflora*, *Curcuma singularis*, *Curcuma thorelii* and *Stahlianthus involucratus* (Table 1).
Route 3: provided 13 species—*A. galanga*, *Globba* cf. *sherwoodiana*, *C. angustifolia*, *Curcuma alismatifolia*, *Curcuma longa*, *C. singularis*, *C. thorelii*, *Curcuma* cf. *comosa*, *Zingiber rubens*, *Zingiber mekongense*, *Zingiber montanum*, *Zingiber chrysostachys* and *Zingiber pyroglassum* (Table 1).
Route 4: had nine species—*Boesenbergia collinsii*, *B. maxwellii*, *B. rotunda*, *Curcuma gracillima*, *G. thoreliana*, *Globba albiflora* var. *albiflora*, *G. laeta*, *Kaempferia rotunda*, *K. albomaculata* and *Zingiber zerumbet* (Table 1).
Route 5: had six ginger species—*A. malaccensis*, *B. rotunda*, *C. angustifolia*, *Z. rubens*, *Z. mekongense* and *Zingiber sadakornii* (Table 1).

Many dominant characteristics of the Zingiberaceae were used for identification, such as rhizomes, organs of the pseudostem, inflorescence, bracteole, bract, fruit and the structure of flowers (corolla, lateral staminodes, labellum, filament, anther-crest and ovary). The key to the species is provided below:

Key to Zingiberaceae species in Nam Nao National Park

1. Filament long exerted; Ovary unilocular with parietal placentation	2
1. Filament not long exerted; Ovary 3-locular (very rarely unilocular) with central placentation	6
2. Labellum 3-lobed, central lobe very short with 2 gland-like, basal swellings; Flower greenish or whitish; no appendix at anther	3
2. Labellum 2-lobed; flower yellow, orange or white; appendix at anther	4
3. Lower leaf surface pubescent to sericeous, flowers greenish	*Gagnepainia godefroyi*
3. Lower leaf surface glabrous, flower whitish	*Gagnepainia thoreliana*
4. Bract absent; flower white	*Globba albiflora* var. *albiflora*
4. Bract present; flower yellow	5
5. Cincinnus exerted from one bract	*Globba* cf. *sherwoodiana*
5. Cincinnus not exerted from more than one bract	*Globba laeta*
6. Lateral staminodes reduced to small teeth at base of labellum or wanting, the plane of distichy of the leaves transverse to the rhizome	7
6. Lateral staminodes well developed, free from the	16

(*continued*)

labellum, the plane of distichy of the leaves parallel to the rhizome	
7. Inflorescence terminal on the leafy shoot	8
7. Inflorescence on a separate shoot at base of the leafy shoot	11
8. Bracteoles dry and brittle when mature	*Alpinia blepharocalyx*
8. Bracteoles fleshy and not brittle	9
9. Labellum red, longitudinally band, irregularly wrinkled surface at median part and callus-like at base	*Alpinia conchigera*
9. Labellum not as above	10
10. Flower one on cincinnus; inflorescence raceme-like	*Alpinia malaccensis*
10. Flower seven on cincinnus; inflorescence panicle-like	*Alpinia galanga*
11. Labellum and filament connate into a distinct tube above the insertion of the petals; anther crest absent, mostly leafy shoot more than 3 m	*Etlingera yunnanensis*
11. Labellum and filament not connate; anther usually crested, leafy shoot varying in height	12
12. Bracteole tube, Inflorescence lax, leafy shoots less than 1 m	13
12. Bracteole not above, Inflorescence dense, leafy shoots more than 1 m	*Elettariopsis triloba*
13. Fruit smooth	14
13. Fruit rough with soft spine	15
14. All parts glabrescent; fruit grapefruit-liked	*Amomum koenigii*
14. All parts pubescent; fruit not above	*Amomum schmidtii*
15. Anther bell-shaped; fruit red	*Amomum* cf. *villosum* var. *xanthioides*
15. Anther cup-shaped; fruit brown	*Amomum uliginosum*
16. Anther-crest long, enclosing the style forming a horn-like structure	17
16. Anther-crest variously shaped, but not enclosing the style forming a horn-like structure 2517. Petiole swollen-liked; inflorescence on a separate shoot; lateral staminodes joined to the labellum as side-lobes	18
17. Petiole not above; inflorescence terminal on the leafy shoot, lateral staminodes free of the labellum	24
18. Peduncle on a separate shoot at base of the leafy shoot, arising oblique with the ground	19
18. Peduncle on a separate shoot at base of the leafy shoot, arising vertical to the ground	20
19. Apex inflorescence tip; labellum cream (sometime pale purple)	*Zingiber rubens*
19. Apex inflorescence rounded; labellum pale yellow mixed red dots	*Zingiber mekongense*
20. Bract brown-dark red	*Zingiber montanum*
20. Bract pale yellow when young and red when mature	21
21. Labellum with red in center	*Zingiber chrysostachys*
21. Labellum pale yellow	22
22. Apex inflorescence rounded	23
22. Apex inflorescence tip	*Zingiber pyroglassum*
23. Ligule entire; flower cream	*Zingiber zerumbet*
23. Ligule bilobed; flower pale yellow	*Zingiber sadakornii*
24. Layers of rhizome in cross section 2; petiole 5–11 cm long	*Cornukaempferia aurantiflora*

(*continued*)

24. Layers of rhizome in cross section 3; petiole 9–13 cm long	*Cornukaempferia longipetiolata*
25. Anther-crest prominent	26
25. Anther-crest inconspicuous or absent	27
26. Inflorescence appears before leaves	*Kaempferia rotunda*
26. Inflorescence appears between the leaves	*Kaempferia albomaculata*
27. Inflorescence surrounded by a bell-shape or glass-shaped involucres with 2 slits	*Stahlianthus involucratus*
27. Inflorescence not as above	28
28. Corolla tube long exerted; bract compact and indistinct	29
28. Corolla tube short not exerted; bract not compact and distinct	31
29. Petiole more 20 cm long; corolla tube distinct	30
29. Petiole up to 10 cm long; corolla tube indistinct;	*Boesenbergia rotunda*
30. Flower pink	*Boesenbergia maxwellii*
30. Flower pale yellow	*Boesenbergia collinsii*
31. Inflorescence without coma bracts	*Curcuma singularis*
31. Inflorescence with coma bract 32	
32. Rhizome yellow	*Curcuma longa*
32. Rhizome cream or white-cream	33
33. Flower yellow	34
33. Flower white with violet	35
34. Rhizome branched; blade more than 7 cm wide	*Curcuma* cf. *comosa*
34. Rhizome unbranched; blade less than 6 cm wide	*Curcuma angustifolia*
35. Coma bract shorter than bract	36
35. Coma bract longer than bract	37
36. Labellum purple, apex 2-lobed	*Curcuma parviflora*
36. Labellum not as above	*Curcuma gracillima*
37. Petiole longer than pseudostem; coma bract pink	*Curcuma alismatifolia*
37. Petiole as long as pseudostem; coma bract white	*Curcuma thorelii*

Habitat

The habitats of the specimens are described in Table 1. Three species (*C. alismatifolia*, *C. thorelii* and *S. involucratus*) were found only in deciduous dipterocarp forest. Only *A. galanga* was found in both deciduous dipterocarp and mixed deciduous forest types. Mixed deciduous forest contained 14 ginger species—*E. triloba*, *G. godefroyi*, *G. thoreliana*, *G. albiflora* var. *albiflora*, *G.* cf. *sherwoodiana*, *B. collinsii*, *B. maxwellii*, *B. rotunda*, *C. gracillima*, *C. parviflora*, *K. rotunda*, *K. albomaculata*, *Z. zerumbet* and *Z. sadakornii*. Eight species were collected from dry evergreen forest—*A. blepharocalyx*, *A. conchigera*, *A. malaccensis*, *A. uliginosum*, *A. koenigii*, *C. longa*, *C.* cf. *comosa* and *E. yunnanensis*. Three species were reported in mixed deciduous forest and dry evergreen forest—*G. laeta*, *C. aurantiflora* and *C. longipetiolata*. Deciduous dipterocarp forest and pine forest contained *C. angustifolia*, *C. singularis*, *Z. chrysostachys*, *Z. montanum*, *Z. rubens*, *Z. mekongense* and *Z. pyroglassum*.

Phenology

The ginger family in the Nam Nao National Park presented the highest flowering bloom during March to August and the highest fruiting bloom during June to September (Table 1).

Flowering periods

Twelve species bloomed in the hot season (March–early May)—*A. blepharocalyx*, *A. malaccensis*, *A. koenigii*, *A. schmidtii*, *A.* cf.

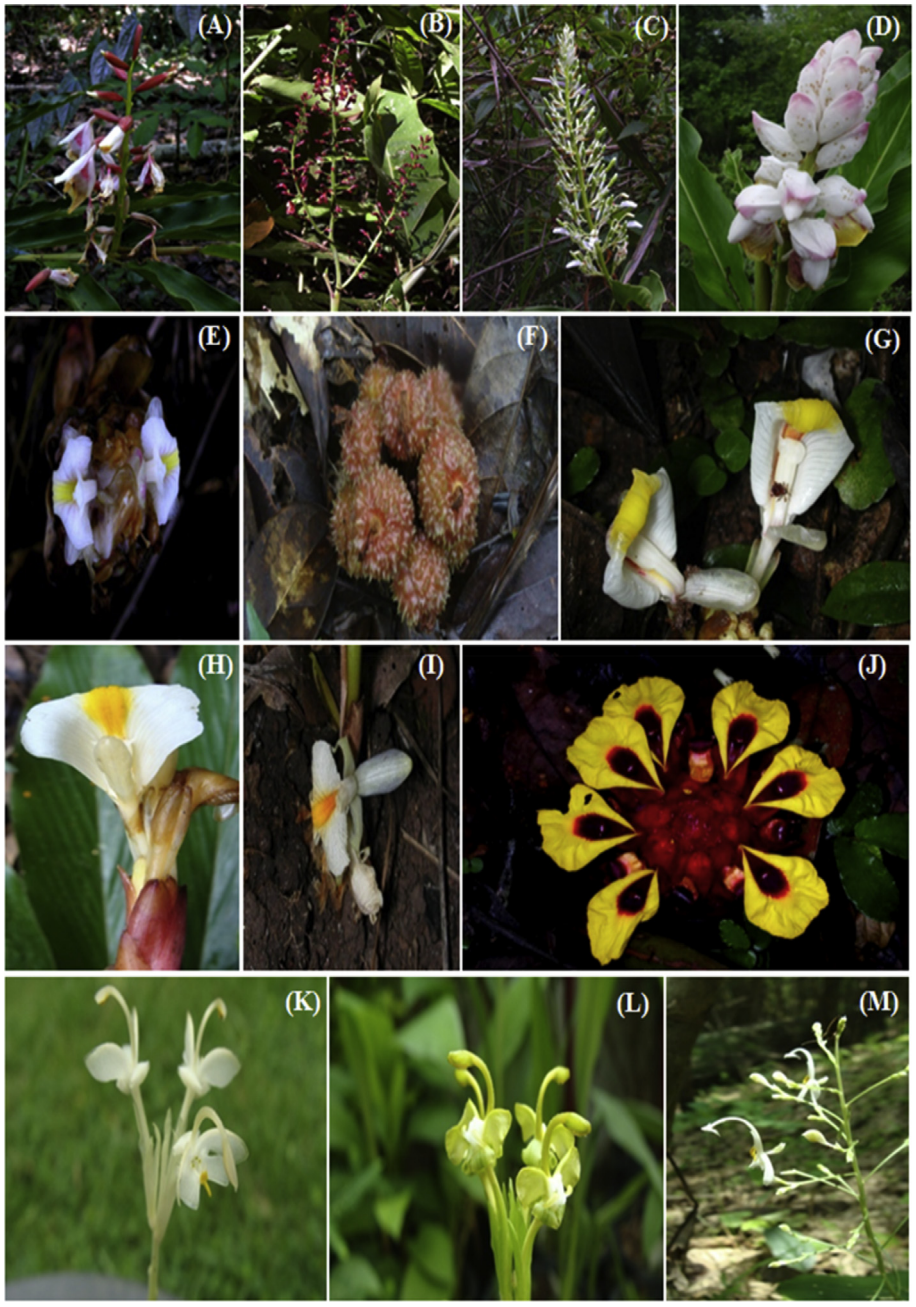

Fig. 2. Zingiberaceae in Nam Nao National Park. A) *Alpinia blepharocalyx*, B) *A. conchigera*, C) *A. galanga*, D) *A. malaccensis*, E) *Amomum koenigii*, F) *A.* cf. *villosum* var. *xanthioides*, G) *A. uliginosum*, H) *A. schmidtii*, I) *Elettariopsis triloba*, J) *Etlingera yunnanensis*, K) *Gagnepainia godefroyi*, L) *G. thoreliana*, M) *Globba albiflora* var. *albiflora*, N) *G. laeta*, O) *G.* cf. *sherwoodiana*, P) *Boesenbergia collinsii*, Q) *B. collinsii*, R) *B. maxwellii*, S) *B. rotunda*, T) *Cornukaempferia aurantiflora*, U) *C. longipetiolata*, V) *Curcuma angustifolia*, W) *C. angustifolia*, X) *C. alismatifolia*, Y) *C.* cf. *comosa*, Z) *C. gracillima*, AA) *C. longa*, AB) *C. parviflora*, AC) *C. singularis*, AD) *C. thorelii*, AE) *Kaempferia rotunda*, AF) *K. albomaculata*, AG) *Stahlianthus involucratus*, AH) *Zingiber chrysostachys*, AI) *Z. mekongense*, AJ) *Z. mekongense*, AK) *Z. montanum*, AL) *Z. rubens*, AM) *Z. zerumbet*, AN) *Z. sadakornii*.

villosum var. *xanthioides*, *A. uliginosum*, *C. angustifolia*, *C. singularis*, *E. triloba*, *E. yunnanensis*, *K. rotunda* and *S. involucratus*. Six species bloomed in the early rainy season (late May–June)—*C. aurantiflora*, *C. longipetiolata*, *G. godefroyi*, *G. thoreliana*, *G. albiflora* var. *albiflora* and *K. albomaculata*. Twenty-one species bloomed in the rainy season (June–August)—*A. conchigera*, *A. galanga*, *B. collinsii*, *B. maxwellii*, *B. rotunda*, *C. angustifolia*, *C. alismatifolia*, *C.* cf. *comosa*, *C. gracillima*, *C. longa*, *C. parviflora*, *C. thorelii*, *G. laeta*, *G.* cf. *sherwoodiana*, *Z. chrysostachys*, *Z. mekongense*, *Z. montanum*, *Z. rubens*, *Z. zerumbet*, *Z. pyroglassum* and *Z. sadakornii*. Only *C. angustifolia* flowered in two seasons (hot and rainy).

Fruiting periods

All species fruited in the rainy season.

Uses of Zingiberaceae in Nam Nao National Park

The Zingiberaceae in Nam Nao National Park were popular as food, as spices, in medicines and rituals and for ornamentation.

The main use of ginger plants (13 species) was as food—*A. blepharocalyx*, *A. conchigera*, *A. galanga*, *A. malaccensis*, *B. rotunda*, *C. angustifolia*, *C. singularis*, *K. albomaculata*, *Z. mekongense*, *Z. montanum*, *Z. zerumbet*, *Z. pyroglassum* and *Z. sadakornii*.

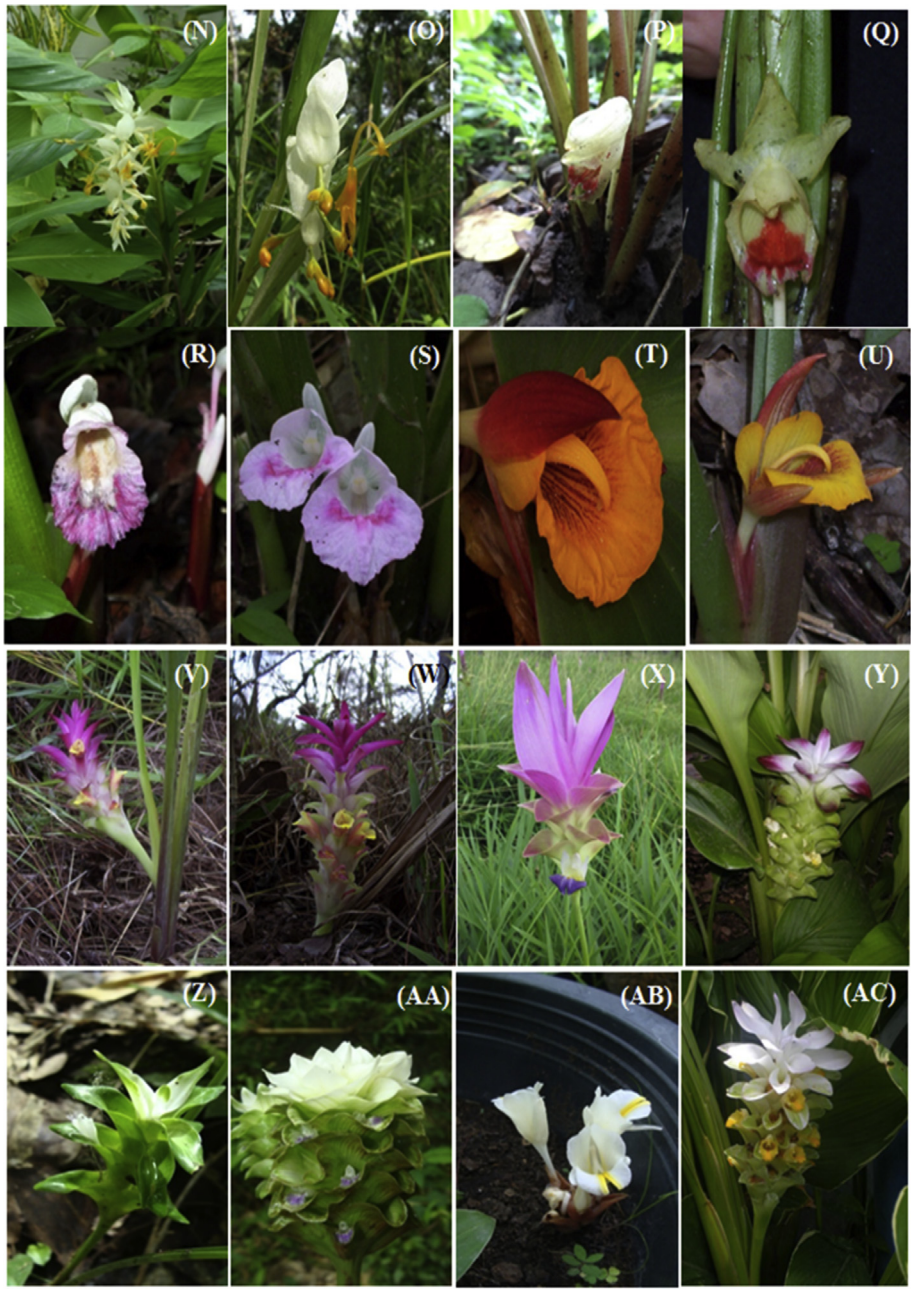

Fig. 2. (*continued*)

Some species were used as spices—*A. conchigera*, *A. galanga*, *C. longa* and *B. rotunda*.

Nine species were identified for medicinal use—*A.* cf. *villosum* var. *xanthioides*, *A. uliginosum*, *A. koenigii*, *C. aurantiflora*, *C. longipetiolata*, *C. longa*, *C.* cf. *comosa*, *K. rotunda* and *S. involucratus*.

Only *A. schmidtii* was used in rituals.

Twelve species were used as ornamental plants—*G. godefroyi*, *G. thoreliana*, *G. albiflora* var. *albiflora*, *G. laeta*, *G.* cf. *sherwoodiana*, *C. aurantiflora*, *C. longipetiolata*, *C. alismatifolia*, *C. gracillima*, *C. parviflora*, *C. thorelii*, *K. rotunda* and *K. albomaculata*.

Conservation status of Zingiberaceae in Nam Nao National Park

The conservation status of plants, based on the evaluation of the IUCN Red List (http://www.iucnredlist.org/search), indicated there were 7 species of least concern and presented in the IUCN Red List—*A. koenigii*, *A. schmidtii*, *A. uliginosum*, *A.* cf. *villosum* var. *xanthioides*, *B. rotunda*, *C. alismatifolia* and *G. albiflora* var. *albiflora* while two rare species—*E. triloba* and *C. aurantiflora*—were reported in the Thailand Red Data: Plants (Santisuk et al., 2006). There were 6 rare Zingiberaceae species based on the evaluation criteria of Saensouk (2011)—*A. blepharocalyx*, *C. aurantiflora*, *C. longipetiolata*, *C. gracillima*, *G. godefroyi* and *G. thoreliana*. Four species (*C. aurantiflora*, *C. longipetiolata*, *K. albomaculata* and *Z. sadakornii*) were endemic to Thailand. *E. yunnanensis* (T. L. Wu & S. J. Chen) R. M. Smith, previously known from China (Yunnan), was a new record for Thailand.

New record for Thailand

Terrestrial herb 2.5–3 m (shoot 3.5 m when flattened). Leafy shoots loose clump, (2–5 shoots but mainly 4), 13–25 cm apart.

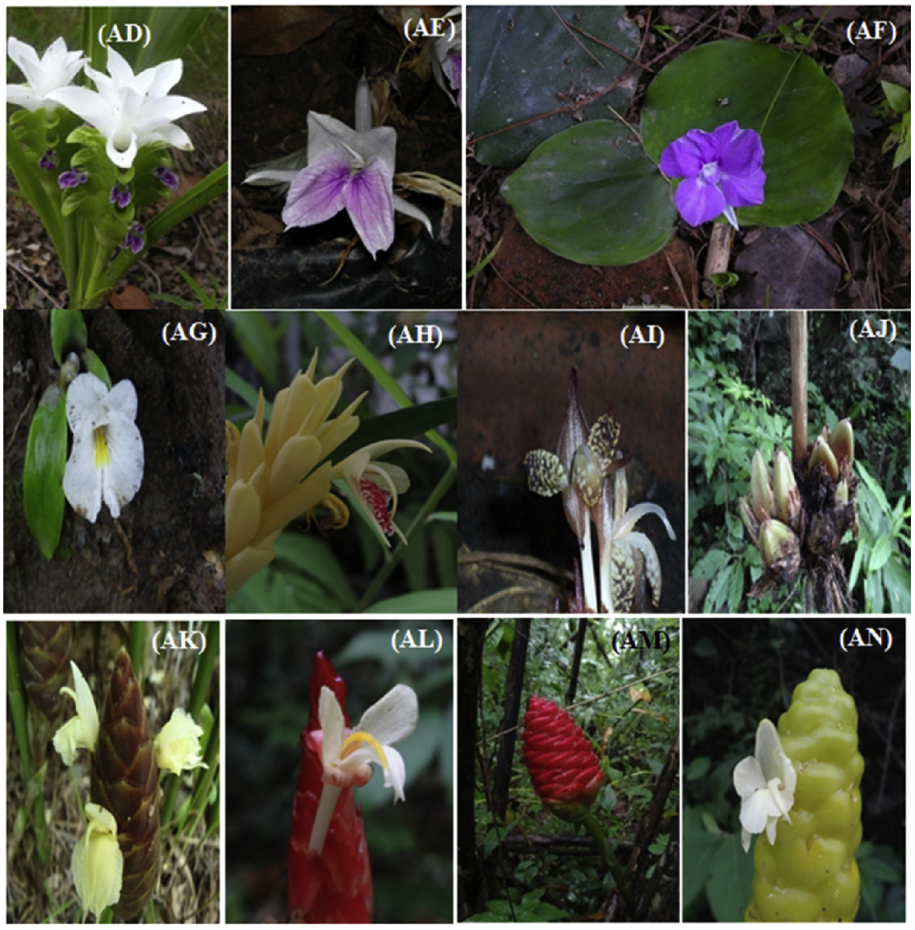

Fig. 2. (*continued*)

Rhizome 1.5 cm diameter; scales to 4.5 cm, reddish when young. Leafy shoot with 17–27 leaves. Base of leafy shoot reddish. Sheath green, tinged purple in upper part. Ligule 12–15 mm. Petiole to 5 mm. Lamina to 54 × 13 cm, narrowly ovate, dull green, slightly plicate, pubescent below, young leaf tinged purple beneath; base rounded; apex asymmetrical. The cut base smells of aniseed, like *Etlingera foetens*. Old inflorescence 14–18 cm. Inflorescence are head borne on surface of ground. Peduncle embedded in ground, short; bracts red, ovate, 2.5–3 × 2–3 cm; bracteoles tubular, circa 2.7 cm × 7 mm. Flowers numerous, six opening together in a circle, red. Calyx 3.5–4 cm, apex 3-toothed. Corolla shorter than calyx. Labellum exerted from corolla, purple at center, yellow at margin, free part 2.5–3 cm, apex 2-cleft. Free part of filament circa 5 mm; anther 6–8 mm. Ovary circa 5 mm, pubescent. Style flat. Infructescence 8 × 11 cm with 28 fruits, capsule turbinate, 3.5 × 3.5 cm, 2.5–3 cm, densely pubescent. Bracts persistent purple (Fig. 2J).

Thailand. — NORTH-EASTERN: Phetchabun.
Distribution. — China (S Yunnan (Xishuangbanna)).
Ecology. — Open dry evergreen forest (16°44′N 101°34′E), 800 m altitude 23 April 2006.
Vernacular. — Pud Yunnan (by author)
Phenology. — Flowering March–April and fruiting June–July.
Material studied. — *S. Saensouk* s.n. (E), *Saensouk* 609 (Mahasarakham University Herbarium or MSU), *A.D. Poulsen & Piyakaset Suksathan* 2406 (AAU, BKF, E, QBG).

Discussion

Three tribes, 12 genera and 38 species of the ginger family (Zingiberaceae) from five routes in Nam Nao National Park were studied for their diversity, ecological status, phonological data, uses and species status. Routes 1, 3 and 2 had the highest species diversity, respectively. The tribe Zingibereae had the highest diversity of species with 6 genera and 21 reported species. The tribe Alpinieae was composed of 4 genera and 10 species. The tribe Globbeae was the smallest tribe with 2 genera and 5 species. Many characteristics of the Zingiberaceae were usable for identification, such as rhizomes, pseudostem, inflorescence and the structure of flowers and were used to develop keys to the species, genera and tribe. Species of the Zingiberaceae were found in four forest-types—deciduous dipterocarp forest, mixed deciduous forest, dry evergreen forest and pine forest. The ginger family in the Nam Nao National Park mostly presented flowering bloom during March to August and most fruiting bloom was during June to September. The Zingiberaceae in Nam Nao National Park are popular for traditional uses as food, spices and medicines and in rituals and for ornamentation. Eight rare species were evaluated as being of least concern based on the IUCN Red List (http://www.iucnredlist.org/search), while two rare species were reported in the Thailand Red Data: Plants (Santisuk et al., 2006). Moreover, six rare Zingiberaceae species were based on the evaluation criteria of Saensouk (2011). Four species—*C. aurantiflora*, *C. longipetiolata*, *K. albomaculata* and *Z. sadakornii*—were endemic to Thailand. *E. yunnanensis*

(T. L. Wu & S. J. Chen) R. M. Smith was a new record for Thailand. Several Zingiberaceae species may be used as ornamentals because of their aesthetic value (Fig. 2 and Table 1).

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