SYSTEMATIC STUDIES OF THE GENUS *AMOMUM* Roxb. (ZINGIBERACEAE) IN THAILAND

INTRODUCTION

Amomum Roxb. is one of the largest genus in ginger family (Zingiberaceae) with about 150-180 species. They occur from the Himalayas to Northern Australia and extend into the central Pacific and widely distribute in Southeast Asia (Kiew, 1982; Smith, 1985) (Figure 1). Sirirugsa (2001) gave an estimated that there are around 15-20 *Amomum* species in Thailand. They are generally evergreen herbs inhabiting wet forests especially in light gaps and at forest margins (Sakai and Nagamasu, 1998). Many species of *Amomum* are used as medicine, spice, condiment and vegetable. Eventhough the plants from this genus have been long utilized, the identification is still confusing because of the absence of good specimens in many herbaria. These lead to many changes in taxonomic status. For instant, many species of *Amomum* were transferred to the other genera: *Aframomum, Elettariopsis, Alpinia, Etlingera* and *Hornstedtia*. Besides, there are frequent changes in identification. For example, *Amomum testaceum* Ridl. (1899) distributed in the Malay Peninsula was later identified as *A. krervanh* Pierre ex Gagnep. (1906) from Cambodia. These problems need an intensive study for clarification.

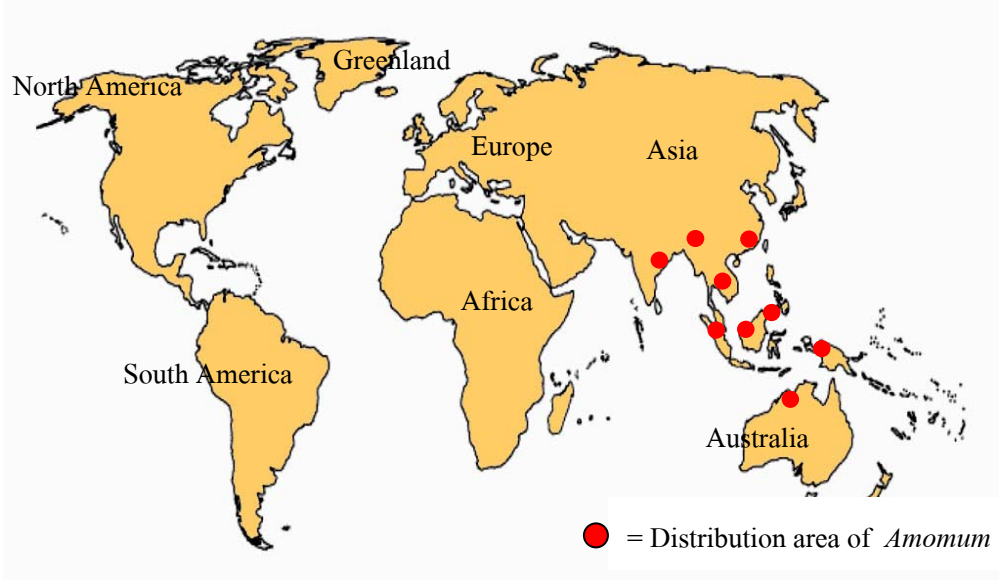

Figure 1 Distribution of *Amomum* Roxb. all over the world

Source: Smith (1985)

Thailand has a very complex biogeography due to its topography and geographic situation. Thus the southern Chinese flora reaches its southern limits in Chiang Mai and Nan provinces while the Malesian flora covers the southern part of peninsular Thailand, the Burmese flora spills over the western limestone mountains, and the central table mountains harbour a rich endemic flora (Larsen, 2003). The diverse ecological habitats lead to a rich diversity of plants including species of *Amomum*. At present, the country forest area decreases rapidly due to deforestation, urbanization and agricultural land expansion. Many plant species in the forest include *Amomum*, are at risk of extinction.

Objective

1. To revise the data and clarify the taxonomic problems of *Amomum*.

2. To clarify the taxonomic status within the genus using characteristics obtained from morphology, palynology and AFLPs marker.

LITERATURE REVIEW

Taxonomic history of the genus *Amomum* Roxb.

The history of the genus *Amomum* is described through a chronological study of contributions by various authors. Four species of *Amomum* first recognized by Linnaeus (1753) included: *A. zingiber, A. zerumbet, A. cardamomum* and *A. grana-paradisi.* These species have been transferred to *Zingiber* Boehm., *Elettaria* Maton and *Aframomum* K. Schum., respectively by Burtt and Smith (1972).

In 1783, Retzius published notes which had been sent to him by J. F. König, a pupil of Linnaeus. J.F. König had made the notes during a visit to Siam while living in India. The notes consisted of detailed descriptions of plants found by König. There were nine *Amomum* species which appeared in these notes but only two of them (*A. uliginosum* and *A. koenigii*) had been now included in the genus *Amomum*. The others were placed in different genera.

Roxburgh and Wallich (1820) defined the genus *Amomum* based on the structure of the inflorescence and flower (corolla with the interior border unilabiate, anther connected with an entire or lobate crest, capsule three-celled and three-valved, seeds many, arillate, embryo simple and furnished with both perisperm and vitellus). Eight species were mentioned in their work included: *A. cardamomum* L., *A. angustifolium* L., *A. aculeatum* Roxb., *A. maximum* Roxb., *A. dealbatum* Roxb., *A. subulatum* Roxb., *A. aromaticum* Roxb. and *A. sericeum* Roxb.

Baker (1892) studied the Scitamineae of British India. He divided *Amomum* L. into 5 sections; *Geanthus* (spike radical, lip broad, anther not crested), *Achasma* (spike radical, lip narrow and margins incurve, anther not crested), *Hornstedtia* (spike radical, lip narrow and margins incurve, anther crested), *Euamomum* (spike radical, lip broad, anther crested) and *Cenolophon* (spike terminal on the leafy stem). At present, most of *Euamomum*'s species are placed in *Amomum*, other sections were assigned to new genera (*Etlingera*, *Hornstedtia* and *Alpinia*).

Oliver & Hanbury (1896) in 'Hooker's Icones Plantarum', described and illustrated 8 species of *Amomum* from Africa.

Ridley (1899) published his first work on the Scitamineae of the Malay Peninsula. He proposed to maintain members of the section *Euamomum* of Bentham (with leafy stems from 2 to 6 feet tall, inflorescence a short dense obconic spike rising on a short peduncle from the root stock, bracts lanceolate or ovate, containing one or more flowers enclosed in thin bracteole, calyx tube as long as the corolla tube, the corolla lobes oblong or lanceolate, staminodes absent, lip large, often very large, and two horn-like or linear processes projecting from the upper angles, style shorter than the crest, fruit usually a succulent capsule often covered with processes and containing a large number of seeds) under *Amomum* and excluded the others from the genus, as described in 'The Flora of British India', the genera *Hornstedtia* (*Achasma* and *Stenochasma*), *Phaeomeria* and *Cenolophon* along with several other species which appeared to be put in by mistake. In the majority of cases the descriptions are base on dried material and field notes are too short.

Gagnepain (1903, 1906, 1908) described numerous new species of *Amomum* L., chiefly from Indochina. Gagnepain's descriptions are based on careful observations of materials, hence he made a key to identify of 19 species of *Amomum* from Cambodia, Vietnam and Laos. Regard to this key, he divided *Amomum* into 3 groups by using the characteristics of flower's morphology such as anther crest and lateral staminode. Although many species were transferred to other genera, combined and reduced to synonyms, his key and descriptions are still very useful for identification.

Schuman (1904) published his monograph of the Zingiberaceae in "Das Pflanzenreich". He accepted Roxburgh's generic concept, removed the Linnaean species from the genus, and retained the name *Amomum*. He also subdivided this genus into two sections and four series: sect. *Geanthus* (distinguished by the absence of an anther appendage and composed of ser. *Oliganthae* and *Polyanthae*) and sect. *Euamomum* (with an anther appendage and comprised of ser. *Lobulatae* and *Integrae*). The four members of ser. *Oliganthae* have been subsequently transferred to the

genus *Etlingera* Giseke, and most members of ser. *Polyanthae*, while including several true *Amomum*, may be more appropriately transferred to that genus as well. The majority of the much larger sect. *Euamomum* has been retained in *Amomum*. Members of ser. *Lobulatae* are distinguished by a bilobed or trilobed anther connective and ser. *Integrae* by an entire anther connective. Furthermore he proposed that 40 African *Amomum* species should be excluded and established in the new genus *Aframomum*. The new genus was distinguished by the shape of fruit and the trilobed anther connective, whereas the reformed genus *Amomum* was wholly Asiatic. Several species were also transferred to four other genera such as *Zingiber*, *Alpinia*, *Curcuma* and *Elettaria.*

Valeton (1913) subdivided *Amomum aculeatum* Roxb. into two varieties: var. *gymnocarpa* Val. and var. *macrocarpa* Val.

Ridley (1922, 1924) described a new species, *A. spiceum* in 'New and Rare Malayan Plants'. His account is not much different in detailed from his paper published in 1899. However, a useful key for the identification of Malaysian species was provided as well as information concerning distribution and habitats. Besides, a few species were added in this paper.

Loesener (1930) described and retained only the section *Euamomum* in the division of the genus *Amomum* proposed in Schumann's monograph. However, his descriptions are too short for identification.

Holttum (1950) gave more details of *Amomum*'s concept especially the important morphological characteristics used for distinguishing it from the closely related genus, *Etlingera*. He explained similarities between species and difference with other genera such as *Alpinia* and *Elettariopsis*. Furthermore, he also constructed a key for the Malayan species and profound descriptions which are necessary for reliable identification of species.

Burtt and Smith (1968) proposed to conserve the generic name *Amomum* Roxb. (1820) non Linnaeus (1753). They mentioned that the name *Amomum* can only be retained in its current

sense if it is conserved. The reason for this is that all the Linnaean species have now been excluded from the genus. It is therefore necessary to decide on the type of Linnaeus's genus *Amomum*.

Backer and Bakhuizen (1968) recorded 13 species of *Amomum* in "The Flora of Java" using Roxburgh's generic concept. They are *A.gracile* Bl., *A. blumeanum* Val., *A. compactum* Soland. ex Maton, *A. maximum* Roxb., *A. aculeatum* Roxb., *A. pseudo-foetens* Val., *A. hochreutineri* Val., *A. parvum* (Val.) Bakh.f., *A. heynianum* (Val.) Bakh.F., *A. walang* (Bl.) Valet., *A. megalocheilos* (Griff.) Baker, *A. coccineum* (Bl.) K. Schum. and *A. foetens* (Bl.) K. Schum. Many of them were transferred to the genus *Etlingera.*

Wu and Chen (1978) subdivided *Amomum villosum* Lour. into two varieties: var. *villosum* and var. *xanthioides.*

Fang (1978) reported some new taxa of Zingiberaceae from Kwangsi including 8 species of *Amomum* (7 new species: *Amomum tuberculatum, A. dolichanthum, A. kwangsiense, A. microcarpum, thyrsoideum, A. hongtsaoko*, and *A. putrescens*).

Tsai and Chen (1979) described 3 new species of Chinese *Amomum*, consist of *Amomum scarlatinum* H. T. Tsai et S. W. Zhao, *A. aurantiacum* H. T. Tsai et P. S. Chen, and *A. mengtzense* H. T. Tsai et P. S. Chen. Furthermore, the new variety *A. villosum* Lour. var. *nanum* H. T. Tsai et S. W. Zhao was proposed. This was later identified as *A. villosum var. xanthioides* Wu & Chen.

Smith (1980a) published additional species of *Amomum* from Borneo. She transferred *Zingiber borneense* K. Schum. to *Amomum* and described a new species, *Amomum epiphyticum* R. M. Smith.

Smith (1980b) described a new species from Australia, *Amomum queenslandicum* R. M. Smith. Smith (1982) placed *Alpinia cylindrostachys* K. Schum. which was misidentified by

Schumann into *Amomum coriaceum* R. M. Smith and described a new species from Borneo, *Amomum anomalum* R. M. Smith.

Smith (1985) reviewed Bornean *Amomum* species. She subdivided them into four groups by morphological features of flower such as flowers born singly or cincinni in sterile bracts, bracteole tubular or open to the base, lateral petals free or connate to the labellum in lower part, and anther dehiscing. Smith's work consist of 25 species (11 new species). Her key to Bornean species is finely described and illustrated and is valuable for identification. In addition, she moved *Hornstedtia sarawacensis* which was collected in Sarawak (Anderson S30713 (E)) to *Amomum*, because she could not located and identified the type specimen.

Smith (1987) described a new species from Sabah, *A. kinabaluense* R. M. Smith. and in year 1990 she described a new species from Borneo, *A. sceletescens* R. M. Smith.

Tong (1989) described 6 new species of *Amomum* from Yunnan province, China. They were *Amomum fragile* S.Q. Tong, *A. quadrato-laminare* S.Q. Tong, *A. verrucosum* S.Q. Tong, *A. glabrum* S.Q. Tong, *A. capsiciforme* S.Q. Tong, and *A. coriandriodorum* S.Q. Tong.

Sabu and Mangaly (1996) undertook taxonomic revision of South Indian Zingiberaceae, they reported that about 60 species of *Amomum* in India; 6 species occur in South India and 3 are endemic: *Amomum cannicarpum* (Wt.) Benth. ex Baker, *A. ghaticum* Bhat., *A. hypoleucum* Thw., *A. masticatorium* Thw., *A. muricatum* Bedd. and *A. pterocarpum* Thw. included one new species (*A. ghaticum* Bhat) and a new record (*A. masticatorium*).

Xia (1997) described a new species of *Amomum* from Yunnan province, China, *Amomum subcapitatum* Y.M. Xia

Sakai & Nagamasu (1998) studied *Amomum* in Lambir Hills, Sarawak. There are twelve species consist of 5 new species, i.e. *Amomum angustipetalum, A. bilabiatum, A. calyptratum, A.*

durum and *A. somniculosum*. Moreover, they gave some informations about andromonoecy and sexual dimorphism of inflorescence found in *A. polycarpum.*

Tripathi and Prakash (1999) studied the Zingiberaceae of north-eastern India, they described the new species, *A. vermanum* S. Tripathi & Prakash.

Wu *et al.* (2000) prepared an account of Zingiberaceae for the Flora of China Vol. 24 and proposed new names for four Chinese and Vietnamese Zingiberaceae. Two *Amomum* species were reduced, *Amomum thyrsoideum* Gagnepain was replaced by the name *A. gagnepainii* T. L. Wu, K. Larsen & Turland and *Amomum aurantiacum* H. T. Tsai & S. W. Zhao was replaced by *A. neoaurantiacum.* T. L. Wu, K. Larsen & Turland.

Wu and Larsen (2000) worked on Zingiberaceae for The Flora of China. They described 39 species of *Amomum* (29 endermic species and 1 introduced species).

Kress *et al.* (2003) made a checklist of The Plants of Myanmar; they listed 10 species of *Amomum*: *Amomum aculeatum* Roxb., *A. aromaticum* Roxb., *A. corynostachyum* Wall., *A. dealbatum* Roxb., *A. gramineum* Wall., *A. koenigii* Baker, *A. robertsonii, A. sericeum* Roxb., *A.subulatum* Roxb. and *A. villosum* Lour.

Taxonomic study of *Amomum* in Thailand

Burtt and Smith (1972) refered to J.G. König, a pupil of Linnaeus collected plant specimens from the Malay Peninsula and Phuket, Thailand. He prepared the flora checklist from Siam (Thailand) and published in Chloris Siamensis. Nine species of *Amomum* appeared in his list. (*Amomum* No. 25, *A. montanum* strobilo cocineo (b), *A.littorale* (b), *Amomum* (c), *A.zerumbet* (c), *A. uliginosum* (b), *A. cardamomum* (a), *A. scyphiferum* (b) and *A. leonurus* (b). Three species of *Amomum* including *A. koenigii* (*Amomum* (c)), *A. globba* (*Amomum* No. 25) and *A. uliginosum* (*A. uliginosum* (b)) has been conserved in *Amomum* genus. The rest have been moved to other genera.

Schumann (1902), described a new species from Koh Chang, Trat province, Eastern Thailand, as *Amomum hirticalyx* K. Schum.

Craib (1912) described the new species, *A. siamense* Craib from Doi Suthep, Chiangmai Province, Thailand.

Smitinand (1980) prepared Zingiberaceous checklist of Thailand. He reported 6 species of *Amomum*s: *Amomum dealbatum* Roxb., *A. krervanh* Pierre, *A. ovoideum* Pierre ex Gagnep., *A. testaceum* Ridl., *A. uliginosum* König ex Retz. and *A. villosum* Lour.

Sirirugsa (1988) in her work of Zingiberaceae in the Southern Thailand reported 6 species of *Amomum*: *A. aculeatum* Roxb., *A. biflorum* Jack, *A. hastilabium* Ridl., A. *rivale* Ridl., *A. testaceum* Ridl., and *A. uliginosum* König ex Retz.

Yuktatat (1990) reported 1 species, *Amomum hastilabium* Ridl., from Phu Phan National Park, Sakolnakhon province.

Larsen (1996) made a preliminary checklist of the Zingiberaceae of Thailand, consist of 14 species of *Amomum*: *Amomum aculeatum, A. biflorum, A. dealbatum, A. globba, A. hastilabium, A. hirticalyx, A. koenigii, A. lappaceum, A. ovoideum, A. pierreanum, A. rivale, A. siamensis, A. testaceum,* and *A. uliginosum*.

Saensook (2000) studied on morphology of 3 species of *Amomum* collected from Phu Phan National Park.

Krukhanan (2000) reported 2 species, *A. testaceum* and *A. lappaceum* in Hala-bala Wildlife Sanctuary, and 10 unidentified *Amomum* species.

Chokthaweepanich and Paisooksantivatana (2001) studied Zingiberaceae in Tao Dam forest, Kanchanaburi Province. They found 6 species of *Amomum*, i.e. *A. testaceum* Ridl. and the other 5 species could not be identified.

Lim (2002) collected ginger specimens in Hala-bala Wildlife Santuary, Yala Province, and described *A. maximum* Roxb. as a newly recorded species for Thailand.

Jenjittikul (2003) listed 7 species of *Amomum*: *A. testaceum* Ridl., *A. uliginosum* König ex Retz. and 5 unidentified species.

Utilization

Rhizome paste of *Amomum aromaticum* Roxb. is used for nausea and vomiting, seed used as a spice in India (Prakash and Mehrotra, 1996). Moreover, it is used in Chinese medicine for malaria and digestive disturbances (Cantoria, 2003). Fruit of *A. krervanh* Pierre (*A. testaceum* Ridl.) is used both as spice and medicine. The whole fruits are put in some special curry dish or are grinded and mixed in some formula of chili paste. In European countries, it is used for seasoning sausages, liquers and especially bitter. As medicine, it is recommended for dyspepsia and diarrhoea. It has been used by the Chinese for febrifuge, sedative and help digestion (Paisooksantivatana, 1996). Seed powder of *A. subulatum* Roxb. used in cough, vomiting, enlarged spleen and diseases of rectum. Decoction of seed powder is used for abdominal pain and as a tonic to the heart and liver and also as a gargle in affections of teeth and gums. Sometimes it is used as substitute for true cardamom (Prakash and Mehrotra, 1996). Seed powder of *A. compactum* Soland. ex Maton is used as medicine for resolves damp, removes stagnancy of food, and promotes digestion (Cantoria, 2003). Seed powder of *A. villosum* var. *xanthioides* T.L. Wu et Senjen is used in eliminating damp and improves appetite, warms the spleen and prevents abortion. (Cantoria, 2003).

Phylogeny of *Amomum* and other zingiberaceae

The genus *Amomum* is in the tribe Alpinieae which consists of 22 genera all over the world. In Thailand there are 9 genera in this tribe, i. e. *Alpinia*, *Amomum*, *Elettaria* (exotic genus), *Elettariopsis*, *Etlingera*, *Geostachys, Hornstedtia*, *Plagiostachys* and *Siamanthus* (a monotypic genus) (Jenjittikul, 2003).

Baker (1892), classified *Amomum* into 5 sections; *Geanthus*, *Achasma*, *Hornstedtia*, *Euamomum* and *Cenolophon* base on morphological characteristics of spike, labellum and anther crest.

Schumann (1904) used the character of anther crest and classified *Amomum* into 2 sections and 4 series; sect. *Geanthus* was divided into 2 series, ser. *Oliganthae* and *Polyanthae*, distinguished by the absence of an anther appendage and sect. *Euamomum* comprised of ser. *Lobulatae* and *Integrae*, characterized by an anther appendege.

Gagnepain (1906) separated *Amomum* into 3 groups by using the characteristics of flower's morphology such as anther crest and lateral staminode.

Loesener (1930) classified *Amomum* to 2 main groups by using anther crest, *Lobulatae* and *Integrae*.

Panunumpa (1993) studied on morphology and isozyme patterns of some *Amomum* species in Thailand. The results showed that they could be classified into 8 species as follows: *A. krervanh, A. uliginosum, A. fulviceps, A. littorale, A. aculeatum, A. dictyocoleum, A. vespertilio* and *A. lappaceum*. Only peroxidase and esterase isozyme systems gave polymorphic banding patterns.

Pedersen (2004) examined the relationship of the subfamily Alpinioideae (Zingiberaceae) particularly *Etlingera* Giseke, based on nuclear and plastid DNA (ITS and *rps*16).

His study revealed that the subfamily Alpinioideae (excluding *Pommereschea* and *Rhynchanthus*) is strongly supported as monophyletic. The basal part of the tree is not resolved but a clade containing the derived genera of Alpinieae is strongly support. The establishment of *Etlingera* by Smith (1986) as the inclusive name for *Achasma*, *Genathus*, and *Nicolaia* is also strongly supported. *Etlingera* is monophyletic with *Hornstedtia* as sister group.

Xia *et al.* (2004) investigated phylogenetic status of *Amomum* using ITS and *mat*K DNA sequence data. They indicated that *Amomum* as currently defined is polyphyletic with three major groups of species (*A. villosum* Group, *A. tsao-ko* Group and *A. maximum* Group) that do not correspond with any previously recognized sectional classification of the genus. Their analysis also identified *Paramomum* as sister to *Elettariopsis*, which are both embedded within one group of *Amomum*. The other two groups of *Amomum* share common ancestors with additional genera of the Alpinioideae. Moreover, ITS and *mat*K sequences provide new data for inferring relationships within *Amomum* and they also mentioned that some morphological characters such as anther crest and fruit type could be useful for classification.

The Amplified Fragment Length Polymorphism (AFLP)

The AFLP technique was developed by Vos *et al.* (1995). The technique is based on the selective PCR amplification of restriction fragments from a total digest of genomic DNA. The technique involves three steps: (i) restriction of the DNA and ligation of oligonucleotide adapters, (ii) selective amplification of sets of restriction fragments, and (iii) gel analysis of the amplified fragments. PCR amplification of restriction fragments is achieved by using the adapter and restriction site sequence as target sites for primer annealing. The selective amplification is achieved by the use of primers that extend into the restriction fragments, amplifying only those fragments in which the primer extensions match the nucleotides flanking the restriction sites. Using this method, sets of restriction fragments may be visualized by PCR without knowledge of nucleotide sequence. The method allows the specific co-amplification of high numbers of restriction fragments. The number of fragments that can be analyzed simultaneously, however, depends on the resolution of the detection system. Typically 50-100 restriction fragments are

amplified and detected on denaturing polyacrylamide gels. The AFLP technique provides a novel and very powerful DNA fingerprinting technique for DNAs of any origin or complexity.

The AFLP technique has been used to study genetic diversity and phylogenetic relationships in wide range of plant species such as: Aggarwal *et al*. (1999) examined phylogenetic relationships among *Oryza* species, Lubberstedt *et al*. (2000) studied relationships among early European maize inbreds, Garcia-Mass *et al*. (2000) used AFLP marker for measuring genetic diversity in melon, Abdalla *et al*. (2001) used AFLP marker to estimate genetic relationships across a wide range of taxonomic levels and to analyze the evolutionary and historical development of cotton cultivars at the genomic level, Larson *et al*. (2001) studied AFLP variation in agamospermous and dioecious bluegrasses of western North America, Santos and Simon (2002) studied in F2 populations of carrot by using AFLP marker, Mizumoto *et al.* (2003) used AFLP to study the diversity of nuclear and chloroplast genome genetic in the wild einkorn wheat (*Triticum urartu*).

Palynological study of Zingiberaceous plant and *Amomum* Roxb.

Palynology is the study of pollen (seed plants) and spores (fungi, algae, bryophytes and pteridophytes). It is an interdisciplinary science including the structure and ontogeny of the sporoderm, the biology of living pollen and spores, their dispersal and fossilisation. For the family Zingiberaceae, a few of publications were published during 1952-2003.

Erdtman (1952) found that the pollen of Zingiberaceae are usually classified as inaperturate. The diameter measured for 90 µm in pollen grain of *Amomum blumeanum*.

Mangaly and Nayar (1990) studied on pollens of South Indian Zingiberaceae by using light microscope (LM). They described the pollen of *Amomum hypoleucum* as a discontinuous exine layer consisting of circular plates joined together at margins, exine is spinose.

Theilade and Maersk Moller (1991) revealed that the pollen morphology of *Zingiber* were inaperturate, spherical or ovoid to ellipsoid. They have a distinct exine with cerebroid or

striate to spira-sriate ornamentation. The result of pollen morphology suggested a division of *Zingiber* into two main groups: species having spherical or subspherical pollen grains with cerebroid sculpturing, and species having ovoid-elliptic pollen grains with striate or spira-striate sculpture. These characters can be accepted as a reliable indicator of sections in the genus.

Jenjitikul (2003) found that pollens of *Alpinia* have two types of sculpturing, echinate in all species except *A. conchigera* Griff. which is verrucate. All species have globose pollens, 50-90 μm in diameter.

MATERIALS AND METHODS

The native *Amomum* spp. were collected from all parts of Thailand during April 2003-June 2005 (Appendix Table C 1). All parts of plants such as inflorescences, fruits, vegetative parts and habitats, were photographed and the field notes were made. The flowers and fruits were preserved in 70% ethyl alcohol. The vegetative part and inflorescences were kept as dry herbarium specimens at two Thai herbaria: Bangkok herbarium (BK) and Forest herbarium (BKF). Some duplicate specimens are kept at Singapore Botanic Garden (SBG) herbarium. Living specimens have been grown at the Department of Horticulture, Kasetsart University. All collected specimens were subjected to the following studies.

1. Morphological Study

Fifty-three accessions representing 27 species of *Amomum* and 3 outgroups genera were included in this study (Appendix Table C2). Both vegetative and reproductive part such as pseudostem, leaf, ligule, inflorescence, flower and fruit, were examined in details in laboratory. Line-drawings were made from dry and spirit specimens, in some case the photographs of the plant were needed as a companion with dry specimen. The details of morphological characters, ecology, distribution and other interesting data were described from living, dry and spirit specimens. All characters were compared and key to species for Thai *Amomum* were constructed. Fifty-eight morphological characters (Table 1) were scored and used for computing phenetic similarities among collections.

Table 1 Fifty-eight characters used in morphological study.

Characters	Score (1)	Score (0)
1.Stilt-rooted	present	absent
2.Rhizome	elongate	short creeping
3.Ligule freshness at pseudostem maturity	dry	fresh
4.Pseudo stem base	not swollen	swollen
5.Pseudostem branching	scatter	clump
6.Pseudostem robustness	slender	stout
7.Leafy stem heights	> 1.5 m	≤ 1.5 m
8.Lamina shape	elliptic	oblong
9.Lamina covering	hairy	glabrous
10. Length /width lamina ratio	> 5	≤ 5
11.Lamina texture	papery	sub-coriaceous
12.Leaf apex	acuminate	cuspidate
13.Leaf margin	entire	wavy
14.Leaf veins appearance	not clear	clear
15.Ligule apex	entire	2-lobed
16.Ligule lengths	≥ 5 mm	< 5 mm
17.Ligule textures	coriaceous	membranous or papery
18.Leaf-sheath surface	striate or reticulate	smooth
19.Petiole length	sessile	petiolate
20.Petiole cushion	swollen	not swollen
21.Petiole covering	hairy	glabrous
22.Inflorescence shapes	globular or ovoid	conical
23.Inflorescence number	≤ 3	many (>3)
24.Inflorescence length	≤5 cm	> 5 cm
25.Inflorescence compactness	loosely	dense
26.Peduncle length	≥ 20 cm	< 20 cm
27.Bract shape	linear or oblong	ovate or broadly oblong
28.Bract apex	rounded or acuminate	mucronate
29.Bract covering	glabrous	hairy
30.Bract texture	papery	succulent or leathery

Table 1 (Continued)

Characteristics	Score (1)	Score (0)
31.Bract persistence at fruiting	persistent	disintegrate
32.Bracteole shapes	split on one side or absent	tubular
33.Bracteole covering	glabrous	hairy
34.Corolla length	longer than calyx	shorter than or equal calyx
35.Dorsal corolla lobe	round or acuminate	mucronate
36.Corolla covering	hairy	glabrous
37.Corolla shapes	ovate	oblong
38. Lateral staminode	absent	present
39. Lateral staminode shapes	other	subulate
40.Labellum spreading	hooded	spreading
41.Labellum colors	yellow	white
42.Labellum margin	entire	wrinkle
43.Labellum shape	obovate	ovate
44.Labellum apex	entire	2 or 3 lobed
45.Labellem apex thickness	thick	thin
46.Filament	wider or equal anther	narrower than anther
47. Anther length	longer than filament	shorter than or equal to filament
48.Labellum rolling	convolute	spread
49.Anther covering	hairy	glabrous
50.Anther shapes	elliptic or obovate	oblong
51.Anther dehiscing	open at middle	splitted lengthwise
52.Anthers-crest shapes	entire	3-lobed
53.Ovary covering	glabrous	hairy
54.Ovary surface	ridge	smooth or rugged
55.Stigma ridge	glabrous	hairy
56.Stigma shape	clavate or capitate	cup-shaped
57.Fruit types	smooth, winged or ridged	spiny
58.Fruit number /infructescence	≤ 5	> 5

Phenetic similarities based on the simple matching (SM) coefficient (Sneath and Sokal, 1973) were calculated using the SIMQUAL module of NTSYS-pc program 2.01d (Rohlf, 1997).

$$S_{ij} = (A+D)/(A+B+C+D)$$

In which S_{ij} = similarity coefficient

A = number of characters present in both j and k

B = number of characters present only in j

C = number of characters present only in k

D = number of characters absent in both j and k

Cluster analysis using the unweighted pair-group method with arithmetic average (UPGMA) (Sokal and Michener, 1958) with SAHN procedure (Sneath and Sokal, 1973) based on the similarity coefficients of morphological data were performed to construct a dendogram representing phenetic relationships among *Amomum* accessions. The SIMQUAL and SAHN procedures are the packaging of NTSYS-pc 2.01d programe (Rohlf, 1997).

2. Amplified Fragmented Length Polymorphism (AFLP) Study

A total of 45 collections of Zingiberaceous plants were including 40 collections of *Amomum* and 5 outgroup taxa: *Alpinia*, *Elettaria*, *Etlingera*, and *Geostachys* were used (Table 2).

Table 2 List of *Amomum* accessions and outgroup taxa used in AFLP study.

Accessions	Botanical Name	Collected Number	Collected Places
1	*A. koenigii* 1	Kaewsri-03	Kanchanaburi
2	*A. koenigii* 2	Kaewsri-29	Nakhon Nayok
3	*A. testaceum* 1	Kaewsri-15	Tak (Cultivated)
4	*A. testaceum* 2	Kaewsri-16	Tak (Cultivated)
5	*A. testaceum* 3	Kaewsri-17	Tak (Cultivated)
6	*A. testaceum* 4	Kaewsri-96	Tak (Cultivated)
7	*Amomum* sp. 1	Kaewsri-01	Kanchanaburi
8	*A. aculeatum*	Kaewsri-02	Kanchanaburi
9	*Amomum* sp.12	Kaewsri-70	Chumphon
10	*A. rivale*1	Kaewsri-04	Kanchanaburi
11	*A. rivale*2	Kaewsri-23	Kanchanaburi
12	*A.*cf. *villosum*1	Kaewsri-12	Tak (Cultivated)
13	*A.* cf. *villosum*2	Kaewsri-13	Tak (Cultivated)
14	*Amomum* sp.4	Kaewsri-22	Kanchanaburi
15	*Amomum* sp.5	Kaewsri-24	Kanchanaburi
16	*Amomum* sp.7	Kaewsri-27	Uthai Thani
17	*A. uliginosum*1	Kaewsri-30	Nakhon Nayok
18	*A. uliginosum*2	Kaewsri-92	Tak
19	*A. uliginosum*3	Kaewsri-32	Trat
20	*A.* cf. *rivale*	Kaewsri-33	Kanchanaburi
21	*Amomum* sp.8	Kaewsri-35	Ranong
22	*Amomum* sp.9	Kaewsri-38	Ranong
23	*Amomum* sp.10	Kaewsri-50	Sakon Nakhon
24	*A. biflorum* Jack	Kaewsri-52	Chanthaburi
25	*A. micranthum* Ridl.	Kaewsri-63	Chanthaburi
26	*Amomum* sp.11	Kaewsri-68	Chumphon
27	*Amomum* sp.13	Kaewsri-81	Ranong
28	*A. siamense* Craib	Kaewsri-14	Tak

Table 2 (Continued).

Accessions	Species	Collected Number	Collected Places
29	*Amomum* sp.3	Kaewsri-19	Prachuap Khiri Khan
30	*Amomum* sp.2	Kaewsri-10	Kanchanaburi
31	*Amomum* sp.6a	Kaewsri-113	Chiang Mai
32	*Amomum* sp.16	Kaewsri-111	Chiang Mai
33	*Amomum* sp.17a	Kaewsri-134	Nan
34	*Amomum* sp.17b	Kaewsri-138	Nan
35	*A. repoense* Gagnep.	Kaewsri-64	Chanthaburi
36	*Amomum* sp.6b	Kaewsri-88	Tak
37	*Amomum* sp.14	Kaewsri-94	Tak
38	*Amomum* sp.15	Kaewsri-108	Chiang Mai
39	*A. dealbatum* Roxb.	Kaewsri-110	Chiang Mai
40	*Elettaria cardamomum* (L.) *Maton*	-	Tak
41	*Etlingera littoralis*	-	Kanchanaburi
42	*Etlingera pavieana*	-	Chanthaburi
43	*Alpinia nigra*	-	Cultivated at KU
44	*Geostachys* sp.	-	Nakhon Nayok
45	*Amomum* cf. *testaceum.*	Kaewsri-86	Chumphon

2.1 DNA Extraction, DNA extraction was modified from QIAGEN DNeasy® Plant Mini Kit protocol. Total genomic DNA of all samples were extracted from fresh young leaves as follows:

2.1.1 Add 400 µl of buffer AP1 to a maximum of 100 mg of fresh leaf and vortex vigorously.

2.1.2 Incubate the mixture for 10 min at 65º C. Mix 2-3 times during incubation by inverting tube (this step is used for cellular lysis).

2.1.3 Add 130 µl of buffer AP2 to the lysate, mix, and incubate for 5 min on ice for precipitation of detergent, proteins, and polysaccharides. Centrifuge the lysate for 5 min at 14,000 rpm.

2.1.4 Apply the lysate to the QIAshredder Mini Spin Column (lilac) placed in a 2 ml collection tube and centrifuge for 2 min at 14,000 rpm.

2.1.5 Transfer flow through fraction from step 2.1.4 to a new tube (not supplied) without disturbing the cell-debris pellet.

2.1.6 Add 1.5 volumes of buffer AP3/E to the cleared lysate and mix by pipetting.

2.1.7 Apply 650 µl of the mixture from the step 2.1.6, including any precipitate which may have formed, to the DNeasy Mini Spin Column sitting in a 2 ml collection tube. Centrifuge for 1 min at ≥ 8,000 rpm and discard flow-through.

2.1.8 Repeat the step 2.1.7 with remaining sample. Discard flow-through (fractions contain Buffer AP3/E, and are therefore not compatible with bleach) and collection tube.

2.1.9 Place DNeasy Mini Spin Column in a new 2 ml collection tube, Add 500 µl Buffer AW to the DNeasy Mini Spin Column and centrifuge for 1 min at ≥ 8,000 rpm. Discard flow-through and reuse the collection tube in step 10.

2.1.10 Add 500 µl Buffer AW to the DNeasy Mini Spin Column and centrifuge for 1 min at 14,000 rpm to dry the membrane.

2.1.11 Transfer the DNeasy Mini Spin Column to a 1.5 ml or 2 ml microcentrifuge tube and pipet 50 µl of buffer AE directly onto the DNeasy membrane. Inclubate for 5 min at room temperature (15-25º C) and then centrifuge for 1 min at ≥ 8,000 rpm to elute.

2.1.12 Repeat step 2.1.11 once.

2.2 AFLP Reaction

2.2.1 DNA digestion, prepare bulk digest cocktail of all components (Appendix Table D1), except genomic DNA, for number of samples + 10%. Distribute 40 µl of genomic DNA (50 ng/µl) to the cocktail. Incubate at 37º C for 3 hours or left overnight. Check completion of digested reaction by using 10 µl + dye loading run 1% in agarose gel (Appendix E1).

2.2.2 DNA ligation, make bulk ligation cocktail for number of DNA samples plus 10% (Appendix Table D2). Aliquat 10 µl per digest tube (total volume in tube now 60 µl) mix and incubate at 37º C for 3 hours. Dilute at 1:10 in dH_2O, then store at -20 º C.

2.2.3 Adapter preparation, *Mse*I and *Eco*RI adapters were prepared for pre-amplification (Appendix Table D2).

2.2.4 Pre amplification reaction, make the cocktail (Appendix Table D3) for number of DNA samples + 10% pre amplify cocktail (per 1 reaction). Run PCR program "AFLP" (Applied Biosystem Mod. Gene Amp® PCR System 9700) (Appendix Table D4). Dilute a portion of PCR product at 1:10 in dH_2O and use as PCR-II template.

2.2.5 Selective amplification, make the cocktail (Appendix Table D5) for DNA sample x number of primer combination +10%. Run PCR program 'AFLP+3' (Appendix Table D6) and verify success of amplification using polyacrylamide gel electrophoresis.

2.3 Gel Electrophoresis

Electrophoresis was performed on polyacrylamide gel using non-denaturing conditions (Appendix E2), Pre-run at 120 watt, for 30 minute or until the temperature increases to 50 ºC. Then, 2.5 µl of samples per well were loaded on a 30 cm x 40 cm x 0.4 mm polyacrylamide gels attached to glass plate in 1x TBE buffer using Sequi-Gen® GT (BIORAD), power supply (power pac 3000). Run gel for 2 hrs (light blue dye should migrate 1 inch below bottom rib of glass plate).

2.4 AFLP analysis

Each accession was scored (1) for presence and (0) for absence of each polymorphic band. AFLP bands within accessions were score as missing if they were poorly resolved on the gel or if the template DNA did not amplify well. Similarity coefficient was calculated on the basis of Dice similarity coefficients (Dice, 1945) and is written as

$$C_{jk} = 2a/(2a+b+c)$$

In which Cjk = Similarity coefficient

a = Number of AFLP markers present in both j and k accessions

b = Number of AFLP markers present only in j accessions

c = Number of AFLP markers present only in k accessions

The similarity matrix was subjected to cluster analysis by the unweighted pair-group method with arithmetic averages (UPGMA) and a dendogram was created using the NTSYS-pc version 2.01d program (Rohlf, 1997).

3. Palynological study

Anthers of 14 Thai *Amomum* (Appendix Table C3) were taken at mature stage and stored in 70% ethanol. All pollen grains were collected from the anthers and washed in 70% ethanol before further treatment.

3.1 Light Microscope (LM)

Each sample was examined at a magnification of 250. The following characters were measured from ten grains: equatorial diameter (E); polar wall thickness; and equatorial wall thickness. Shapes were described according to P/E ratio (the length of the polar axis to the equatorial diameter) (Erdtman, 1943). They are grouped as follow: Oblate (oblate spherical = 0.88-0.99; suboblate = 0.76-0.87; oblate = 0.51-0.75; peroblate = 0.50 or lower); Spherical (= 1); Prolate (perprolate = 2 or over; prolate = 1.34-1.99; subprolate = 1.15-1.33; prolate spherical = 1.01-1.14).

3.2 Scanning Electron Microscope (SEM)

3.2.1 All samples (in 70% ethanol) were poured into filter bag to collect pollen grains soak with 70% ethanol. The samples were passed through an ethanol dehydration series consisting of a 90%, 10-15 min and three changes in absolute alcohol at 10 min each.

3.2.2 The pollens were processed using Critical Point Drying. The Critical Point Dryer (BALZERS LINION CPD-020) was used to dry the samples.

3.2.3 The pollens were then mounted on SEM stub using double-sided sticky tape and sputter-coated. Photographs were taken with a JSM Jeol 5410LV scanning electron microscope.

4. Places of the study

4.1 Department of Horticulture, Faculty of Agriculture, Kasetsart University, Thailand.

4.2 Department of Biology, Faculty of Science, Prince of Songkla University, Thailand.

4.3 Department of Biology, Faculty of Science, Chiang Mai University, Thailand.

4.4 Bangkok Herbarium (BK), Department of Agriculture, Ministry of Agriculture, Thailand.

4.5 Bangkok Forest Herbarium (BKF), Department of National Park, Wildlife and Plant conservation, Thailand.

4.6 Queen Sirikit Botanic Garden Herbarium (QBG), Office of the Priminister, Thailand.

4.7 Singapore Botanic Garden Herbarium (SBG), Singapore.

5. Duration of the Study

April 2003-June 2005.

RESULTS AND DISCUSSION

Morphological study

1. Species diversity of Thai *Amomum* and their collected localities

Thirty-one accessions of *Amomum* were collected from all over Thailand: 13 species were identified, 18 accessions were considered to be new species (Table 3).

Table 3 List of *Amomum* species collected in Thailand during April 2003-June 2005.

No.	Botanical Name	Collector No.	Locality
1.	*Amomum aculeatum* Roxb.	Kaewsri-2, 6, 20, 65, 74	Kanchanaburi
2.	*Amomum biflorum* Jack	Kaewsri-52, 58, 66	Chanthaburi
3.	*Amomum dealbatum* Roxb.	Kaewsri-110	Chiang Mai
4.	*Amomum hastilabium* Ridl.	Kaewsri-37	Ranong
5.	*Amomum koenigii* Gmelin.	Kaewsri-03, 29, 136	Kanchanaburi
6.	*Amomum micranthum* Ridl.	Kaewsri-63, 84	Chanthaburi
7.	*Amomum pierreanum* Gagnep.	Kaewsri-122	Nakhon Nayok
8.	*Amomum repoense* Pierre ex Gagnep.	Kaewsri-64, 103, 121	Chanthaburi
9.	*Amomum rivale* Ridl.	Kaewsri-04, 23, 142	Kanchanaburi
10.	*Amomum siamense* Craib	Kaewsri-14, 116, 123	Tak
11.	*Amomum testaceum* Ridl.	Kaewsri-15, 16, 96	Tak (Cultivated)
12.	*Amomum uliginosum* König ex Retz.	Kaewsri-30, 32, 33, 92	Nakhon Nayok
13.	*Amomum* cf. *villosum*	Kaewsri-12, 13	Tak
14.	*Amomum* sp.1	Kaewsri-01, 93	Kanchanaburi
15.	*Amomum* sp.2	Kaewsri-10, 139	Kanchanaburi
16.	*Amomum* sp.3	Kaewsri-19, 75	Prachuap Khiri Khan
17.	*Amomum* sp.4	Kaewsri-22	Kanchanaburi
18.	*Amomum* sp.5	Kaewsri-24, 147	Kanchanaburi
19.	*Amomum* sp.6	Kaewsri-25, 88, 89, 113	Kanchanaburi
20.	*Amomum* sp.7	Kaewsri-27	Uthai Thani

Table 3 (Continued)

No.	Scientific Name	Collector No.	Locality
21.	*Amomum* sp.8	Kaewsri-35	Ranong
22.	*Amomum* sp.9	Kaewsri- 38	Ranong
23.	*Amomum* sp.10	Kaewsri -50, 54, 104, 105, 107	Sakon Nakhon
24.	*Amomum* sp.11	Kaewsri -68, 79	Chanthaburi
25.	*Amomum* sp.12	Kaewsri -70	Chumphon
26.	*Amomum* sp.13	Kaewsri -81	Ranong
27.	*Amomum* sp.14	Kaewsri -93, 94	Tak
28.	*Amomum* sp.15	Kaewsri -97, 108	Chiang Mai
29.	*Amomum* sp.16	Kaewsri -111, 114, 137	Chiang Mai
30.	*Amomum* sp.17	Kaewsri -134, 135	Nan
31.	*Amomum* sp.18	Kaewsri -151	Kanchanaburi

2. General description of Thai *Amomum*

Rhizome short or elongate, occasionally raised above ground on stilt roots. *Leafy shoot* slender or stout, up to 4 m, scatter or in clump; sheath glabrous, margin ciliate; ligule entire or 2-lobed; petiole sessile, glabrous. *Leaf blade* oblong-lanceolate, oblong or linear. *Inflorescence* arising from rhizomes, a densely spike or spike-like raceme or panicle, usually cone-like, and absence of invorucre of sterile bracts; peduncle short or rather long, clothed with imbricate, peduncular bracts. *Bracts* imbricate, persistent, sometimes soon disintegrating. *Bracteole* tubular or open to the base. *Calyx* usually tubular, apex 3-fid. *Corolla* tubular cylindric; lobes oblong or linear-oblong, central one erect, usually wider and more convex than lateral ones, lateral ones free or connate to the labellum. *Lateral staminode* subulate, small, or absent. *Labellum* conspicuous, usually yellow or orange at center, with some red veins or marks, often white at margin, usually obovate, broadly concave. *Filament* well develop. *Anther* locules parallel or diverging, dehiscing throughout their length or in the upper half only; anther crest entire or 3-lobed or absent. *Ovary* 3-loculed; ovules many per locule, superposed; style filiform; stigma usually funnelform, small;

stylodes blunt. *Fruit* 3-lobed, irregularly dehiscent or indehiscent, smooth, prickly, ridged or winged; seeds oblong or many-angled; aril fleshy or membranous, apex laciniate (Figure 2, 3).

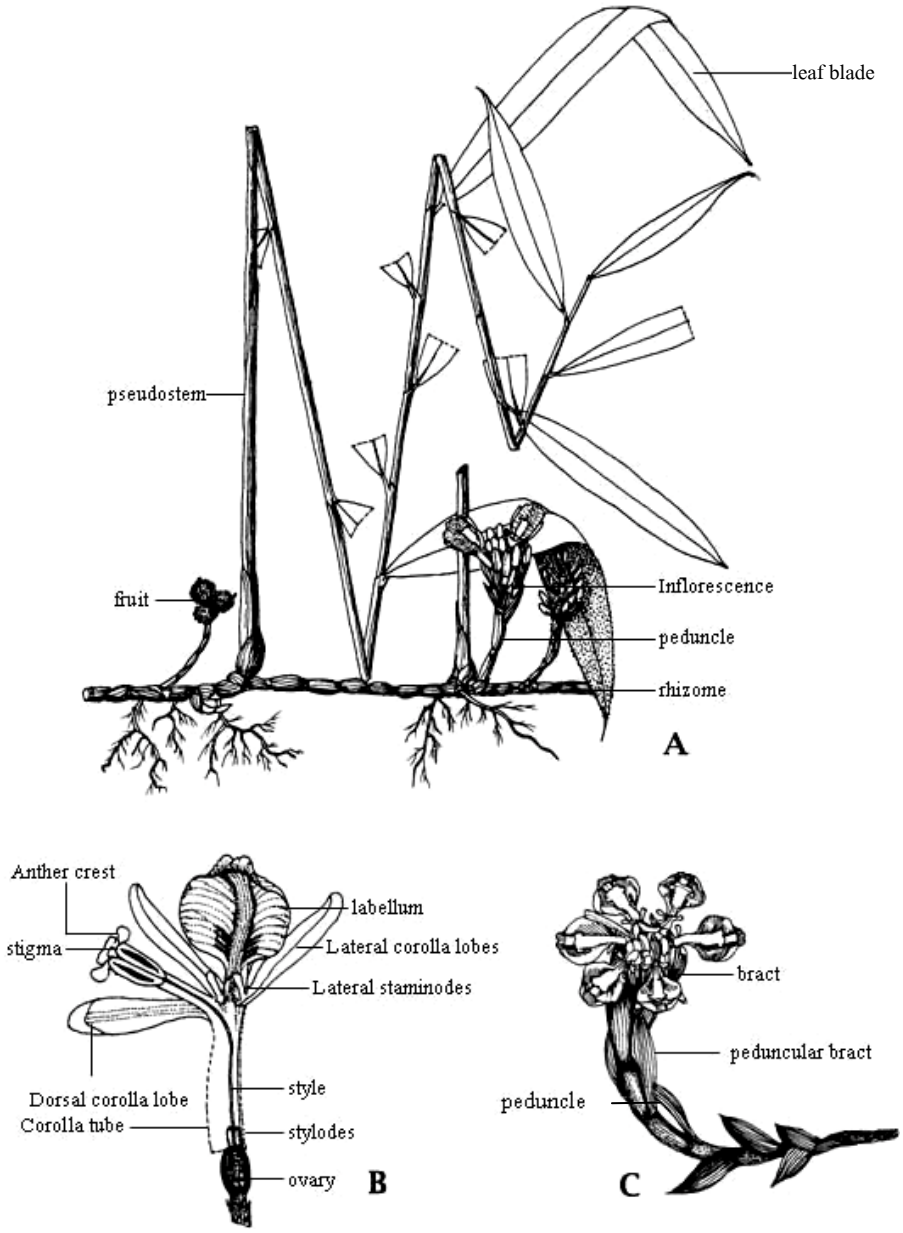

Figure 2 Morphology of *Amomum* Roxb. A, leafy stem of *Amomum rivale* Ridl.; B-C, flower and inflorescence of *A. uliginosum* König ex Retz., respectively.

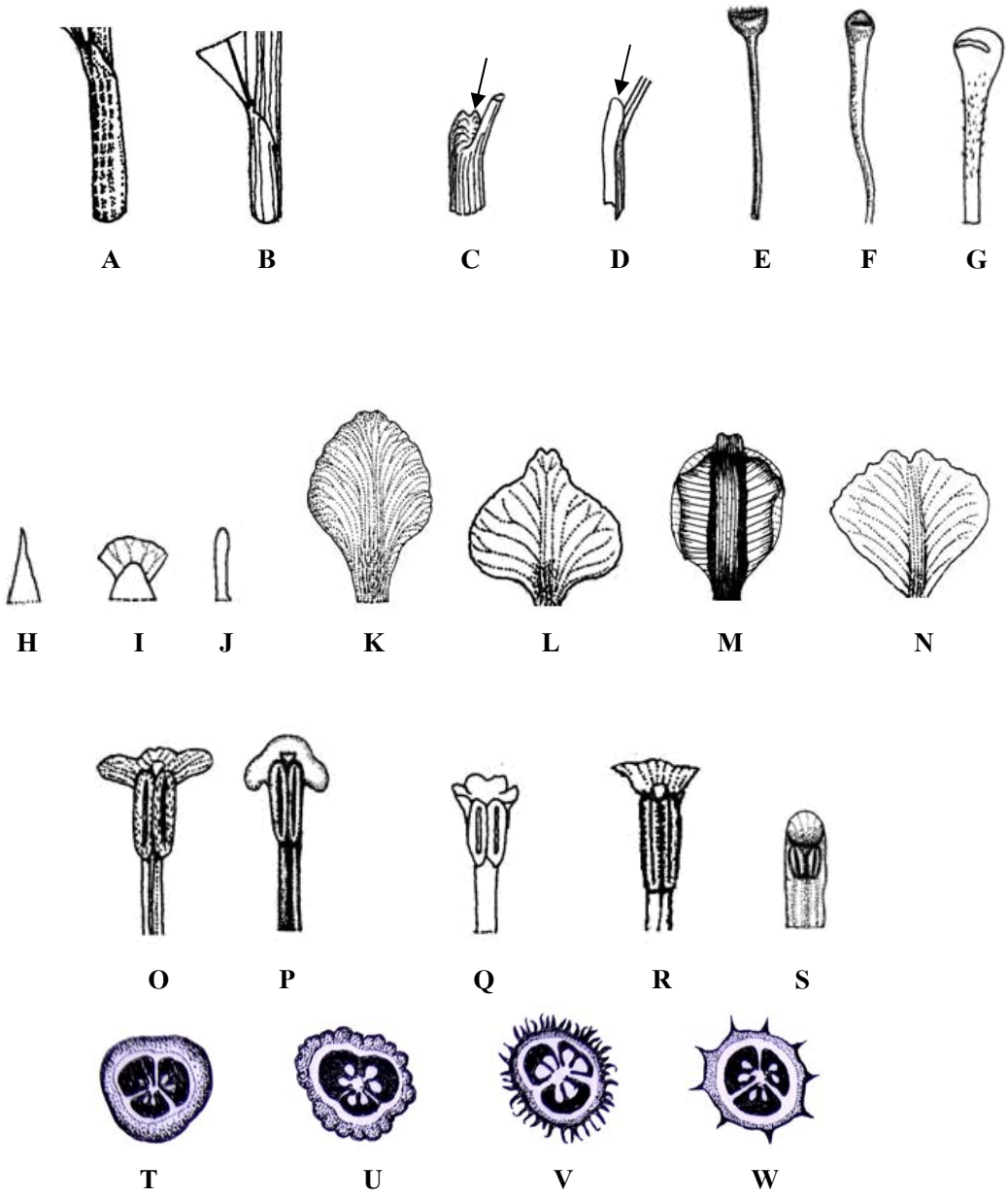

Figure 3 Morphological characteristics of some organs of the genus *Amomum* Roxb. A-B, leaf sheath (A. reticulate and B. striate); C-D, ligule (C. 2-lobed and D. rounded); E- G, stigma (E. cup, F. ampullate and G. clavate); H-J, lateral staminode (H. subulate, I. fin-shaped and J. linear); K-N, labellum (K. ovate, L. deltoid M. orbiculate and hooded and N. flabellate); O-S, anther crest (O. reniform, P. auriculate, Q. 3-lobed or horn-shaped, R. truncate and S. rounded); T-W, fruit types, x-section (T. smooth, U. ridged, V. spiny and W. wing).

3. Key to species of Thai *Amomum* (excluding non-collected taxa)

1. Fruit smooth, neither winged nor spiny
  2. Bract persistent when fruiting
    3. Labellum entired or 2-lobed, white; inflorescence conical, cylindric or ellipsoid
      4. Ligule entired; inflorescence ellipsoid; lateral staminodes narrowly subulate...**4. A. hastilabium**
      4. Ligule 2-lobed; inflorescence conical or cylindric; lateral staminode absent.…**11. A. testaceum**
    3. Labellum 3-lobed, bright yellow; inflorescence broadly ovate or globose……**7. A. pierreanum**
  2. Bract soon disintegrated when fruiting
    5. Labellum elliptic, margin entired, pale yellow; lateral staminode absent; anther crest truncate or slightly 3-lobed.……...……**29. Amomum** sp.16
    5. Labellum rhomboid, margin 3-lobed, white; lateral staminode subulate; anther crest rounded ……..……**5. A. koenigii**
1. Fruit ridged, winged or spiny
  6. Fruit ridged or winged
    7. Leaf hairy beneath; lateral staminodes present
      8. Peduncle sessile; fruit 7- 13- ridged ……..……..…**10. A. siamense**
      8. Peduncle 1 cm; fruit 9- or 11- winged
        9. Fruit 11- winged, pale green; peduncle 1-1.5 cm……..…**19. Amomum** sp.6
        9. Fruit 9- winged, pink or red; peduncle longer than 1.5 cm
          10. Ligule ca. 5 mm long; bracteole tubular; leaf silvery white pubescent on underside ……..**28. Amomum** sp.15
          10. Ligule longer than 5 mm; bracteole absent; leaf brown or white pubescent on underside
            11. Leaf brownish pubescent beneath; petiole 0.3- 1 cm long; labellum entired; anther crest truncate; fruit ellipsoid……..……..……..….**3. A. dealbatum**
            11. Lower surface of leaf whitish pubescent; petiole longer than 10 cm; labellum 3-lobed; anther crest 3-lobed; fruit globose…….……...…**30. Amomum** sp.17
    7. Leaf glabrous beneath; lateral staminode absent
      12. Fruit 9-winged; bracteole absent; labellum 3-lobed; anther crest 3-lobed; petiole 10-25 cm long ……..…**8. A. repoense**
      12. Fruit 6-winged; bracteole split to base; labellum entired; anther crest rounded; petiole sessile-10 cm long

13. Wing 6, regular spacing……**15. Amomum** sp.2

13. Wing 3, apex of wing bifid……...……....**16. Amomum** sp.3

6. Fruit spiny

14. Labellum convolute

15. Labellum pale yellow or greenish yellow; lateral staminode absent…….. **25. Amomum** sp. 12

15. Labellum white or pink; lateral staminodes linear……...……..…...**1. A. aculeatum**

14. Labellum speading or hooded

16. Staminodes present

17. Leaf sheath reticulate

18. Stilt root present; staminodes fin-shaped; peduncle ca.1.5 cm…….....**26. Amomum** sp.13

18. Stilt root absent; lateral staminodes subulate; peduncle ca.10 cm……..**23. Amomum** sp.10

17. Leaf sheath smooth or striate

19. Leaf surface pubescent; labellum yellow

20. Petiole ca.2 cm long; anther shortly dehiscing at middle; stigma hairy…….**9. A. rivale**

20. Petiole sessile; anther dehiscing throughout their length; stigma glabrous

…….…… ……..……**17. Amomum** sp.4

19. Leaf surfaces glabrous; labellum white

21. Labellum spreading; ligule entire…….……..……....…**6. A. micranthum**

21. Labellum hooded; ligule 2-lobed

22. Peduncle 2-3 cm long; stigma hairy…….……..…**24. Amomum** sp.11

22. Peduncle 13-15 cm long; stigma glabrous…..……..…**12. A. uliginosum**

16. Staminodes absent

23. Stigma hairy

24. Labellum spreading; inflorescence 2-3- flowered……..….**2. A. biflorum**

24. Labellum hooded; inflorescence 3-many- flowered

25. Ligule entire; petiole sessile; peduncle 5-11 cm long …….**13. A.** cf. **villosum**

25. Ligule 2-lobed; petiole 3-10 mm long; peduncle 1.5-2.5 cm long

26. Leaf glabrous…….……....**27. Amomum** sp.14

26. Leaf pubescent on underside…….….....**14. Amomum** sp.1

23. Stigma glabrous

27. Inflorescence loose; fruit elliptic or obovate …….....….**18. Amomum** sp. 5

27. Inflorescence compact; fruit globose…….…….……...……**20. Amomum** sp.7

Amomum sp.8, *Amomum* sp.9 and *Amomum* sp.18 are excluded from this key because the flowers are lacking and morphological characters are not enough for distinguishing. Five species previously recorded include *A. hirticalyx* Schumm., *A.lappaceum* Ridl., *A. maximum* Roxb., *A. spiceum* Ridl. and *A. squarrosum* Ridl. were also excluded because they were not collected during field exploration.

4. Ecological habitats and their distribution

The typical habitats of *Amomum* are wet and light forest edges and gaps (Sakai and Nagamasu (1998). In Thailand, the genus is usually found in evergreen forest especially tropical rain and dry evergreen forests (Table 4). Most species have distribution in Peninsula of Thailand (Table 5). The floristic regional division followed from Smitinand (2001).

Table 4 The number of *Amomum* species which were found in each ecological habitats.

Habitats	Number of *Amomum* species
Tropical rain forest	15
Hill evergreen forest	6
Dry evergreen forest	18

Table 5 The number of *Amomum* species which were found in each regions of Thailand.

Regions	Number of *Amomum* species
Northern	11
Northeastern	3
Eastern	4
Southwestern	9
Central	2
Southeastern	7
Peninsular	14

5. Descriptions of Thai *Amomum* (The province names followed Smitinand (2001))

1. Amomum aculeatum Roxb., Asiat. Res. 2. t.6: 344. 1810; Fl. Ind. Ed. 1, 1: 40. 1820; Valet., Ic. Bog. 2: t. 154: 157.1905; *A. elephantorum* Pierre ex Gagnep., Bull. Soc. Bot. Fr. P. 137, 1906; *A. flavum* Ridl., J. Str. Br. Roy. Asiat. Soc. 32: 133, 1899; *A. aurantiacum* Ridl., Fl. Mal. Pen. 4: 262, 1924. **Type:** Calcutta. **Figure** 4. **Picture:** Appendix A1.

Rhizome short. *Leafy shoot* stout, growing in clump, 4.0-7.0 m tall, swollen at base, 5-6 cm dia. *Leaves* 32-46; sheath green, glabrous or sparsely pubescent, smooth; ligule 2-lobed, round, pale green, membranous, glabrous or pubescent, ca. 8.0 mm long; petiole ca. 5 mm long; lamina ovate-oblong, narrowly oblong or lanceolate-oblong, 19.7-43.0 by 4.5-8.0 cm, glabrous (rarely lower surface pubescent), base round or oblique, apex acuminate. *Inflorescence* globose or cylindric, 4.0-9.0 by 4.0-14.0 cm, pinkish brown, mucilaginous; peduncle decumbent, stout, 20.0-38.0 cm long; peduncular bract ovate to deltoid, brown when dry, leathery, pubescent scatter, apex mucronate, ca. 4.0 by 3.5 cm. *Bract* oblong, 3.8-5.5 by 2.0-2.4 cm, brown, both surfaces hairy especially at base, apex apiculate, mucilaginous, soon disintegrating. *Bracteole* tubular, 1.5-4.0 cm long including ovary, apex obscurely 2-lobed, shallowly split on 1 side, pinkish cream, outer surface with scattered brown pubescent. *Calyx* 1.7-3.5 cm long, apex 2-fid, shallowly split on 1 side, membranous, scatter pubescent at base, cream with pinkish red spots. *Corolla* creamy white, tube hairy, 1.0-3.5 cm, dorsal lobe oblong, hooded, ca. 2.8-3.0 by 1.8-2.0 cm, apex blunt, hooded or mucronate, lateral lobes narrow. *Lateral staminode* linear, ca. 3 mm, hairy. *Labellum* slightly 3-lobed, transversly elliptic or obdeltoid, convolute, 2.8-4.5 by 2.5-4.3 cm, base cuneate, middle lobe slightly reflexed, apex 2-fid or rounded, margin dry, lateral lobes broad, round, white with pinkish dotted lines radiate from base upward, yellowish marks at apex. *Filament* 7.0-12.0 mm long, flat, creamy white, sparsely pubescent; anther 13.0-15.0 by 5.0 mm, sparsely strigose, dehiscing lengthwise; anther crest reniform, 3-lobed, round, ca. 10.0-11.0 by 3.5-4.0 mm, pinkish white, central lobe ca. 3.0 by 1.0-4.0 mm, lateral ones ca. 4.0 by 4.0 mm. *Ovary* cylindric, 5.0-6.0 by 3.0-4.0 mm, glabrous; stigma cup-shaped, aperture edge hairy; style with scattered hairs near tip, stylodes blunt, ca. 5 mm long. *Fruit* globose or elliptic, covered with rigid spines, 1.5-3.5 cm

dia. including spines, green when young turning brown at maturity, spines ca. 3-4 mm long; fruit stalk ca. 0.5-2.0 cm long, stout, tomentose; seeds angular, ca. 5-6 by 2-3 mm.

Phenology. — Flowering and fruiting during April- August.

Thailand.— SOUTH-EASTERN: Trat (Koh Chang), Chantaburi (Khlong Khuar Wai, Khao Soi Dao); NORTHERN: Tak (Cultivated at Doi Musur Horticulture Research Station); SOUTH-WESTERN: Kanchanaburi (Sai Yok, Thong Pha Phum), Prachuap Khiri Khan (Kaeng Krachan); PENINSULAR: Surat Thani, Phatthalung (Khao Poo-Khao Yah), Nakon Si thammarat (Khao Luang, Tung Song, Lan Sa Gah, Ta Sa La), Trang (Khao Chong), Songkla (Haad Yai, Sabayoi), Satun (Khuan Kalong), Krabi, Phangnga (Koh Surin) (Appendix B1).

Distribution.— India, Myanmar, Thailand, Malay Peninsula, Indonesia.

Ecology.— Tropical rain or dry evergreen forest, shaded place, limestone bedrock, 1-800 m.

Vernacular name.— Reo Chang (เร่วช้าง)

Note.— *A. aculeatum* Roxb. is characterized by yellow-pink flowers and a globose or cylindric inflorescence with mucilage and convolute labellum. Leaf is rarely pubescent on lower surface.

Specimens examined.— *C. Chermsirivattana & T. Smittinand 2078*, 14 April 1976, Phangnga (BK); *C. Maknoi T9,* 27 April 1999, Songkla (PSU); *C. Maknoi T93,* 27 July 2000, Songkla (QBG); *Kaewsri-2*, 25 April 2003, Sai Yok (BK, BKF); *Kaewsri-6*, 25 April 2003, Sai Yok (BK, BKF); *Kaewsri-20*, 16 May 2003, Prachuap Khiri Khan (BK, BKF); *Kaewsri-65*, 25 March 2004, Chanthaburi (BK, BKF); *Kaewsri-74*, 7 April 2004, Chumphon (BK, BKF); *Kerr* 6906, 5 April 1923, Trat (BK); *Kerr 13337*, 14 April 1927, Surat Thani (BK); *Kerr 15202*, 14 April 1928, Trang (BK); *Maxwell 74-486*, 14 May 1974, Chantaburi (BK); *Maxwell* 85-600, 18 June 1985, Songkla (PSU); *Maxwell* 86-188, 22 March 1986, Phatthalung(PSU); *Maxwell* 86-315, 1 June 1986, Surat Thani (BKF, PSU); *Maxwell 87-293*, 4 April 1987, Khao Poo-Khao Yah (BKF, PSU); *M. Newmen 14*, 23 August 1984, Songkla (PSU); *M. Newmen 17*, 25 August 1984, Satun (PSU); *M. Newmen 57*, 18 March 1985, Nakorn Si thamarat (PSU); *Rabil 162*, 23 July 1929, Nakhon Si Thammarat (BK); *Rabil 361*, 4 August 1929, Trang (BK); *Wichian 597*, 14 May 1946, Wang Ka (BK); *T. wongprasert* , 31 May 1997, Prachuap Khiri Khan (BKF); *Y.Paisooksantivatana 1599-85*, 18 August 1985, Krabi (BK); *y 2259-88*, 20 May 1988, Tak (BK); *y 2281-88*, 8 November 1988, Tak (BK).

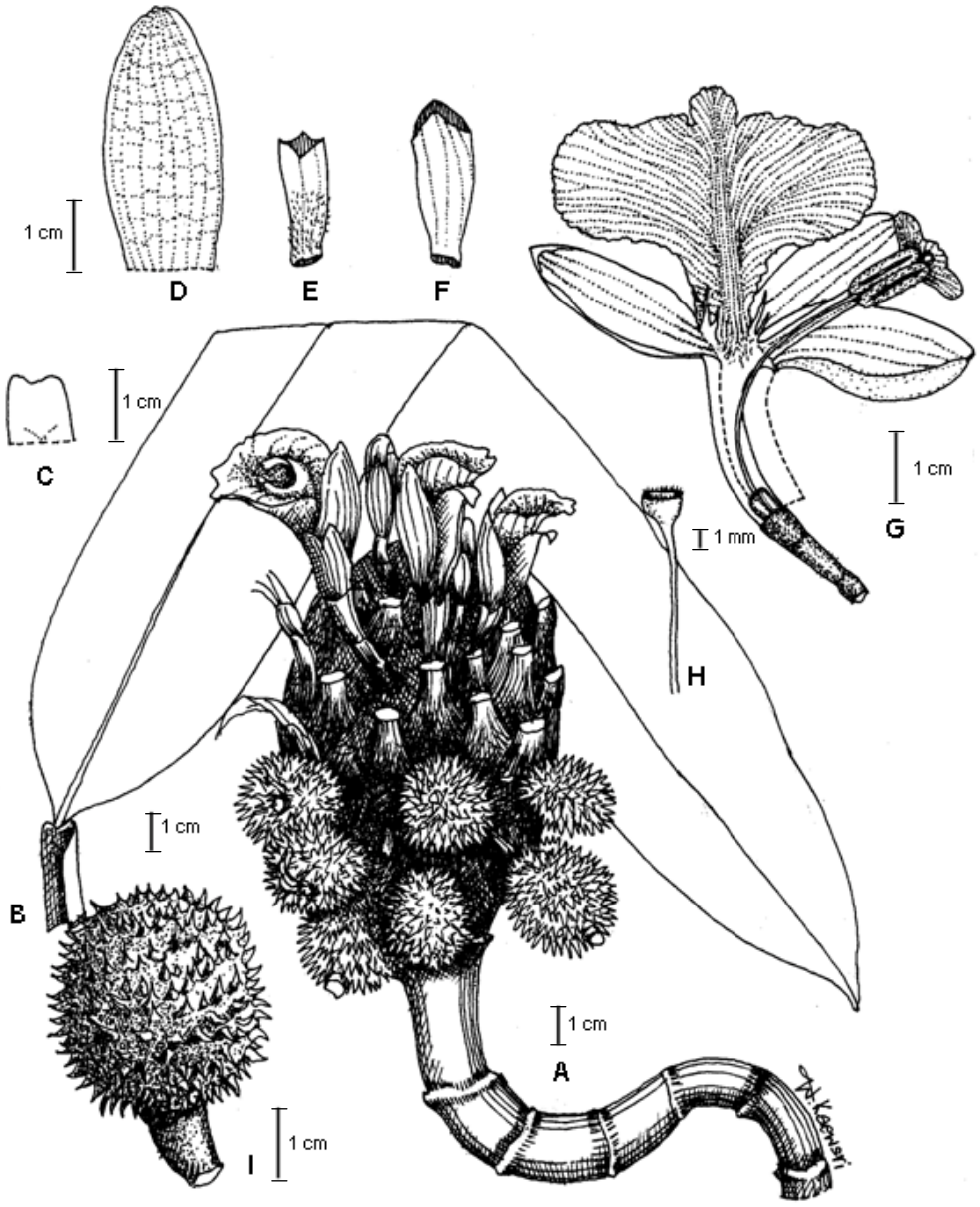

Figure 4 *Amomum aculeatum* Roxb.: A. inflorescence; B. leaf; C. ligule; D. bract; E. bracteole; F. calyx; G.flower, dissected; H. stigma (drawn from Kaewsri-2); I. fruit (drawn from Kaewsri-74).

2. Amomum biflorum Jack, Mal. Misc. 1:2. 1820; Holttum, Gard. Bull. Sing. 13:199. 1950; *A.elettarioides* Bak. in Hook. F., Fl. Brit. Ind. 6:240. 1892; *Elettariopsis pubescens* Ridl., J. Str. Br. Roy. As. Soc. 32:155. 1899; *E. schmidtii*, K. Schum., Bot. Tidsskr. 24:167. 1902; *Cyphostigma schmidtii* (K. Schum.) K. Schum., Pflanzenr. Zing. 274. 1904; *A.schmidtii* (K. Schum.) Gagnep., Fl. Gen. Indoch. 6:111, 1904. **Type**: K**. Figure** 5. **Picture:** Appendix A2.

Rhizome elongate, yellowish white. *Leafy shoot* slender, 1.0-1.5 m tall, base swollen ca. 1.0-1.5 cm dia. *Leaves* ca. 8; sheath with brown pubescent; ligule entire and dried papery, villous, 1.0-2.0 mm long; petiole 0.5-3.0 cm long; lamina oblong, ovate-oblong or elliptic, 8.5-35.0 by 5.0-8.5 cm, upper surface glabrate, lower surface densely pubescent, base attenuate, apex acuminate, tip caudate, 2.5-4.0 mm. *Inflorescence* ovate to conical, ca. 3.0-4.0 by 1.0-2.0 cm, 2-3 flowers; peduncle ca. 1.0 cm long; peduncular bracts oblong, ca. 5-8 by 3-5 mm, pinkish brown, glabrous, papery, apex round and hooded. *Bract* broadly oblong, 1.5-2.2 by 1.0-1.2 cm, glabrous, apex round and mucronate, pale brown with scattered brown dots. *Bracteole* tubular, ca. 1.5-1.6 cm long including ovary, apex unequally 2-fid, membranous, pinkish cream, outer surface glabrous, pubescent at base. *Calyx* 3.0-3.5 cm long including ovary, apex 2-fid and shallowly split on 1 side, outer surface glabrous, white pubescent at base, pinkish cream. *Corolla* creamy white, tube glabrous, 3.5-4.5 cm long including ovary, dorsal lobe broadly oblong, apex hooded, 1.8-2.3 by 0.9 cm, lateral lobes narrower. *Lateral staminode* absent. *Labellum* flabellate, spreading, ca. 3.0 by 2.5-3.1 cm, base attenuate, apex shallowly split and revolute, white with yellow band along center, lateral red veins along the band and paler upward, white pubescent base. *Filament* 8.0-10.0 mm long, glabrous; anthers ca. 4.0-5.0 mm long, dehiscing lengthwise, pale yellow, with slightly pubescent; anther crest 3-lobed, 4.0-5.0 by 3.0 mm, creamy white, central lobe ca. 3.0 by 3.0 mm, round, erect, lateral ones ca. 2.0 by 1.5 mm, apex round, spreading. *Ovary* cylindric, ca. 5.0 by 3.0 mm, villous; stigma cup-shaped, ca. 2.0 by 1.5 mm, aperture narrowly transverse, edge hairy; stylodes blunt, slender, 6.0-7.0 mm long. *Fruit* globose, ca. 1.5 cm, sparsely tuberculate spines, pinkish red, fruit stalk 3-5 mm long.

Phenology. — Flowering: April- July, fruiting: August.

Thailand.— SOUTH-EASTERN: Chonburi (Sri Ra Cha), Trat (Koh Chang), Chantaburi (Khao Soi Dao); SOUTH-WESTERN: Kanchanaburi (Sai Yok, Thong Pha Phum), Prachuap Khiri Khan (Kaeng Krachan); PENINSULAR: Ranong (Kraburi), Phatthalung (Khao Poo-Khao Yah), Songkla, Satun (Appendix B1).

Distribution.— Laos, Cambodia, Thailand, Malaysia.

Ecology.— Tropical rain and dry evergreen forest, under shade of shrubs or trees, upto 1300 m.

Vernacular name.— Reo Hom (เร่วหอม), Pud Nu (ปุดหนู), Sa Neh Ma Ha Pom (เสน่ห์มหาพรหม), Wan Ron Tong (ว่านร่อนทอง).

Note.— *A. biflorum* Jack, a common species in Thailand, is characterized by slender leafy stem, leaves pubescent on lower surface, inflorescence small (2-3 flowers), and rhizome and leaves usually fragrant.

Specimens examined.— *C. Chermsiri & Kasem 1462*, 10 April 1969, Kraburi (BK); *C. Curtis 2216*, 6 May 2003, Singapore (SBG); *C. Maknoi T54*, 26 October 1999, Sa Ba Yoi (PSU); *Kaewsri 58*, 23 March 2004, Khao Soi Dao (BK, BKF); *Kaewsri 66,* 1 April 2004, Khom Luang Chumphon (North) (BK, BKF); *Kerr 4153*, 5 April 1920, Sriracha (BK); *Kerr 6877,* 4 April 1923, Satul (BK); *Kerr 14633,* 17 March 1928, Satul (BK); *Kerr 21319,* 30 April 1932, Weing Chan (BK); *Maxwell 74-408*, 7 May 1974, Koh Chang (BK); *Maxwell 75-472,* 4 May 1975, Khao Soi Dao (BK); *Maxwell 96-1615*, 14 December 1996, Jae Sawn (CMU); *O. Petrmitr 6*, 23 May 1997, Doi Luang, Payao (CMU); *P. Sirirugsa 1169*, 17 May 1988, Khao Chong (PSU); *Wiriya Khanarak 2*, 22 August 2002, Chiangmai (CMU).

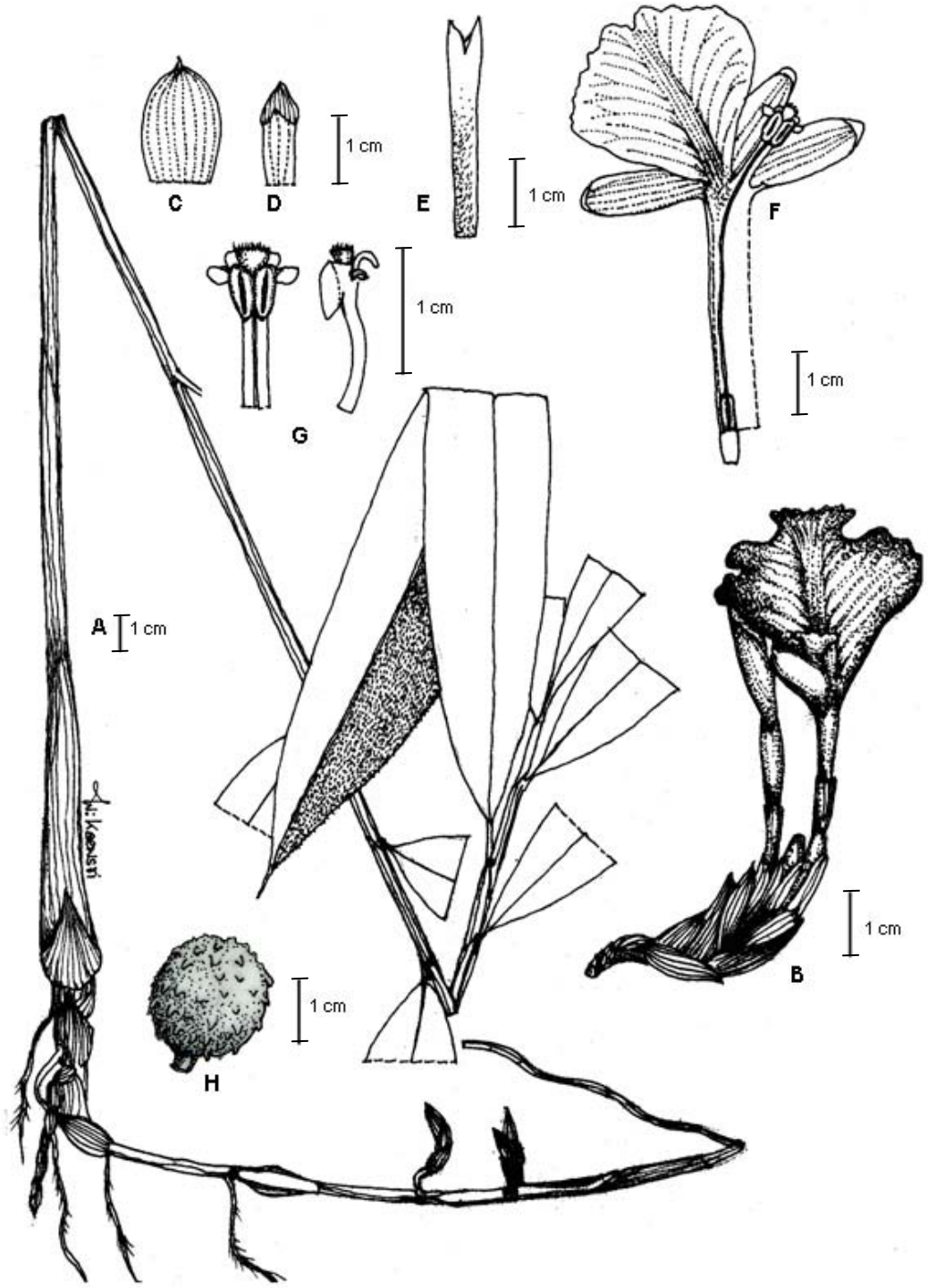

Figure 5 *Amomum biflorum* Jack: A. habit; B. inflorescence; C. bract; D. bracteole; E. calyx; F. flower, dissected (drawn from Kaewsri-58); G. stamen and stigma; H. fruit.

3. Amomum dealbatum Roxb., Fl. Ind, 1:42 (1820); Wu & Larsen, Fl. China Vol.24: 354 (2000). **Type:** Calcutta. **Figure** 6. **Picture:** Appendix A3.

Rhizome short. *Leafy shoot* 1.2-2.0 m tall. *Leaves* 9-14; sheath green and red at base; ligule entire, apex dried papery, 0.6-2.0 cm long; petiole 0.3-4.5 cm long; lamina oblong, ovate-oblong or elliptic-oblong, 20.0-68.0 by 3.0-18.0 cm, upper surface glabrous, lower surface brownish pubescent, base attenuate or cuneate, apex acuminate, tip caudate, 2.0-2.5 cm. *Inflorescence* ovoid, cylindric or conical, emerge near base of pseudostem, 5.0-11.0 by 3.5-4.0 cm, purplish red; peduncle stout, 4.0-6.0 cm long. *Bract* ovate, 3.0-4.5 by 2.5-2.7 cm, glabrous, apex apiculate, pinkish red. *Bracteole* split on one side. *Calyx* ca. 3.2 cm long including ovary, apex 3-fid, white pubescent base. *Corolla* creamy white, sparsely white pubescent or glabrous, tube 2.5-3.0 cm long including ovary, dorsal lobe hooded, oblong , ca. 7.0 by 2.0 mm, apex blunt, hooded, lateral lobes narrower. *Lateral staminode* subulate, ca. 2.0 mm long. *Labellum* broadly ovoid, spreading, ca. 3.0 by 2.0 cm, base attenuate, apex round, white with yellow blotch from base to middle, pinkish veins radiate from base to margin. *Filament* ca. 3.0 mm long, glabrous; anthers ca 1.0 cm long, dehiscing lengthwise; anther crest entire, apex truncate, spreading, 5.0 by 3.0 mm, creamy white. *Ovary* cylindric, ca. 6.0 mm long, pubescent; stigma cup-shaped, scattered red-dots, aperture narrowly transverse, edge hairy; stylodes blunt, ca. 8.0 mm long. *Fruit* ellipsoid, with longitudinal 9-winged, 2.5-3 by 1.0-1.2 cm, purplish green to dark red, fruit stalk 1.0-2.0 cm long.

Phenology.— Flowering: April- July.

Ecology.— Hill evergreen forest, in light gaps, ca. 2,200 m.

Thailand.— NORTHERN: Chiang Mai (Doi Inthanon, N 18° 34′ 26.3′′, E 98° 28′ 08.2′′), Kamphaeng Phet (Mae Wong, 5 km. from Chong Yen towards HQ) (Appendix B1).

Distribution.—India, China, Myanmar, Laos, Cambodia, Vietnam?, Thailand.

Note.— *A. dealbatum* is distributed in the highlands. The leafy stem of the Thai species is much shorter than the type's description from India. The species is characterized by reddish inflorescence, white pubescent on lower leaf surface and pseudostem is painted by red stain. The description of fruit is taken from Wu and Larsen (2000).

Specimen examined.— Kaewsri-*110*, 18 May 2004, Doi Inthanon (BK, BKF) ; *M. Newman 896*, 12 July 1999, Mae Wong (BKF); *M. Newman 897*, 12 July 1999, Mae Wong (BKF).

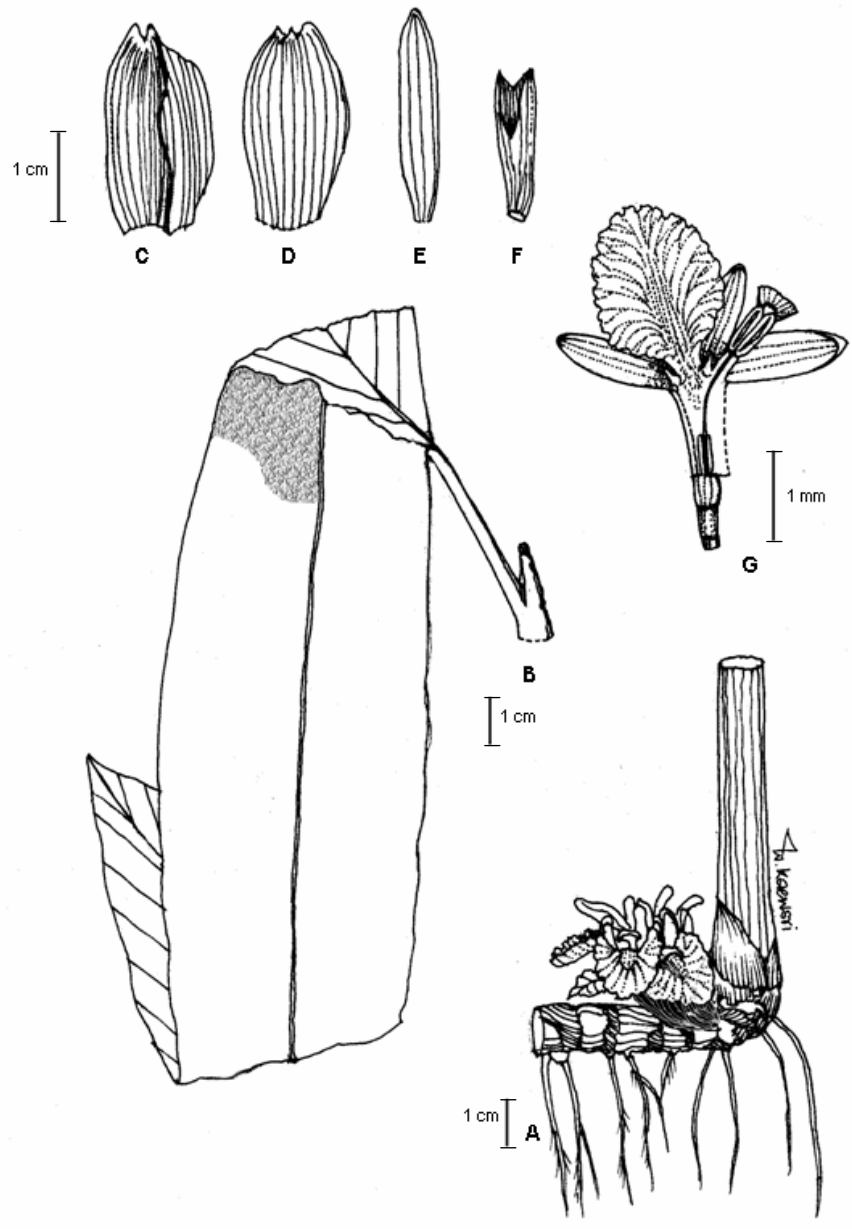

Figure 6 *Amomum dealbatum* Roxb.: A. inflorescence and rhizome; B. leaves; C,D. bract; E. bracteole; F. calyx; G. flower, dissected (drawn from Kaewsri-110).

4. Amomum hastilabium Ridl., J. Str. Br. Roy. Asiat. Soc. 32:137. 1899; K. Schum., Das Pflanzenreich. 20. Heft. IV:250. 1904; *A. holttumii* Ridl., Fl. Mal. Pen. 4:264, 1924; **Lectotype**: L. Wray Jr. (SBG). **Figure** 7. **Picture:** Appendix A4.

Rhizome short. *Leafy shoot* stout, growing in clump, ca. 3.0 m tall. *Leaf sheath* glabrous; ligule entired, apex round, 4.0-7.0 mm long, glabrous; petiole sessile to 2.0 cm long; lamina oblong to oblanceolate-oblong, 30.0-55.0 by 3.0-7.0 cm, glabrous, base attenuate, apex acuminate. *Inflorescence* ellipsoid, ca. 9.0 by 3.5 cm; peduncle ca. 10.0 cm; peduncular bract broadly ovate, 1.0-2.0 by 1.0-1.5 cm, stramineous, glabrous. *Bract* lanceolate, ca. 3.5 by 1.0 cm, apex acuminate, persistent. *Bracteole* tubular, 4.0-7.0 mm long, apex truncate and oblique, crustaceous, slightly split on 1 side, creamy white, glabrous. *Calyx* 2.0-2.8 cm long including ovary, apex obliquely truncate, entire or slightly split on 1 side, creamy white, outer surface, pubescent base. *Corolla* creamy white, outer surface sparsely pubescent, tube, 3.5-5.0 cm long including ovary, slender; dorsal lobe oblong , ca. 2.5 by 1.1 cm, apex hooded; lateral lobes oblong-spathulate, apex blunt, hooded, ca. 2.7 by 0.6 cm. *Lateral staminode* narrow subulate, ca. 4.0 mm. *Labellum* broad-ovate , ca. 4.0 by 2.5 cm, narrowly at base, margin crispate, recurved, white with yellow band along center, with purplish red short streaks on each side of band, sparsely pubescent at base. *Filament* ca. 7.0 by 2.0 mm long, glabrous; anthers 7.0-9.0 by 3.0 mm, glabrous, pale yellow, dehiscing lengthwise; anther crest slightly 3-lobed, creamy white, central lobe ca. 3.0 by 3.0 mm, round, apex slightly recurved to back of anthers, lateral ones erect, ca. 2.5 by 1.5 mm. *Ovary* cylindric, ca. 8.0 mm long, sericeus pale brown; stigma cup-shaped, aperture narrowly transverse, edge hairy; stylodes blunt, ca. 7.0 mm long. *Fruit* globose, smooth with longitudinal lines, 0.7-1.7 cm dia., brownish cream, glabrous or sparsely pale brown hirtellous; fruit stalk sessile to 5 mm long; seed angular, fragrant, ca 3.0 by 2.0 mm. black, aril white.

Phenology.— Flowering and fruiting during January - June.

Thailand.— PENINSULAR: Ranong (Khlong Naka), Phatthalung (Khao Poo-Khao Yah), Phuket, Trang, Nakhon Si thammarat (Khao Luang), Naratiwat (Su-ngai Padi) (Appendix B2).

Distribution.— Thailand (Peninsula), Malaysia.

Ecology.— Tropical rain forest, shaded area, limestone bedrock or along streams, 50- 150 m.

Note.— *Amomum hastilabium* Ridl. is similar to *A. testaceum* Ridl., but differs in its glossy bracts, broader labellum and recurve margin. The species is common in Southern Thailand.

Specimen examined.— *C. Maknoi 96*, 23 March 2000, Trang(QBG); *C. Maknoi T78*, 10 March 2000, Narathiwat (PSU, QBG); *Kaewsri-37*, 10 January 2004, Ranong (BK, BKF); *L. Wray Jr. 3476*, May 1889, Perak (SBG); *Maxwell 85-509*, 19 May 1985, Nakhon Si Thammarat (PSU); *Maxwell 86-379*, 15 June 1986, Phatthalung (CMU, PSU); *M. Newman54,* 17 March 1985, Nakhon Si Thammarat (PSU).

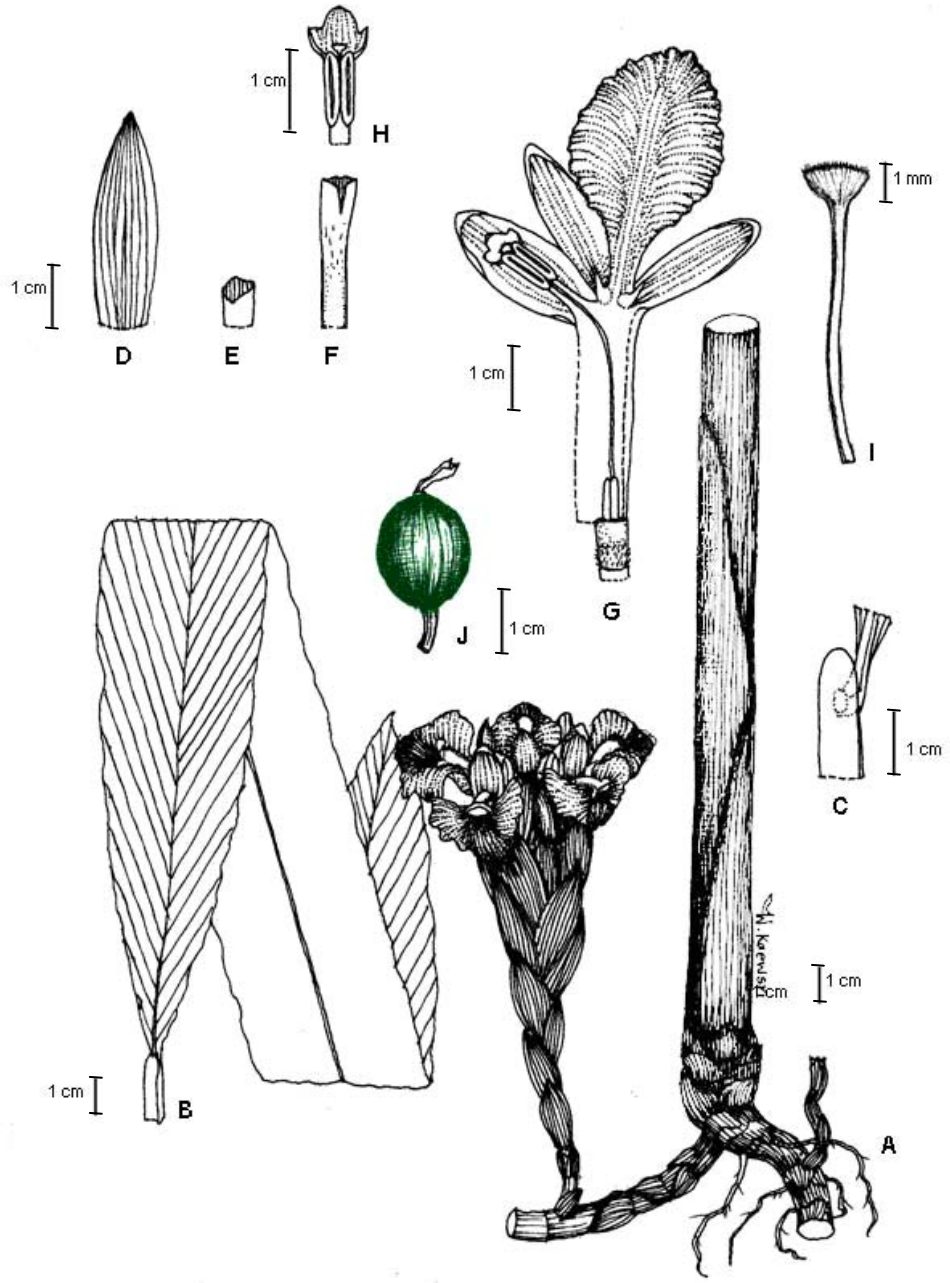

Figure 7 *Amomum hastilabium* Ridl.: A. inflorescence; B. leaf; C. ligule; D. bract; E. bracteole; F. calyx; G. flower, dissected; H. anther; I. style and stigma (drawn from Kaewsri-37); J. fruit (drawn from L. Wray Jr. 3476).

5. Amomum koenigii Gmelin., Linn. Syst. Nat. 2:6. (1791); Wu & Larsen, Fl. China, 24:352. (2000). **Type:** König (K). **Figure** 8. **Picture:** Appendix A5.

Rhizome short. *Leafy shoot* slender, growing in clump, 2.0-3.0 m tall. *Leaves* 10-25; sheath green, glabrous; ligule subleathery, pubescent, apex 2-lobed, round, purple, 3.0-5.0 mm long; petiole ca. 8.0 mm long, glabrous; lamina oblong-lanceolate to lanceolate, 14.5-34.5 by 4.5-8.6 cm, glabrous, base attenuate or round, apex acuminate. *Inflorescence* subglobose, ca. 2.5-3.0 cm dia.; peduncle 17.0-37.0 cm long; peduncular bract oblong, ca.4.0 by 2.7 cm, sparsely pubescent, leathery, apex mucronate. *Bract* oblong or obovate-oblong, ca. 2.0 by 1.0 cm, outer surface pubescent at base, purplish green, apex obtuse, apiculate. *Bracteole* tubular, ca. 1.0 cm long, apex unequally 2-fid, glabrous. *Calyx* ca. 2.0 cm long including ovary, apex 3-fid and shallowly split on 1 side, white pubescent base. *Corolla* creamy white, tube glabrous, 2.0-2.5 cm long including ovary, dorsal lobe hooded, ovate, ca. 1.4 by 1.0 cm, apex blunt hooded, lateral lobe narrower. *Lateral staminode* subulate, ca. 1.0 mm long. *Labellum* rhomboid, spreading, ca. 1.5 by 1.5 cm, base attenuate, apex 2-fid and attenuate, margin revolute toward apex, white with pale yellow mid-band, with pale red lateral stripes, sparsely white pubescent base. *Filament* 1.0-2.0 mm long, glabrous; anther 9.0 by 2.5-3.0 mm, dehiscing lengthwise; anther crest entire, round, 4.0-5.0 by 3.0 mm, creamy white, glabrous. *Ovary* cylindric, ca. 2.0 by 2.0 mm, white pubescent; stigma cup-shaped, the aperture edge hairy, stylode blunt, ca. 3 mm long. *Fruit* oblong, elliptic or globose, smooth with 3 longitudinal grooves, glabrescent, 2.5 by 2.0 cm, reddish brown, fruit stalk sessile to 3 mm long, apex with calyx; seed angular, 6.0-7.0 by 4.0-5.0 mm, brown, enclosed by white arile.

Phenology.— Flowering and fruiting during April- July.

Thailand.— CENTRAL: Nakorn Nayok; SOUTH-EASTERN: Chon Buri (Khao Kiew), Chantaburi (Khlong Khuar Wai, Khao Soi Dao); SOUTH-WESTERN: Kanchanaburi (Sai Yok and Thong Pha Phum); NORTHERN: Tak (Mae Moei), Kamphaeng Phet (Mae Wong), Chiang Mai (Doi Inthanon); EASTERN: Nakhon Ratchasima (Khao Phrik); PENINSULAR: Chumphon, Phuket, Phatthalung (Khao Poo-Khao Yah) (Appendix B2).

Distribution.— India, Sri Langka, China, Myanmar, Laos, Cambodia, Vietnam?, Thailand.

Ecology.— Dry or hill evergreen forest, Open disturbed place along the road, secondary growth in a primary evergreen forest, deciduous bamboo forest, along the river, limestone or granite bedrock, 200-1,300 m.

Note.— *A. koenigii* Gmelin. widely distribute from northern Thailand to upper part of southern Thailand. The species is characterized by its reddish ligule and fruit is smooth and reddish brown similar to grape's fruit.

Specimen examined.— *C. Phengklai et al 6840*, 23 July 1988, Doi Inthanon (BKF); *Kaewsri 21*, 24 May 2003, Thong Pha Phum (BK, BKF); *Kaewsri 29*, 7 June 2003, Hub luk (BK, BKF); *Maxwell 76-446*, 25 July 1976, Khao Kiew (BK); *Maxwell 86-377*, 15 June 1986, Khao Poo-Khao Yah (PSU); *Maxwell 87-1089,* 1 October 1987, Doi Suthep (CMU); *Maxwell 88-837,* 2 July 1988, Doi Suthep (CMU); *Maxwell 91-508*, 26 May 1991, Fang (CMU); *M. Newman 885,* 6 July 1999, Mae Mae Wong (BKF); *M. Newman 899,* 12 July 1999, Mae Wong (BKF); *M. Newman 915,* 16 July 1999, Mae Moei (BKF); *Kaewsri-3*, 25 April 2003, Sai Yok (BK, BKF); *P. Srisanga 1449*, 27 May 2000, Doi Phu Ka (QBG).

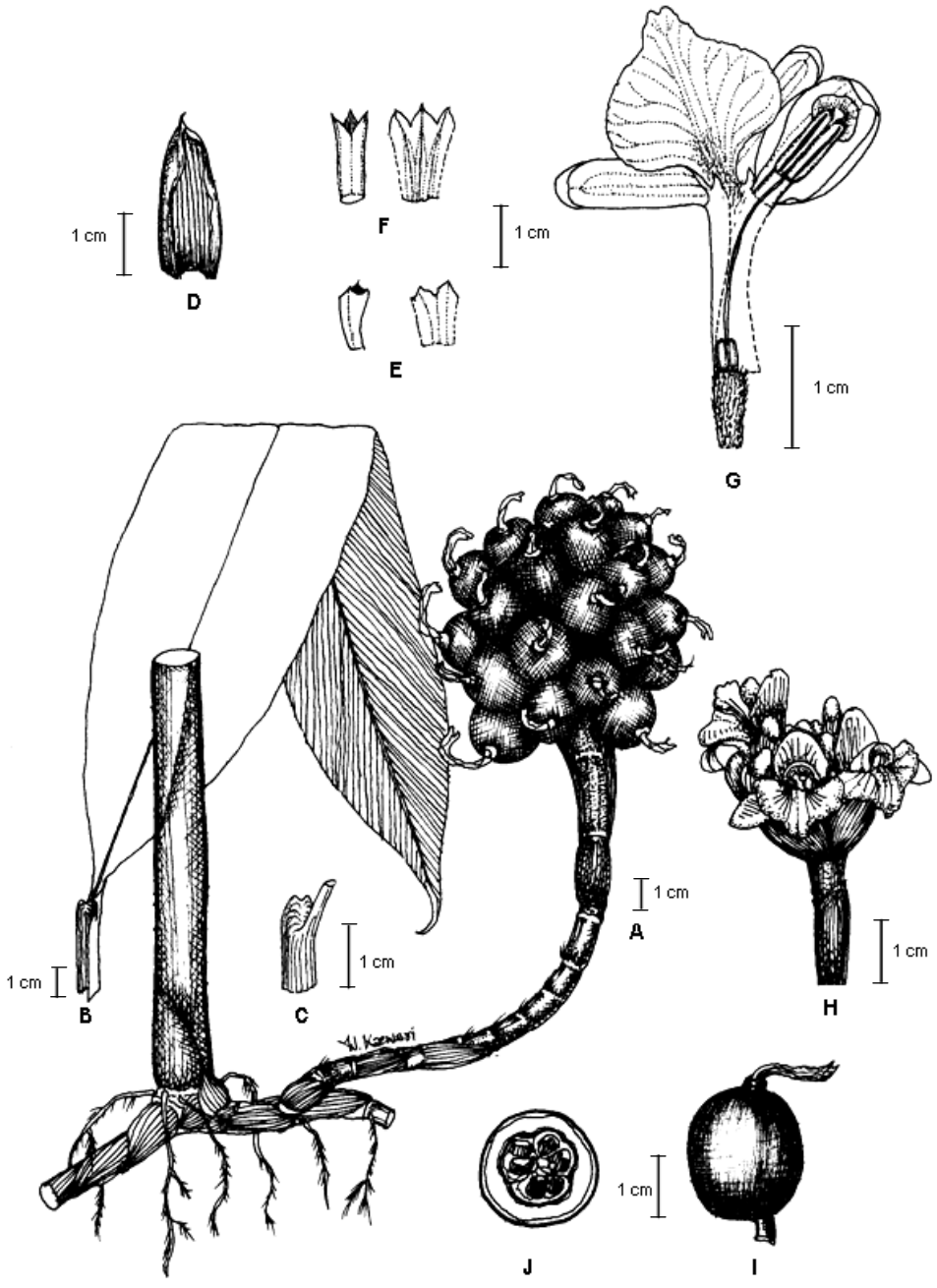

Figure 8 *Amomum koenigii* Gmelin.: A. infructescence; B. leaf; C. ligule; D. bract; E. bracteole, dissected; F. calyx, dissected; G.flower, dissected; H. inflorescence (drawn from Kaewsri-3); I. fruit, J. fruit, X-section (drawn from Kaewsri-21).

6. Amomum micranthum Ridl.**,** J.S.B.R.A.S. 32:138. 1899, Fl. Malay Penninsula. 4:267. **Lecto type:** SBG. **Figure** 9. **Picture:** Appendix A6.

Rhizome elongate. *Leafy shoot* slender, 0.9-1.2 m tall. *Leaves* 19-25; sheath glabrous, margin ciliate; ligule entire, apex round, margin ciliate, papery, 1-2 mm long; petiole sessile; lamina oblong to narrowly oblong, 15.0-22.0 by 2.0-3.0 cm, glabrous, base attenuate, apex acuminate, tip caudate, 1.0-2.5 cm. *Inflorescence* densely obovate or conical, 3.0-4.0 by 2.0-2.5 cm, dark red; peduncle 8.0-11.0 cm long; peduncular bract ovate, ca. 0.8-1.4 by 0.8-1.0 cm, reddish brown, apex hooded, mucronate. *Bract* oblong to obovate-oblong, 1.3-1.7 by 0.7-0.9 cm, brownish red, base pubescent, apex acuminate. *Bracteole* tubular, ca. 8.0 mm long including ovary, apex unequally 2-fid, creamy white, base pubescent. *Calyx* 1.5-1.8 cm long including ovary, apex 3-fid, outer surface, base slightly pubescent, creamy white. *Corolla* creamy white, tube glabrous, ca. 1.8 cm long including ovary, dorsal lobe oblong, ca. 8.0 by 4.0 mm, apex acuminate, hooded, lateral lobe narrower. *Lateral staminode* linear, ca. 1-2 mm long, base swollen, apex truncate, with sparsely hair. *Labellum* obovoid, spreading, 10.0-12.0 by 6.0-7.0 mm, base attenuate, apex truncate, slightly revolute, creamy white with pinkish red dots at base and radiate upward. *Filament* ca. 5.0 mm long, linear, introrse; anther 3.0-4.0 by 2.0-3.0 mm, dehiscing lengthwise; anther crest 3-lobed, ca. 4.0 by 2.0 mm, creamy white, central lobe ca. 3.5 by 1.0 mm, round, recurve, lateral lobe ca. 2.0 by 1.0 mm, auriculate, apex acute, erect. *Ovary* cylindric, ca. 3.0 by 1.5 mm; stigma capitate, the aperture narrowly transverse, edge hairy; style pubescent; stylode blunt, ca. 2.5 mm long. *Fruit* sub-globose, ca. 1.0-1.6 cm, sparsely covered with fleshy curve spines, brownish green when young, turning dark red when ripe, with persistent calyx and stigma, 1.2-1.4 cm long at apex, 1-6; seed angular, ca. 7.0 by 4.0 mm, arile white.

Phenology.— Flowering and fruiting during April- July.

Thailand.— SOUTH-EASTERN: Chantaburi (Khlong Khuar Wai); PENINSULAR: Ranong (Krom Luang Chumphon Wildlife Sanctuary (WS), South) (Appendix B2) .

Ecology.— Tropical rain or dry evergreen forest, bamboo forest, ca. 250 m.

Note.— The specimens collected in Thailand are more robust than the type specimen deposited in SBG.

Specimen examined.— *Kaewsri 63*, 25 March 2004, Chanthaburi (BK, BKF); *Kaewsri-84*, 7 April 2004, Ranong (BK, BKF).

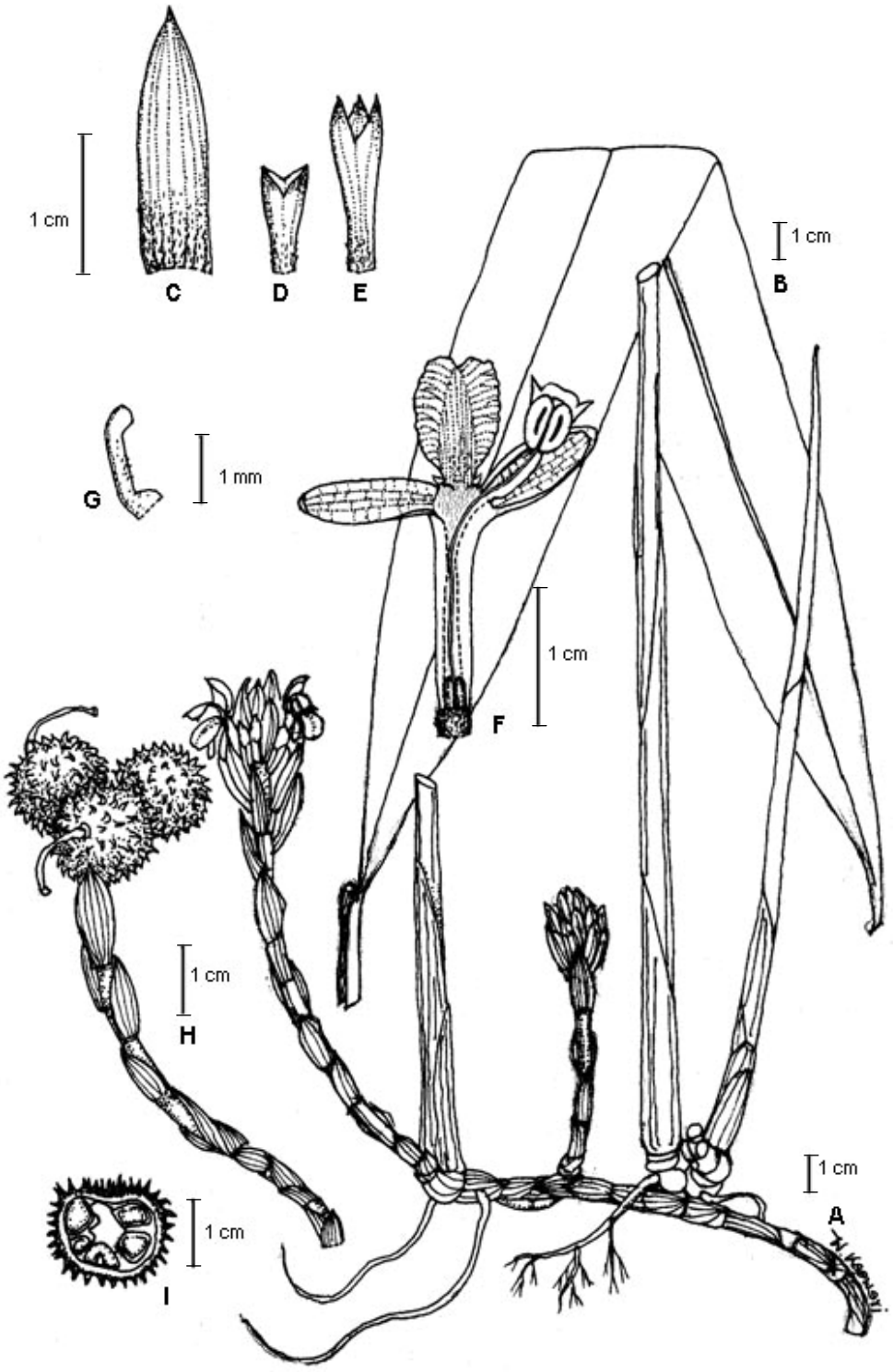

Figure 9 *Amomum micranthum* Ridl.: A. inflorescences and rhizome; B. leaf; C.bract; D. bracteole; E. calyx; F. flower, dissected; G. lateral staminode; H. infructescence, I. fruit, L-section (drawn from Kaewsri-63).

7. Amomum pierreanum Gagnep., Bull. Soc. Bot. Fr. 53: 143(1906); Gagnep. Fl. Indo-China. Vol. 6: 112 (1908). **Type:** Paris. **Figure** 10. **Picture:** Appendix A7.

Rhizome short, elevate by stilt root 25-50 cm above ground; stilt root brown, quadrangular at base, ca. 8 mm dia. *Leafy shoot* stout, 1.0-2.3 m tall. *Leaves* 17-22; sheath greenish red at base; ligule entire, apex round, glabrate, ca. 6.0-10.0 mm long; petiole 1.0-3.0 cm long; lamina oblong, 9.0-60.0 by 4.5-9.0 cm, upper surface green, lower surface paler, young leaf brownish green, base cuneate, apex acuminate, margin undulate. *Inflorescence* broadly ovate, globose or cylindric, emerge near base of pseudostem, 5.0-7.0 by 3.0-5.0 cm, pale brown; peduncle, 1.0-5.0 cm long, stout; peduncular bract broadly ovate, ca. 1.5 by 1.0 cm, pale brown, densely pubescent. *Bract* hooded, oblong, 2.5-4.0 by 1.5-2.0 cm, pale brown, apex acuminate or apiculate, persistent. *Bracteole* tubular, ca. 2.5 -2.8 cm long, apex 3-lobed, pale brown, reddish tinged at base, outer surface white pubescent. *Calyx* 1.5-2.0 cm long including ovary, apex obscurely 3-fid, pinkish white. *Corolla* bright red, glabrous, tube, 2.5-3.0 cm long including ovary, dorsal lobe broadly hooded, oblong, ca. 1.9 by 1.6 cm, apex 3-lobed, hooded, lateral lobes hooded, oblong, ca. 2.0 by 0.7 cm, apex acuminate. *Lateral staminode* subulate or linear, ca. 5.0 by 1.0 mm, margin overlap with labellum. *Labellum* obovate, apex 3-lobed, ca. 2.9 by 2.5 cm, spreading, middle lobe narrow round, ca. 6 mm wide, lateral lobe wider, base attenuate, occasionally auriculate, bright yellow with pale red lines radiate from base to margin. *Filament* distinctly incurve to labellum, ca. 11.0 by 2.0 mm; anther ca. 8.0 by 3.0 mm, pale yellow, dehiscing lengthwise; anther crest 3-lobed, ca. 9.0 by 2.0 mm, pale yellow, central lobe ca. 3.0 by 1.0 mm, round, lateral lobe 5.0 by 1.5 mm, horn-liked. *Ovary* cylindric, ca. 8.0 mm long, pubescent; stigma cup-shaped, aperture narrowly transverse, edge hairy; style glabrous, stylode blunt, ca. 3.0 mm long. *Fruit* not seen.

Phenology.— Flowering: April.

Thailand.— CENTRAL: Nakhon Nayok (Khao Yai, N 14° 26′ , E 101° 22′); SOUTH-EASTERN: Chantaburi (Khao Khitchakut National Park, N 12° 50′ 31′′, E 102° 09′ 43′′) (Appendix B3).

Ecology.— Dry evergreen forest, hard wood forest, granite or sandstone bedrock., 774-1,100 m.

Distribution.— Laos, Cambodia, Vietnam, Thailand.

Note.— *Amomum pierreanum* Gagnep., is a highland species. It is characterized by elevated pseudostems supported by stilt root, reddish corolla and yellowish labellum. This species is similar to *A. utriculosum* Ridl. but differs in its broadly ovate inflorescence and shorter peduncle. The species is distributed in Khao Yai (Khao-kiew).

Specimen examined.— *Kaewsri-122*, 2 June 2004, Khao Yai (BK, BKF); *Maxwell 74-799*, 24 April 2000, Khao Yai (BK, CMU); *Newman 929,* 20 July 1999, Khao Khitchakut (BKF); *S. Chongko 60*, 14 April 2000, Khao Yai (BKF).

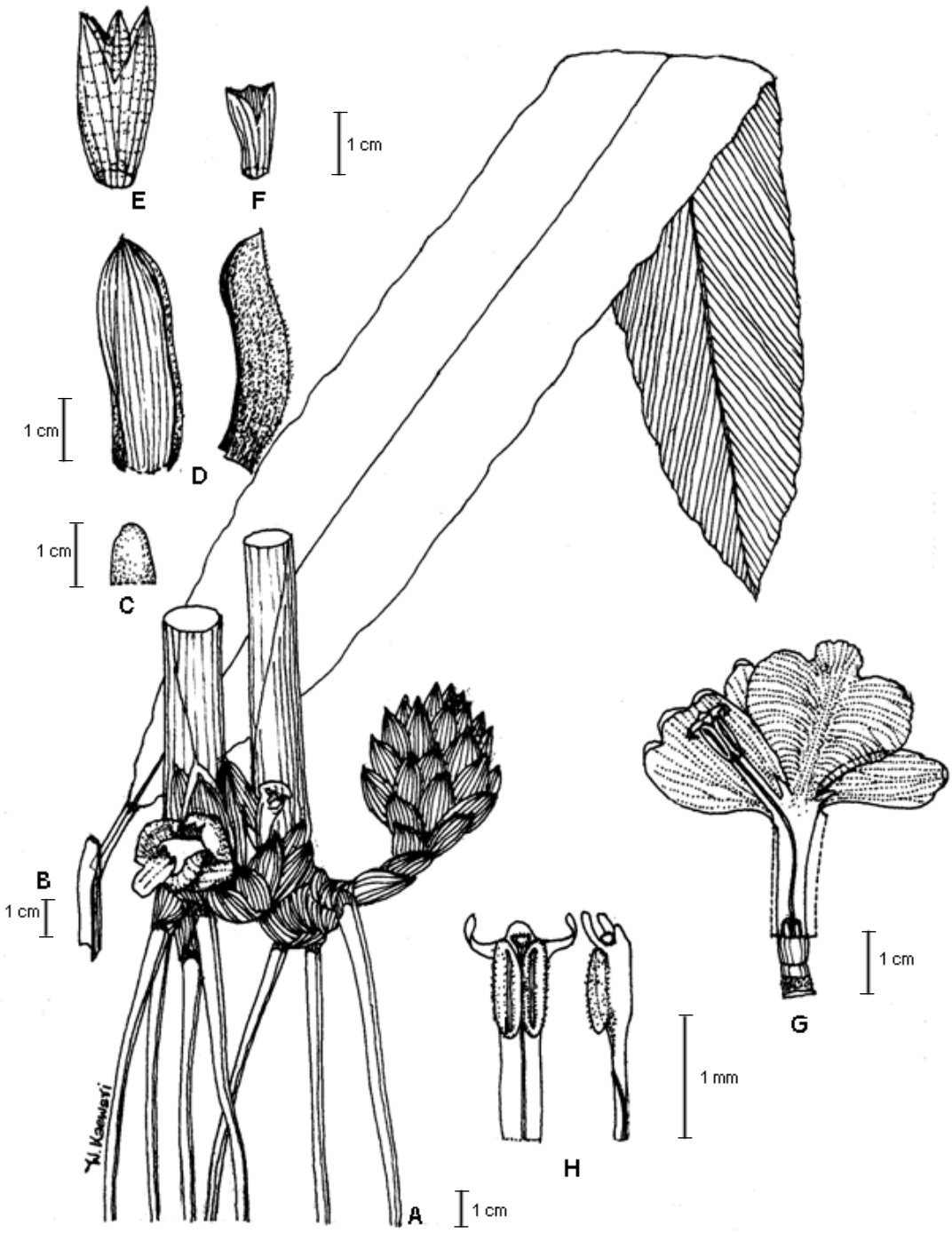

Figure 10 *Amomum pierreanum* Gagnep.: A. inflorescence and stilt roots; B. leaf, C. ligule; D. bract; E. bracteole; F. calyx; G. flower, dissected; H. stamen (drawn from Kaewsri-122).

8. Amomum repoense Pierre ex Gagnep., Bull. Soc. Bot. Fr. 53: 144. (1906); Gagnep., Fl. Indo-China. Vol. 6: 114. (1908); Wu & Larsen, Fl. China, 24:356. (2000). **Type**: Paris**. Figure** 11. **Picture:** Appendix A8.

Rhizome short. *Leafy shoot* slender, 0.3-0.5 m tall. *Leaves* 4-5; sheath dark green, reticulate; ligule 2-lobed, apex dried papery, 3-7 mm long; petiole 10-25 cm long; lamina obovate-oblong to elliptic, 20.0-46.0 by 9.0-15.0 cm, paperly, base attenuate to obtuse, apex acuminate, tip caudate, 0.5-1.5 mm. *Inflorescence* conical, ovate or obovate, ca. 6.0-10.0 by 4.5-8.0 cm; peduncle 5-16 cm long; peduncular bract broadly oblong, pinkish green, pubescent, 1.0-2.3 by 1.2-2.5 cm, apex emarginate. *Bract* broadly ovate, 0.8-1.8 by 0.5-1.5 cm, brown, apex round. *Bracteole* absent. *Calyx* 1.4-2.0 cm long including ovary, apex 3-fid, pubescent base. *Corolla* cream, tube glabrous, ca. 1.8 cm long including ovary, dorsal lobe oblong, ca. 1.5 by 0.5 cm, apex mucronate, lateral lobe narrower, apex blunt, hooded. *Lateral staminode* absent. *Labellum* 3-lobed, orbiculate, ca. 2.0 cm dia., spreading, base clawed ca. 3.0 mm long, apex emarginate, white with pale yellow blotchs from base toward apex and radiate reddish purple spots from base to middle. *Filament* 2.0-3.0 by 1.0 mm, linear, glabrous; anther ca. 7.0-8.0 by 2.5-3.0 mm, glabrous, dehiscing lengthwise; anther crest 3-lobed, round, ca. 7.0 by 2.0 mm, whitish, central lobe 3.0-1.0 mm, slightly reflex on to back of anther, lateral lobe ca. 2.0 by 1.0 mm. *Ovary* oblong to elliptic, ca. 5.0 by 2.0 mm, sparsely pubescent; stigma abruptly widened, the aperture edge hairy; stylode blunt, 3.0-4.0 mm long. *Fruit* globose or broadly elliptic, 9-longitudinally winged, young fruit ca. 1.0 by 0.8 cm, pale yellow or reddish yellow, glabrous or sparsely pubescent; fruit stalk ca. 5 mm.

Phenology.— Flowering and fruiting during April- August.

Ecology.— Dry evergreen n forest, shade of trees or shurbs, GPS.- N 12° 47′ 57.4′′, E 102° 20′ 27.6′′; 322-700 m.

Thailand.— EASTERN: Nakhon Ratchasima (Khao Yai); SOUTH-EASTERN: Chanthaburi (Khlong Khuar Wai), Sa Kaeo (Pang Si Da), (Appendix B3). **New record for Thailand.**

Distribution.— Thailand, Laos, Cambodia, Vietnam and Southern China

Note.— *Amomum repoense* Pierre ex Gagnep. is limited to eastern and north-eastern Thailand. It is characterized by a short and net-liked pseudostem, long petiole (similar to that of *Elettariopsis*) many flowers per bract.

Specimen examined: *Kaewsri-64*, 25 March 2004, Khlong Khuar Wai (BK, BKF); *Kaewsri 103*, 2 May 2004, Pang Sida (BK, BKF); *Kaewsri 121*, 2 June 2004, Khao Yai (BK, BKF).

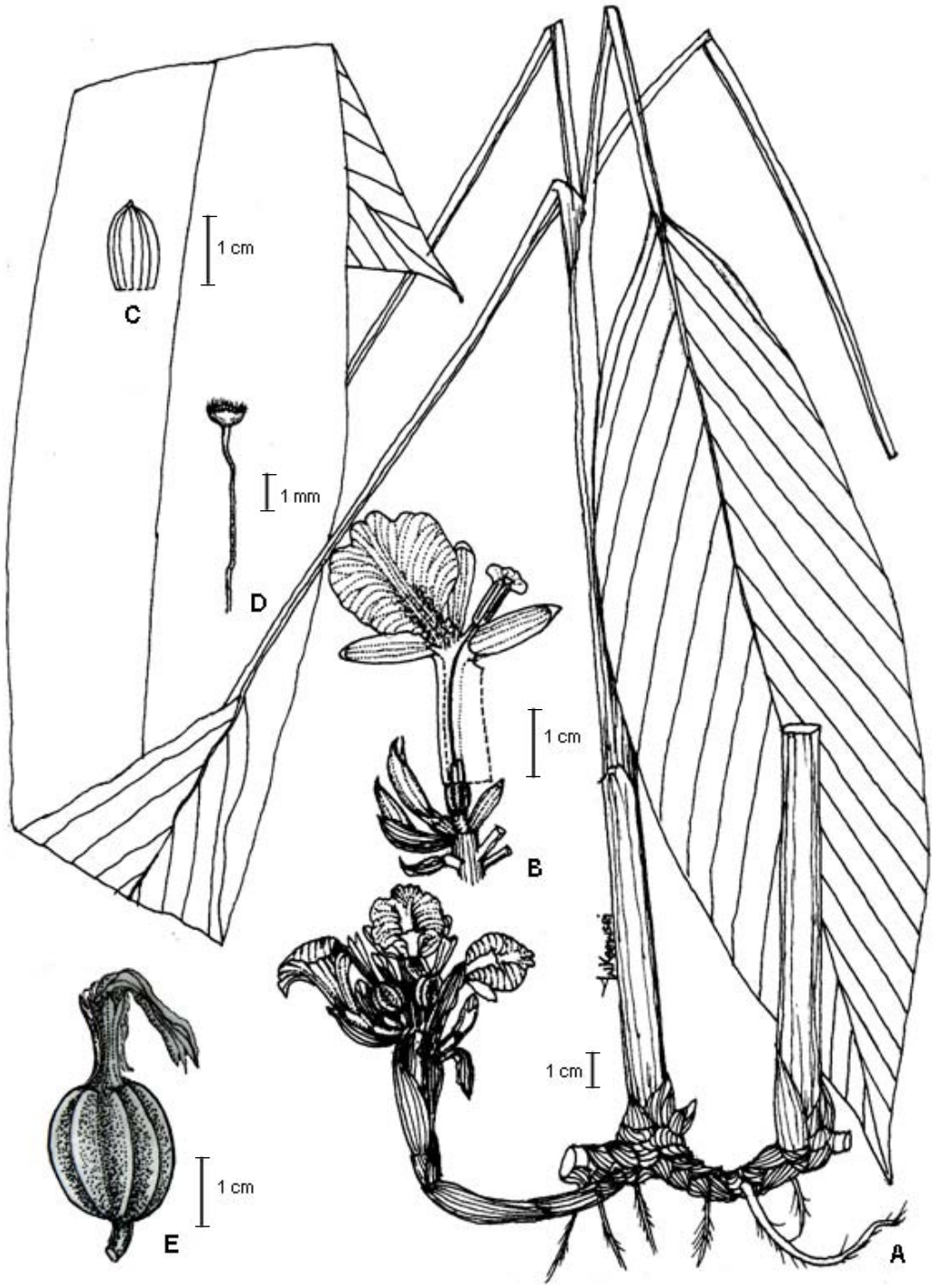

Figure 11 *Amomum repoense* Pierre ex Gagnep.: A. inflorescence and rhizome; B. flower, dissected; C. bract; D. style and stigma; E. fruit (drawn from Kaewsri-121).

9. Amomum rivale Ridl., Flora Mal. Pen. 5: 338. (1925); Holt. Gard. Bull. S. 13: 205. (1950) . **Isotype**: Burkill (SBG). **Figure** 12. **Picture:** Appendix A9.

Rhizome elongate. *Leafy shoot* slender, ca. 1.0-1.2 m tall. *Leaves* 6-16; sheath longitudinally striate; ligule 2-lobed, papery, outer surface and margin hairy, 3.0-5.0 mm long; petiole sessile to 2.0 cm long, villous; lamina narrowly oblong to elliptic-oblong, 25.0-41.0 by 2.5-7.5 cm, lower surface pale green, densely pubescent, base cuneate or obtuse, apex acuminate, tip caudate, 1.0-4.0 cm. *Inflorescence* conical or cylindric, 5.0-6.0 by 2.0-3.5 cm; peduncle 5.0-8.0 cm long; peduncular bract oblong, 1.3-4.0 by 1.2-1.5 cm, with pubescent, brown, papery, apex acuminate. *Bract* deltoid to lanceolate, ca. 3.0-5.0 by 1.0-1.5 cm, papery, outer surface and margin pubescent, apex acuminate. *Bracteole* tubular, shallowly split on 1 side, ca. 1.5 cm long, apex unequally 3-fid, outer surface hairy. *Calyx* ca. 1.7-2.0 cm long including ovary, apex unequally 3-fid and shallowly split on 1 side, pinkish white, outer surface pubescent. *Corolla* creamy white, outer surface puberulous, tube ca. 2.5 cm long including ovary, dorsal lobe hooded, oblong, ca. 0.7 by 1.5 cm, abruptly narrowed at apex; lateral lobe narrower, apex acuminate. *Lateral staminode* minute subulate, surface hairy. *Labellum* spathulate or obovate, hooded, slightly 3-lobed , ca. 2.0-2.9 by 1.0-1.5 cm, base attenuate, middle lobe erect, apex 2-fid, lateral lobe broadly rounded and magin revolute, yellow with red stripes from base to the middle, base pubescent. *Filament* ca.5.0 mm long, glabrous; anther ca. 5.0 by 3.0 mm, short dehiscing at the middle; anther crest 3-lobed, ca. 4.0 by 3.0 mm, pale yellow, large central lobe, round and emarginate, reflex on to back of anther, smaller lateral lobes triangular, apex acute, erect. *Ovary* cylindric, 2-3 mm long, sericeous; stigma cup-shaped, the aperture ciliate, stylode blunt, ca. 3 mm long. *Fruit* 1-4 per infructescence, globose, covered with short spines, 1.6-1.8 cm dia. include spines; spines red, ca. 1 mm long; fruit stalk sessile; seed angular, ca. 7 by 4 mm.

Phenology.— Flowering and fruting during April- July.

Thailand.— SOUTH-WESTERN: Kanchanaburi (Sai Yok, Thong Pha Phum); PENINSULAR: Songkhla (Haad Yai, Rataphum), Nakhon Si Thammarat (Tah Sa La), Phatthalung (PSU) (Appendix B3).

Ecology.— Tropical rain or dry evergreen forest. ca. 400-1,200 m.

Note.— *A. rivale* Ridl. is similar to *A. macrodous* Scort., but differs in its leaves are pubescent on the lower surface, inflorescence and flower are bigger and bracts are hairy.

Specimen examined.— *Burkill 16945a*, 12 November 1924, Pahang (SBG); *C. Maknoi 2,* 20 May 1998, Trang (QBG); *Kaewsri-4*, 25 April 2003, Sai Yok (BK, BKF); *Kaewsri-5*, 25 April 2003, Sai Yok (BK, BKF); *Kaewsri–23*, 24 May 2003, Thong Pha Phum (BK, BKF); *Maxwell 85-433,* 4 May 1985, Haad Yai (PSU); *Maxwell 85-523,* 25 May 1985, Haad Yai (PSU); *Maxwell 86-342,* 3 June 1986, Tah Sa La (PSU); *Maxwell 86-550,* 9 August 1986, Phatthalung (PSU); *Newman 13,* 11 August 1984, Haad Yai (PSU); *Newman 23,* 16 October 1984, Rattaphum (PSU); *P. Sirirugsa 1062*, 24 April 1987, Rataphum (PSU); *P. Sirirugsa 1069,* 24 April 1987, Rattaphum (PSU); *P. Sirirugsa 1088*, 20 June 1987, Haad Yai (PSU).

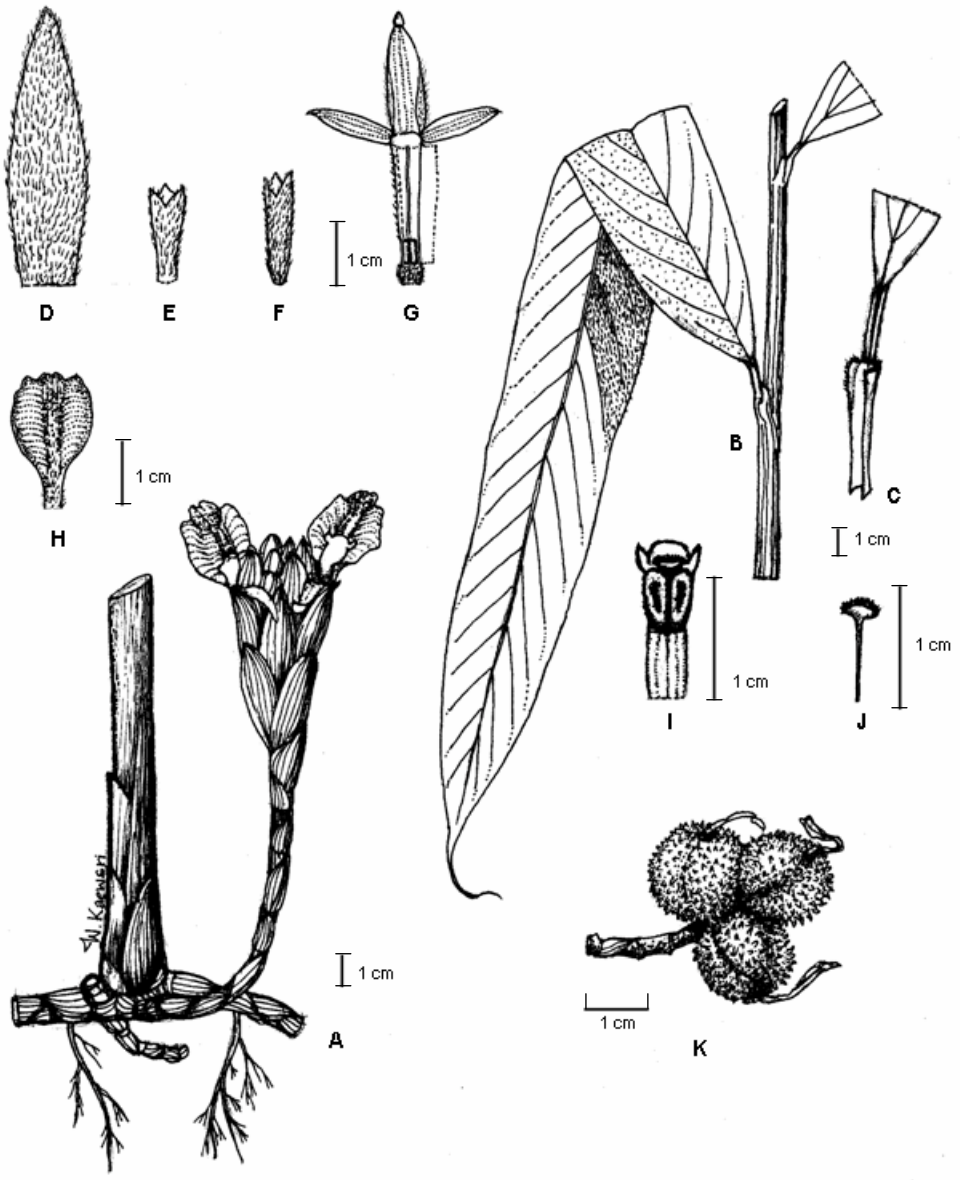

Figure 12 *Amomum rivale* Ridl.: A. inflorescence and rhizome; B. leaf; C. ligule; D. bract; E. bracteole; F. calyx; G. flower, dissected; H. labellum; I. stamen; J. stigma; K. fruit (drawn from Kaewsri-4).

10. Amomum siamense Craib, K.B. 10: 402. (1912). **Type**: K?. **Figure** 13.

Picture: Appendix A10.

Rhizome short, pinkish white. *Leafy shoot* stout, ca. 1.8 m tall. *Leaves* 4-6; sheath pale green; ligule 2-lobed, ca. 6.0 mm long, sparsely white pubescent; petiole 3.0-6.0 cm long; lamina oblong, 15.0-67.0 by 7.0-17.0 cm, lower surface silver-green, densely appressed silverly pubescent, base attenuate, apex acuminate. *Inflorescence* ovoid, ca. 5.0 by 4.0 cm; peduncle short or absent; peduncular bract broadly ovate, brown, glabrous, leathery, apex acute. *Bract* lanceolate, ca. 4.0 by 1.0 cm, glabrous, papery, brown, apex acuminate, soon disintegrated. *Bracteole* tubular, ca.1.5 cm including ovary, apex obliquely truncate, membranous, outer surface glabrous, yellowish cream. *Calyx* ca. 4.0 cm long including ovary, apex 3-fid, with shallowly split on 1 site, membranous, glabrous, brownish white. *Corolla* creamy white, glabrous, tube ca. 4.0 cm long including ovary, dorsal lobe hooded, oblong , ca. 3.3 by 1.0 cm, apex apiculate, lateral lobe ca. 3.0 by 1.0 cm, apex acuminate, hooded. *Lateral staminode* subulate, 1.0-2.0 mm long, white, red at base. *Labellum* broadly ovate, spreading, ca. 4.0 by 3.0 cm, base attenuate, apex obtuse, margin wrinkle, white with yellow blotch at center and rediate toward margin, red dotted lines radiate from base toward margin. *Filament* ca. 2.0 mm long, with white pubescent; anther ca. 12.0 by 4.5 mm, dehiscing lengthwise; anther crest entire, apex broader and truncate, ca. 10.0 by 2.5 mm, creamy white. *Ovary* cylindric, ca. 5.0 by 4.0 mm long, smooth, glabrous; stigma cup-shaped, the aperture narrowly transverse, edge hairy; style white, glabrous, stylode blunt, ca. 8.0 mm long. *Fruit* obovate-truncate or obpyriform, with 7-13-longitudinal ridged, 2.5-3.0 cm dia, pale green when young turning brown when dried, glabrous, fruit stalk ca.7.0 mm long; seed subglobose, ca. 3.0-4.0 mm dia., aril white.

Phenology.— Flowering and fruiting during April- August.

Thailand.— NORTHERN: Tak (Doi Musur), Chiang Mai (Doi Suthep), Nan (Si Nan), Kampaengpet (Mae Wong) (Appendix B4).

Distribution.— Thailand.

Ecology.— Hill or dry evergreen forest, mostly shaded, moist area in rugged limestone terrain, muddy stream area in the primary evergreen forest, granite bed rock, 500-1,300 m.

Vernacular name.— Reo Huo-Chang (เร่วหัวช้าง).

Uses.— Its young fruit is edible.

Note.— *A. siamense* Craib widely distribute in northern Thailand. It is characterized by silvery hairs on lower leaf surface and ridged fruit.

Specimen examined.— *Kaewsri-14*, 3 May 2003, Doi Musur (BK, BKF); *Kaewsri 116*, 4 July 2004, Srinan (BK, BKF); *Kerr 5336*, 3 May 1921, Doi Inthanon (BK); *Maxwell 87-806*, 11 May 1987, Doi Suthep (CMU); *Maxwell 88-582*, 5 May 1988, Doi Suthep (CMU); *Maxwell 88-616*, 12 August 1988, Doi Suthep (CMU); *Maxwell 88-645*, 19 May 1988, Doi Suthep (CMU); *Maxwell 89-935*, 22 July 1989, Doi Suthep (CMU); *Maxwell 90-739*, 8 July 1990, Doi Suthep-Pui (CMU); *Maxwell 93-583*, 5 June 1993, Doi Kuhn Dahn (CMU); *Maxwell 96-791*, 2 June 1996, Jae Sawn (CMU); *Maxwell 04-235*, 22 April 2004, Mae Wang (CMU); *Newman 906*, 13 July 1999, Mae Sot-Umphang (BKF); *R. Geesink 5567,* 30 May 1973, Tak (BK).

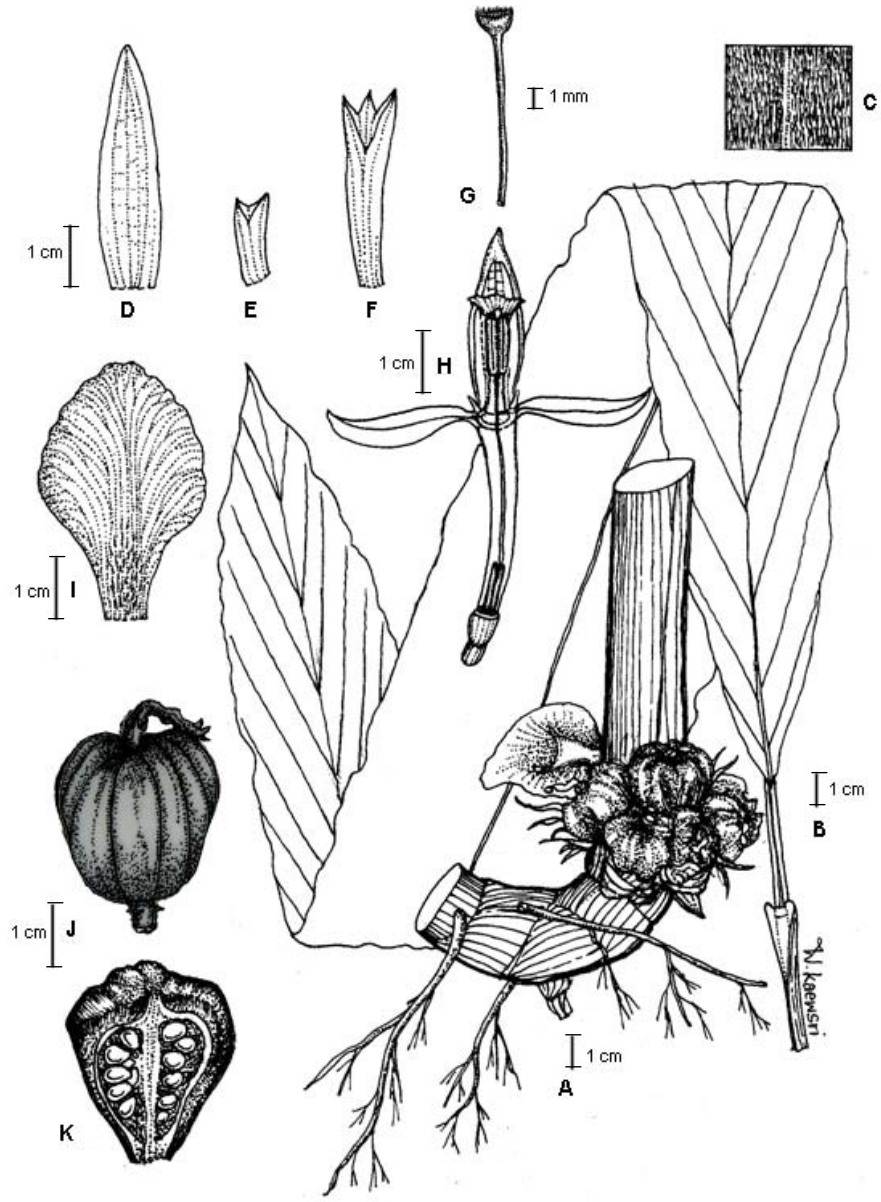

Figure 13 *Amomum siamense* Craib: A. inflorescence and rhizome; B. leaf; C. lower surface of leaf with silvery hair; D. bract; E. bracteole; F. calyx; G. stigma; H. flower, dissected; I. labellum; J. fruit, K. fruit, L-section (drawn from Kaewsri-14).

11. Amomum testaceum Ridl., Str. Br. Roy. Asiat. Soc.32:135. 1899; *A. krervanh* Pierre ex Gagn., Bull. Soc. Bot. Fr. 53:138. 1906; Holt., Gard. Bull. Sin. XIII:205. 1950. **Lectotype:** SBG. **Figure** 14. **Picture:** Appendix A11.

Rhizome short, white. *Leafy shoot* slender to stout, 1.3-3.2 m tall, base swollen, green or purplish tinged. *Leaves* 7-18; sheath green, glabrous, ciliate near ligule or glabrous; ligule 2-lobed, usually dried papery, margin ciliate, ca. 5 mm long; petiole sessile, glabrous; lamina oblong, 13.0-62.0 by 6.0-13.0 cm, surfaces glabrous, base attenuate, apex acuminate. *Inflorescence* conical or cylindric, 5.0-14.0 by 2.5-5.0 cm; peduncle 4.0-75.0 cm; peduncular bract oblong to lanceolate, 2.5-5.0 by 1.0-2.0 cm, stramineous, outer surface pubescent, margin ciliate. *Bract* lanceolate, oblong or ovate-oblong, 3.0-5.0 by 1.0-2.0 cm, apex acuminate or apiculate, papery, stramineous, outer surface with narrow longitudinal grooves and sparsely appressed hairs, pale brown, margin ciliate, persistent. *Bracteole* tubular, 2.0-2.5 cm long including ovary, apex 2 or 3-fid, shallowly split down to 1 cm on one side, creamy white, outer surface with pale brown hairs. *Calyx* 2.3-2.8 cm long including ovary, apex 3-fid, creamy white, outer surface appressed with light brown pubescent. *Corolla* creamy white, outer surface pubescent, tube 2.3-2.5 cm long including ovary, dorsal lobe narrowly obovate or oblong, 1.4-1.5 by 0.5-0.7 cm, apex hooded, apiculate, lateral lobe hooded, oblong, narrower, apex acuminate. *Lateral staminode* absent. *Labellum* hooded, obovate, apex round, 1.5-2.0 by 0.8-1.7 cm, wrinkle and narrowly reflex, base attenuate, white with a broad dull yellow band at apex and paler toward base, with dull red lines on each side of band, from base toward middle. *Filament* 5.0-6.0 by 2.0-3.0 mm long, glabrous; anther 2.5-3.0 by 2.0-2.5 mm, glabrous, pale yellow, dehiscing lengthwise; anther crest 3-lobed, membranous, creamy white, central lobe ca. 2.0-2.5 by 1.0 mm, round and emarginate, slightly recurve to the back of anthers, lateral lobe ca. 1.0-2.0 by 1.0 mm, horn-like, round. *Ovary* cylindric or subovoid, ca. 4.0-5.0 by 3.0-4.0 mm, with pale brown sericeous; stigma cup-shaped, ca. 3.0 by 2.0 mm, the aperture narrowly transverse, edge hairy; style hairy, curl, stylode blunt, ca. 5.0-3.0 by 1.5-2.0 mm. *Fruit* globose, smooth with longitudinal lines, 0.7-1.7 cm dia., brownish cream, glabrous or sparsely pale brown hirtellous; seed angulate, ca 3.0 by 2.0 mm. black, aril white, fragrant.

Key to varieties

1. Young shoot and pseudostem base red …….....11.1) var. **rubrum**

1. Young shoot and pseudostem base green

  2. Peduncle up to 22 cm long

    3. Leafy shoot usually 1.5 m tall or taller; lamina 10-13 cm wide 11.1) ..11.2) var. **testaceum**

    3. Leafy shoot less than 1.5 m tall, lamina 6-9 cm wide…….……..…11.3) var. **nanum**

  2. Peduncle 22 cm long or longer…….…..……....11.4) var. **longipedunculatum**

11.1) **A.testaceum** var. **rubrum** var. nov.

Thailand.— PENINSULAR: Nakon Si Thammarat, cultivated in Tak (Doi Musur).

Distribution.— Thailand.

Ecology.— Tropical rain forest, slightly shade, 100-400 m.

Phenology.— Flowering and fruiting during April-July.

Vernacular name.— Krawan Noh Dang (กระวานหน่อแดง).

Note.— The var. *rubrum* differs from var.*testaceum* in its reddish sheath at base of pseudostem and common in Southern Thailand.

Specimens examined.— *Kaewsri-96*, 23 April 2004, Tak (BK, BKF).

11.2) **A.testaceum** var. **testaceum**

Thailand.— NORTHERN: Tak (Doi Musur); SOUTH-EASTHERN: Chanthaburi (Khao Soi Dao, Khao Pechakut, Pong Nam Ron), Chon Buri, Trat (Ban Rai, Koh Chang) ; SOUTH-WESTERN: Prachuap Khiri Khan, Kanchanaburi (Sai Yok, Sanklaburi); PENINSULAR: Yala (Bala), Trang (Khao Chong), Nakhon Si Thammarat, Satun (Tung Nui, Muang), Surat Thani (Khao Luang, Khao Phu Thawng), Pattani, Pattalung (Appendix B4).

Distribution.— Malay Peninsula, Thailand, Indo-china.

Ecology.— Shaded area in the primary evergreen forest, granite bedrock. 200-1,000 m.

Phenology.— Flowering: February-May, fruiting: September-November.

Vernacular name.— Krawan (กระวาน) (Chanthaburi, Pattani); Krawan khao (กระวานขาว), Krawan phothisat (กระวานโพธิสัตว์) (Central); Pla ko (ปล้าก้อ) (Pattani) (Appendix B4.

Note.— var. *testaceum* is usually distributed above 350 m. The populations found in eastern Thailand have a larger fruit size and a stouter pseudostem than the populations found in southern Thailand.

Specimens examined.— *C. Niyomtham & Kasem 1405*, 19 April 1969, Satun (BK); *C. Niyomtham & P. Puudjaa 5515*, 2 May 1998, Yala (BKF); *Kaewsri-1*6, 3 May 2003, Tak (BK, BKF); *Kerr 9452*, 28 November 1924, Trat (BK); *Kerr 9671*, 14 December 1924, Chanthaburi (BK); *Kerr 10806*, 4 July 1926, Surat Thani (BK); *Kerr 11871*, 8 February 1927, Surat Thani (BK); *Kerr 12475*, 29 March 1927, Surat Thani(BK); *Kerr 14641*, 17 March 1928, Satun (BK); *Maxwell 75-465*, 4 May 1975, Chanthaburi (BK); *Maxwell 85-708*, 13 July 1985, Trang (PSU); *Maxwell 87-453*, 19 May 1987, Trat (PSU); *Maxwell 89-653*, 22 July 1989, Trat (PSU); *Maxwell 93-899*, 13 August 1993, Kanchanaburi(BKF); *Nainae 63*, 14 April 1925, Chanthaburi (BK); *P. Sirirugsa 1158*, 16 January 1988, Pattalung (PSU); *Sakol 1344*, 15 July 1966, Surat Thani(BK); *Sakol 3727*, 8 May 1976, Tak (BK); *T. Santisuk 6671*, 12 June 1987, Chanthaburi (BKF); *T. Santisuk 6700*, 12 June 1988, Chanthaburi (BKF); *Yingyong 2326-89*, 10 April 1989, Chanthaburi (BK).

11.3) **A.testaceum** var. **nanum** var. nov.

Thailand.— PENINSULAR: Krabi, Nakon Si Thammarat. cultivated in Tak (Doi Musur).

Distribution.— Thailand.

Ecology.— Tropical rain forest, slightly shade, 100-400 m.

Phenology.— Flowering: April.

Vernacular name.— Krawan Krabi (กระวานกระบี่).

Note.— The var.*nanum* differs from var.*testaceum* in its slender leafy stem, smaller inflorescences and fruits. It is difficult to separate from the var. *testaceum* by dried specimen because its size is

similar. The living specimens are useful for identification. The examined specimens were collected from Tak (Doi Mu Sur) which were introduced from Krabi province.

Specimens examined.— *Kaewsri-17*, 3 May 2003, Tak (BK, BKF).

11.4) **A.testaceum** var. **longipedunculatum** var. nov.

Thailand.— PENINSULAR: Narathiwat (Bacho, N 06° 35′,E 101° 40′), Yala (Bang Lang), Pattani (Pla Kaw), Tak (cultivated at Doi Musur) (Appendix B4).

Distribution.— Thailand.

Ecology.— Tropical rain forest, 100-400 m.

Phenology.— April-July.

Vernacular name.— Krawan Kan Yao (กระวานก้านยาว).

Note.— The var. *longipedunculatum* differs from var. *testaceum* in its longer peduncle and smaller inflorescence, with limited distribution in southern Thailand.

Specimens examined.— *Kaewsri-15*, 3 May 2003, Doi Musur, originally collected by Y. Paisooksantivatana from Su-ngai Padi, Narathiwat (BK); *Kerr 7107*, 7 July 1923, Pattani (BK); *K. Larsen et al. 42988*, 18 June 1992, Narathiwat (PSU).

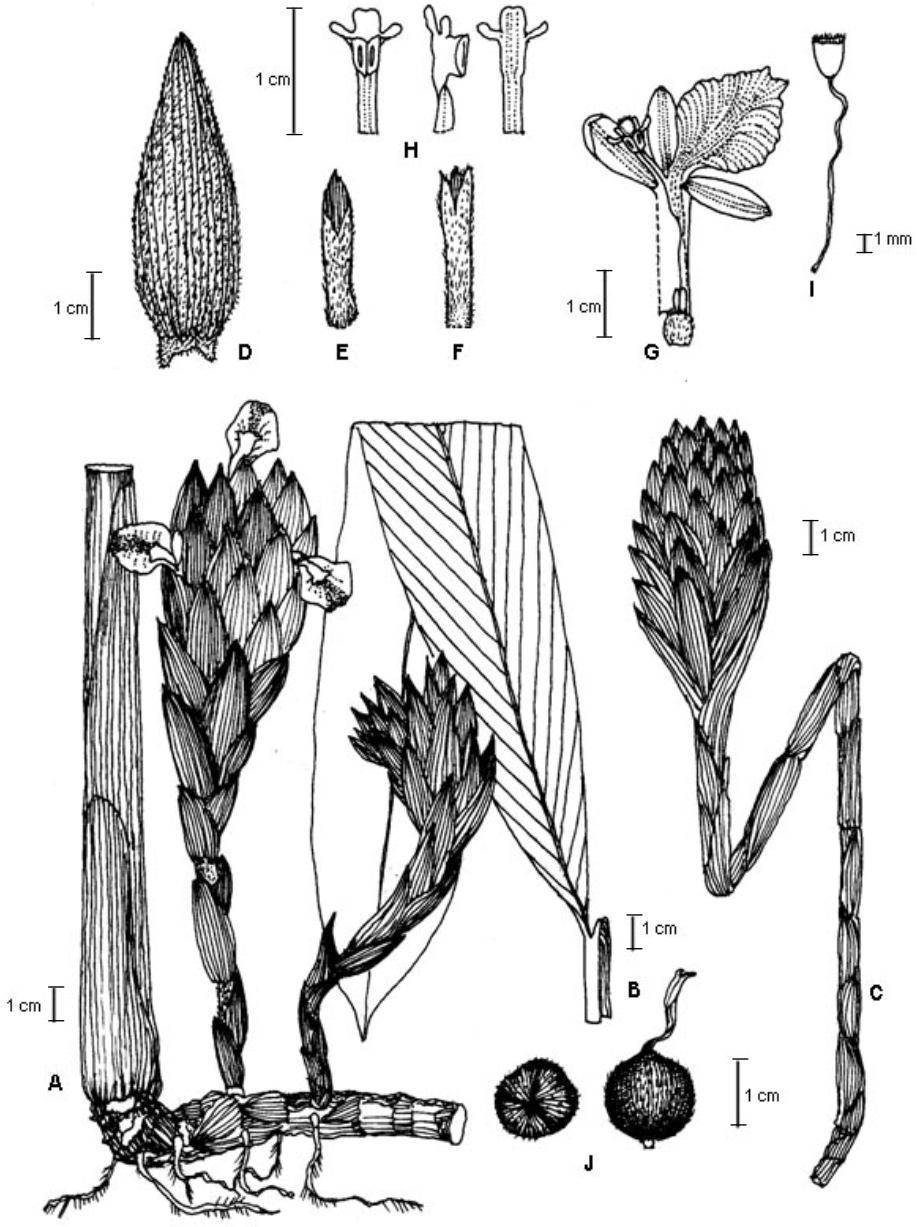

Figure 14 *Amomum testaceum* Ridl.: A. inflorescence and rhizome; B. leaf (drawn from Kaewsri-16); C. inflorescence of the var. *longipedunculatum* (drawn from Kaewsri-15); D. bract; E. bracteole; F. calyx; G. flower, dissected; H. stamen; I. stigma (drawn from Kaewsri-16); J. fruit (drawn from Kaewsri-96).

12. Amomum uliginosum König ex Retz. Obs. 3:56. 1783.; Bak. in Hook. F. Fl. Brit. Ind. VI:241. 1892; Ridl. in Journ. Asiat. Soc. Bengal. 136. 1899; K. Schum., Das Pflanzenreich. 20. Heft. IV:240. 1904; syn. *A. ovoideum* Pierre ex Gagnep.. Bull. Soc. Bot. Fr. 53:140. 1906. **Type**: König s. n. Phuket, Thailand. **Figure** 15. **Picture:** Appendix A12.

Rhizome elongate. *Leafy shoot* stout, 2.4-4.1 m tall. *Leaves* 35-43; ligule 2-lobed, apex round and emarginate, leathery, 4.0-7.0 mm long, with 2 transversal ridges at axil, sparsely brown hairs; petiole ca. 3 mm long; lamina oblong, 23.0-64.0 by 3.0-12.0 cm, base attenuate or obtuse, apex acuminate or obtuse , tip caudate, 1.5-6.0 cm. *Inflorescence* obovoid, ca. 4.5 cm dia., ca. 25 flowers; peduncle 13.0-15.0 cm long, procumbent; peduncular bract obovate-oblong, ca. 2.0 by 0.8 cm, pale brown, outer surface pubescent, apex hooded, apiculate. *Bract* hooded, oblanceolate, ca. 2.8 by 0.8 cm, soon decaying, submembranous, pale brown, outer surface pubescent, apex acuminate. *Bracteole* tubular, ca. 2.0 cm long including ovary, apex 2-fid, shallowly split on 1 side, creamy white with pinkish red at base, membranous, outer surface glabrous, whitish pubescent base. *Calyx* 2.0-2.8 cm long including ovary, apex 3-fid with shallowly split on 1 side, pinkish white, outer surface glabrous. *Corolla* creamy white, glabrous, tube ca. 2.5 cm long including ovary, with pinkish red at base, dorsal lobe oblong, apex blunt, hooded, ca. 1.5 by 0.4 cm, lateral lobes narrower. *Lateral staminode* linear, ca. 3.0 mm long, base red, apex white. *Labellum* suborbicular, ca. 1.2-2.3 cm dia, base clawed, apex 2-fid and reflex, white with yellow band along center and broader at apex, crimson veins on each side of band, 2-3 crimson stripes on each side at base. *Filament* 5.0-6.0 mm long, linear, glabrous; anthers 6.0-7.0 mm long, dehiscing lengthwise, glabrous; anther crest 3-lobed, 5.0-7.0 by 2.0 mm, white, central lobe round and emarginate, reflex, lateral ones auriculate, horn-like. *Ovary* cylindric, 4.0 by 2.0-3.0 mm, surface with densely brownish pubescent; stigma small bulbous, edge glabrous; stylode blunt, ca. 2.0 by 1.0 mm, glabrous. *Fruit* 7-8 per infructescence, globose, ca. 1.7-2.0 cm dia., densely covered with rigid spines, greenish red.

Phenology.— Flowering and fruiting during April-August.

Thailand.— CENTRAL: Saraburi (Khao Sahm Lahn, Hin-Lap), Nakhon Nayok (Khao Yai); EASTERN: Nakhon Ratchasima (Khao Phrik, Sicue District), Buri Ram (Dong Yai); SOUTH-

EASTERN: Chantaburi (Khlong Khuar Wai, Khao Soi Dao), Rayong, Chonburi (Khao Kiew), Sa Kaeo (Pang Si Da), Trat (Khlong Kaew, Khao Saming, Tub Muang); SOUTH-WESTERN: Kanchanaburi (Sai Yok, Sangkhla Buri); NORTHERN: Lampang (Jae Sawn), Phayao (Doi Luang) NORTH-EASTERN: Sakon Nakhon (Phu Pan), Nakhon Phanom (Dong Bang-i); EASTERN: Ubon Ratchathani, Roi Et (Ban Lao Hot); PENINSULAR: Phatthalung (Khao Poo-Khao Yah), Pattani (Sai Khao waterfall), Songkla (Haad Yai, Muang), Nakhon Si Thammarat (Ta Sa la), Narathiwat (Phukhao Thong, Hala) (Appendix B4).

Distribution.— Thailand, Malay Peninsula, Laos, Cambodia, Vietnam?, China.

Ecology.— Dry evergreen forest, deciduous and bamboo forests, limestone or granite bedrock, 200-1,325 m.

Uses.— Seed used as medicine.

Vernacular name.— Klam-Wang (กลำวาง), Reo (เร่ว), Reo-Ya (เร่วยา), Krawan pa (กระวานป่า), Naeng (แหน่ง), Mak Neng Noi (หมากแหน่งน้อย).

Note.— *Amomum uliginosum* König ex Retz. is common in Thailand. The species is characterized by a hooded labellum, tall leafy shoots and dense inflorescence. In this work, I combined *Amomum ovoideum* Pierre ex Gagnep. (1906) to this species because I found that its type specimen (Pierre 542) collected by J. B. L. Pierre in 1870 that deposited at Paris Herbarium is *A. uliginosum* König ex Retz.

Specimen examined.— *A. Boonkongchart 205*, 12 May 2003, Khao Yai (CMU); *A. Boonkongchart 205*, 12 May 2003, Nakhon Nayok (CMU); *C. Niyomdham 5673*, 14 March 1999, Narathiwat (BK); *C. Maknoi 8*, 28 June 1998, Songkla (QBG, PSU); *C. Maknoi 6*, 22 September 1999, Ton Ngachang (QBG, PSU); *C. Phengklai et al* 3863, 25 August 1977, Rayong (PSU); *Kaewsri-30*, 7 June 2004, Hub Luk (BK, BKF); *Kaewsri-32*, 12 August 2004, Khlong Kaew (BK, BKF); *Kerr 21508*, 16 May 1932, Nakhon Phanom (BK); *Kerr 21554*, 22 May 1932, Ubon Ratchathani (BK); *Maxwell 73-404,* 12 August 1972, Chantaburi (BK); *Maxwell 74-484,* 14 May 1974, Chantaburi (BK); *Maxwell 74-523,* 19 May 1974, Saraburi (BK); *Maxwell 75-360,* 6 April 1975, Chonburi (BK); *Maxwell 76-329*, 9 May 1976, Nakhon Ratchasima (BK) ; *Maxwell 85-524,* 25 May 1985, Songkla (PSU); *Maxwell 85-618,* 21 June 1985, Songkla (PSU); *Maxwell 86-338,* 2 June 1986, Nakhon Si Thammarat (PSU) ; *Maxwell 93-889*, 12 August 1992, Kanchanaburi (CMU); *Maxwell 96-621*, 26 April 1996, Lampang (CMU); *Maxwell 96-794*, 2 June 1996,

Lampang (CMU); *Maxwell 96-877*, 24 June 1996, Lampang (CMU); *Maxwell 97-486*, 23 May 1997, Phayao (CMU); *Maxwell 03-125*, 14 May 2003, Chiangmai (CMU); *Maxwell 03-172*, 9 July 2003, Chonburi (CMU); *M. Newman 22*, 5 October 1984, Songkla (PSU); *Nainoe 29*, 30 March 1925, Trat (BK); *P. Sirirugsa 1094*, 18 July 1987, Pattani (PSU); *P. Sirirugsa 1098*, 18 July 1987, Pattani (PSU); *P. Sirirugsa 1114*, 29 October 1987, Suratthani (PSU); *P. Sirirugsa 1159*, 16 January 1988, Phatthalung (PSU); *Put 2485*, 18 May 1980, Trat (BK) ; *Put 2433*, 20 August 1928, Saraburi (BK); *y 1255-83,* 8 September 1983, Chantaburi (BK); *Yingyong 6077*, 23 July 1984, Roi Et (BK).

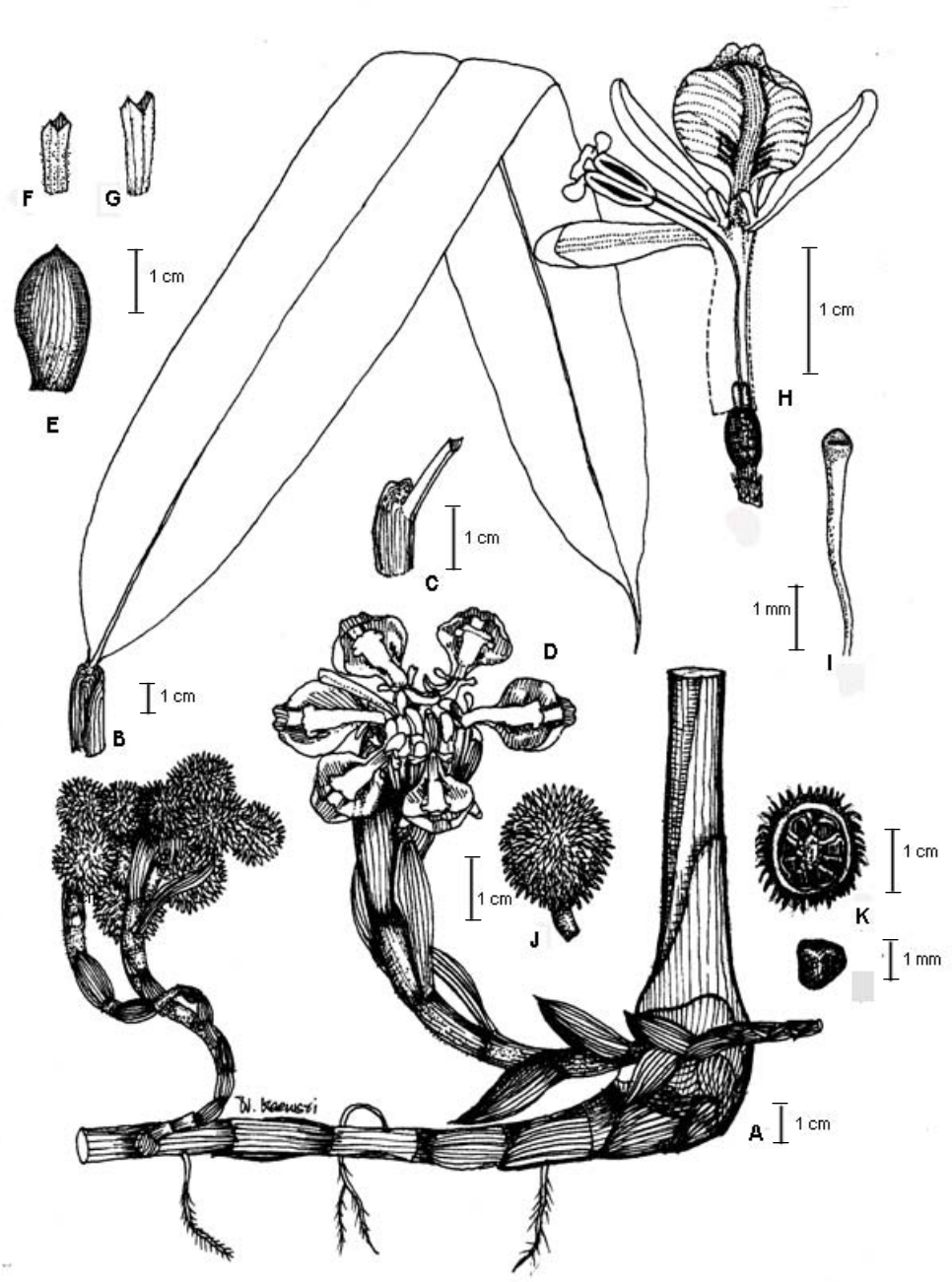

Figure 15 *Amomum uliginosum* König ex Retz.: A. infructescence and rhizome; B. leaf; C. ligule; D. inflorescence; E. bract; F. bracteole; G. calyx; H. flower, dissected; I. stigma; J. fruit, K. fruit, L-section and seed (drawn from Kaewsri-30).

13. Amomum cf. **villosum** Lour. Fl. Cochinch. 1:4. (1790): Fl. China. Vol.24. (2000). **Figure** 16**. Picture:** Appendix A13.

Rhizome elongate, pinkish white. *Leafy shoot* stout, 3-3.4 m tall, purple and swollen ca. 4 cm dia. at base. *Leaves* 34-42; ligule entire, apex round and dried papery, 0.5-1.0 cm long; petiole sessile; lamina narrowly oblong to lanceolate-oblong, 16.0-58.0 by 3.0-8.0 cm, base attenuate, apex acuminate, tip caudate, 2.0-3.0 cm. *Inflorescence* conical, ca. 2.5-3.0 by 2.0-2.5 cm; peduncle 5.0-11.0 cm long; peduncular bract ovate-oblong, ca. 2.0-2.5 by 0.8-1.0 cm, brown, indurate, papery, apex acuminate, rachis pubescent. *Bract* oblong, 1.8-3.5 by 1.0-1.2 cm, papery, apex acute. *Bracteole* tubular, ca. 8.0 mm long including ovary, apex 2-fid, membranous, brownish cream. *Calyx* ca. 2.0-2.5 cm long including ovary, apex 2-fid and shallowly split on 1 side, outer surface glabrate, pinkish cream. *Corolla* white, tube glabrous, ca. 2.5 cm long including ovary, dorsal lobe oblong, ca. 1.5 by 0.5 cm, membranous, hooded, apex apiculate, lateral lobes narrower. *Lateral staminode* absent. *Labellum* orbicular and hooded, ca. 1.8 cm dia., base clawed, apex shallowly 2-or 3-fid, white with yellow band along center and wider at apex, lateral red veins along the band and paler upward, red stripes radiate from base to middle. *Filament* ca. 6.0 mm long, linear, glabrous; anther ca. 6.0 by 3.0 mm, dehiscing lengthwise; anther crest 3-lobed, horn-liked, ca. 6.0 by 2.0 mm, creamy white, central lobe ca. 4.0 by 2.0 mm wide, emarginate, reflex on to back of anther, lateral lobe ca. 2.0 by 2.0 mm, apex round, spreading. *Ovary* cylindric, ca. 4.0 by 2.0 mm, densely white pubescent, with stalk at base; stigma cup-shaped, the aperture narrowly transverse, edge hairy; stylode blunt, ca. 4 mm long. *Fruit* 2-3 per infructescence, ellipsoid, ca. 1.5-2.0 by 1.2-1.5 cm, densely covered with fine spines, pinkish red, fruit stalk ca. 1.0-1.5 cm long; seed subglobose, ca. 2 mm dia., aril white.

Phenology.— Flowering and fruiting during April-July.

Thailand.— NORTHERN: Tak (Doi Mu Sur) (Appendix B5).

Distribution.— Thailand.

Ecology.— Dry evergreen forest, light gaps. 800-900 m.

Vernacular name.— Reo Mu Sur (เร่วมูเซอ).

Note.— *A* .cf. *villosum* Lour. is a common species only in Doi Musur, Tak Province.

Specimen examined.— *Kaewsri 13*, 2 May 2003, Doi Musur (BK, BKF); *Kaewsri 98*, 23 April 2004, Doi Musur (BK, BKF).

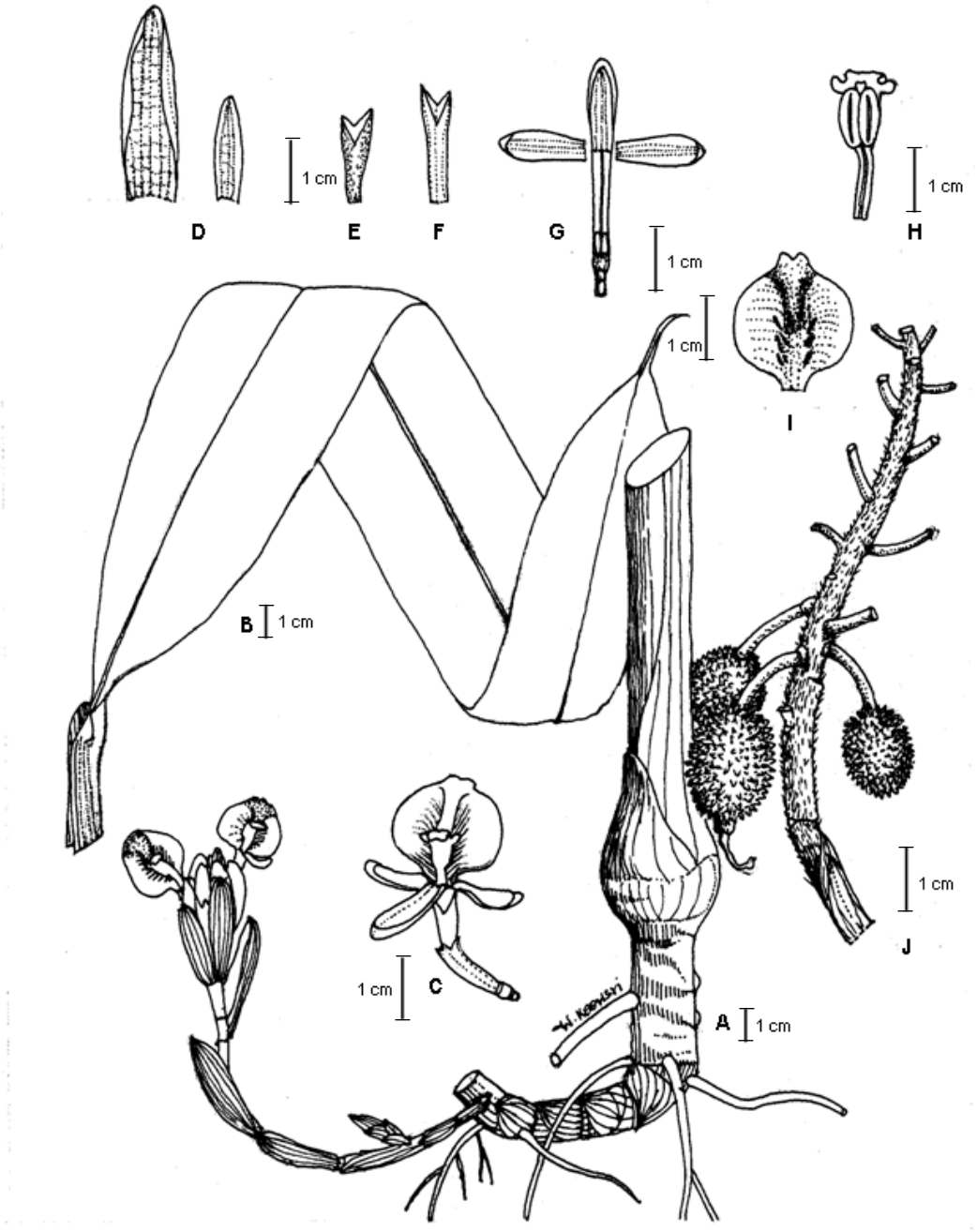

Figure 16 *Amomum* cf.*villosum* Lour.: A. inflorescence and stem base; B. leaf; C. flower ; D. bract; E. bracteole; F. calyx; G. corolla, dissected; H. stamen; I. labellum (drawn from Kaewsri-13); J. young fruits (drawn from Kaewsri-98).

14. Amomum sp.1. **Figure** 17. **Picture:** Appendix A14.

Rhizome short. *Leafy shoot* slender, 0.9-1.0 m tall. *Leaves* 8-15; ligule 2-lobed, papery, 1.0-2.0 mm long, sparsely pubescent; petiole 3.0-6.0 mm long; lamina broadly elliptic to oblong, 10.0-14.0 by 5.0-6.8 cm, glabrous or pubescent beneath, base attenuate or round, margin undulate, apex acuminate to round, tip caudate, 1.0-2.0 cm. *Inflorescence* conical or obovate, ca. 3.0 by 1.5 cm; peduncle ca. 1.5 cm long; peduncular bract ovate to oblong, densely pubescent, leathery, apex round. *Bract* ovate to elliptic, ca. 1.8 by 0.9 cm, margin ciliate, outer surface brownish pubescent, apex mucronate. *Bracteole* tubular, ca. 1.0 cm, apex 2-fid and shallowly split on 1 side, outer surface brownish pubescent, margin ciliate. *Calyx* ca. 1.6 cm long, apex 3-fid and split to 5 mm on 1 side, outer surface brown pubescent, margin ciliate. *Corolla* creamy white, tube glabrous, ca. 1.7 cm long including ovary, dorsal lobe hooded, broadly oblong to ovate-oblong, ca. 1.9 by 0.7 cm, apex apiculate, lateral lobe slightly smaller, apex blunt, hooded. *Lateral staminode* absent. *Labellum* broadly ovate, spreading, ca. 2.3 by 2.0 cm, base attenuate, apex obtuse and wrinkle, margin wavy and revolute, white with orang-yellow blotch spread to apex, reddish lateral stripes from base upward to middle, 2-grooved near apex, sparsely pubescent base. *Filament* ca. 6.0 by 2.5 mm, glabrous; anther 3-4 by 3 mm, dehiscing lengthwise; anther crest horn-liked, 3-lobed, ca. 4 by 4 mm, creamy white, central lobe slightly reflex, apex round, lateral ones smaller, apex acute, spreading. *Ovary* cylindric, ca. 3 mm long, pubescent; stigma cup-shaped, the aperture with ciliate edge, ca. 2.5 mm wide, stylode blunt, ca. 3 mm long. Fruit 2-3 per infructescence, globose to elliptic, ca. 1.7-1.8 cm dia., densely covered with rigid spines, green when young turning dark red when ripe.

Phenology.— Flowering and fruiting during March- July.

Thailand.— SOUTH-WESTERN: Kanchanaburi (Sai Yok) (Appendix B5).

Ecology.— Dry evergreen forest, under shade of shrubs and trees, N 14° 16′ 15.7′′, E 098° 44′ 12.6′′, 400 m.

Note.— The species is commonly distributed in Sai Yok (Tao Dam Forest), Kanchanaburi province.

Specimen examined.— *Kaewsri 1*, 26 April 2003, Sai Yok (BK, BKF).

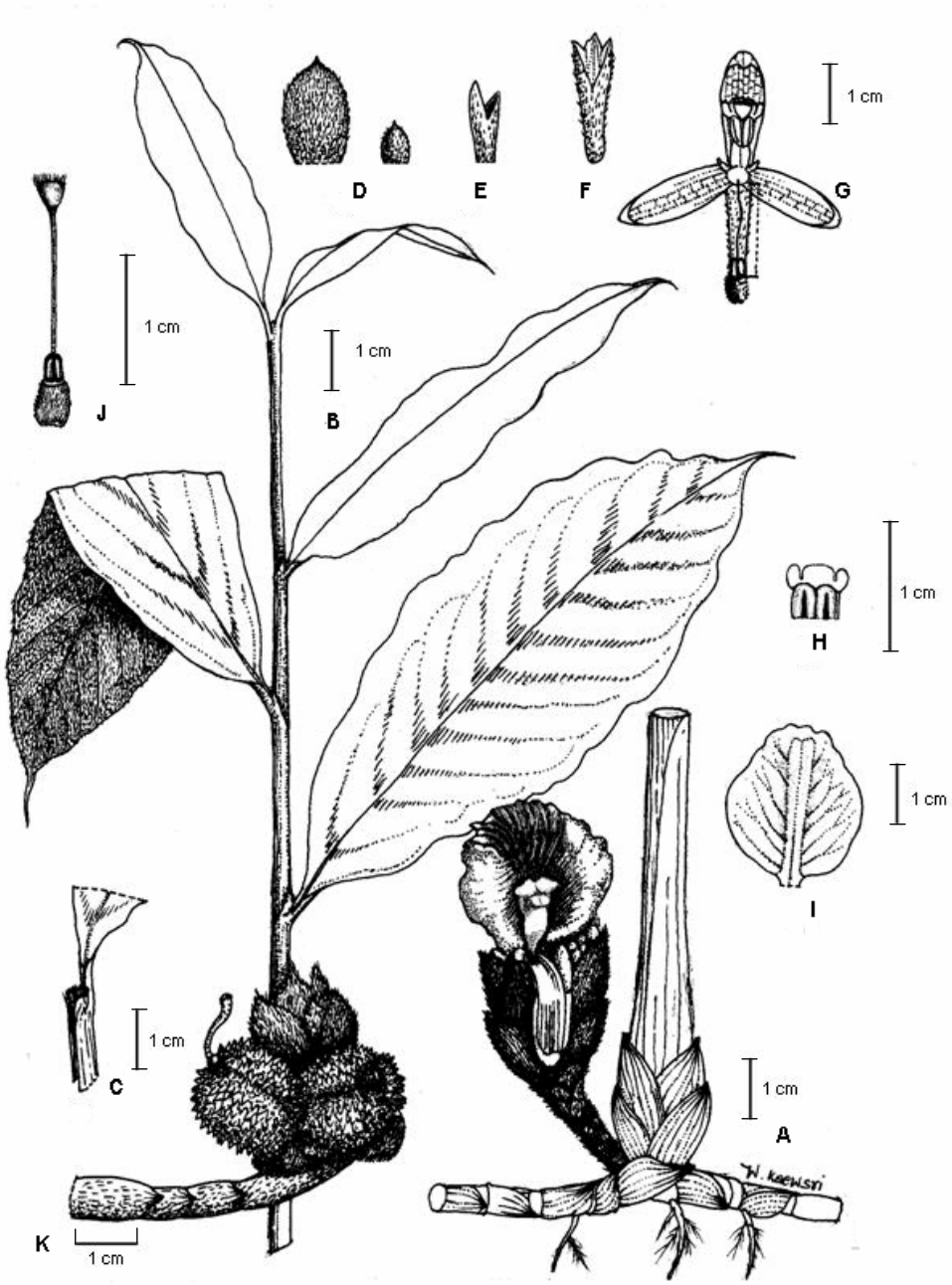

Figure 17 *Amomum* sp.1 : A. inflorescence; B. pseudostem with leaves; C. ligule; D. bract (left) and peduncular bract (right); E. bracteole; F. calyx; G. flower, dissected; H. anther crest; I. labellum; J. pistil; K. infructescence (drawn from Kaewsri-1).

15. Amomum sp.2. **Figure** 18. **Picture:** Appendix A15.

Rhizome short, white. *Leafy shoot* slender, 0.4-0.9 m tall. *Leaves* 6-7; sheath green and white when dried; ligule 2-lobed, 2-5 mm long, membranous, greenish white; petiole sessile to 2.0 cm long; lamina oblong, ovate, elliptic or narrowly oblong, 17.0-41.0 by 3.5-7.0 cm, base attenuate or obtuse, apex acuminate, tip caudate, 0.5-2.0 cm. *Inflorescence* 4-6 flowers, conical, emerge near base of pseudostem, ca. 5.0 by 5.0 cm; peduncle, 1.3-3.0 cm long, pinkish cream; peduncular bract deltoid , ca. 8.0 by 6.0 mm, pale brown, glabrous; bract narrowly oblong, ca. 1.5 by 0.5 cm, glabrous, apex acuminate, submembranous, brownish white. *Bracteole* split to base on 1 side, lanceolate, 8.0 by 4.0 mm long, creamy white, membranous, glabrous. *Calyx* ca. 1.2 cm long, apex 3-fid, pinkish white. *Corolla* creamy white, tube ca. 1.5 cm long, dorsal lobe hooded, ovate, oblong, ca. 1.5 by 0.8 cm, apex blunt, hooded, lateral lobe oblong, narrower. *Lateral staminode* absent. *Labellum* flabellate, spreading, slightly 3-lobed, ca. 2.5 by 2.5 cm, base clawed, apex round, margin wrinkle, white with narrowly pale reddish stripes along center. *Filament* oblong, flat and broad, ca. 8.0 by 3.0 mm, glabrous; anther ca 4.0 by 2.5 mm, dehiscing lengthwise, attach on the flat filament; anther crest hooded, entire, 4.0-5.0 by 3.0 mm, apex round, connect to filament, slightly recurved, creamy white. *Ovary* cylindric, 2.0-3.0 by 2.0 mm long, glabrous, with 6-longitudinal ridges, yellowish white; stigma broadly cup-shaped, unequal 2-lobed, edge hairy; stylode blunted, ca. 4.0 mm long. *Fruit* 1-2, ovoid, longitudinal 6-winged, regular spacing, ca. 2.2 by 1.8 cm, apex acuminate, base round, dark brown, fruit stalk ca. 3 mm long.

Phenology.— Flowering and fruiting: April.

Thailand.— SOUTH-WESTERN: Kanchanaburi (Sai Yok) (Appendix B5).

Ecology.— Dry evergreen forest, light gaps, N 14° 15′ 27′′, E 98° 45′ 2.4′′, 442 m.

Note.— *Amomum* sp.2 is similar to *A. calyptratum* Sakai & Nagam., differ in its glabrous lamina, ligule longer, flower white, labellum smaller, fruit bigger and 6-winged.

Specimen examined.— *Kaewsri 10,* 26 April 2003, Sai Yok (BK, BKF); *Kaewsri 139*, 11 May 2005, Sai Yok (BK, BKF).

16. Amomum sp. 3. **Figure** 18. **Picture:** Appendix A16.

Rhizome short, white. *Leafy shoot* slender, 0.4-0.9 m tall. *Leaves* 6-7; sheath green and white when dried; ligule 2-lobed, 2-5 mm long, membranous, greenish white; petiole sessile to 2.0 cm long; lamina oblong, ovate,elliptic or narrowly oblong, 17.0-41.0 by 3.5-7.0 cm, base attenuate or obtuse, apex acuminate, tip caudate, 0.5-2.0 cm. *Inflorescence* 4-6 flowers, conical, emerge near base of pseudostem, ca. 5.0 by 5.0 cm; peduncle, 1.3-3.0 cm long, pinkish cream; peduncular bract deltoid, ca. 8.0 by 6.0 mm, pale brown. *Bract* narrowly oblong, ca. 1.5 by 0.5 cm, glabrous, apex acuminate, submembranous, brownish white. *Bracteole* split to base on 1 side, lanceolate, 8.0 by 4.0 mm long, creamy white, membranous. *Calyx* ca. 1.2 cm long, apex 3-fid, pinkish white. *Corolla* creamy white, tube ca. 1.5 cm long , dorsal lobe hooded, ovate, oblong, ca. 1.5 by 0.8 cm, apex blunt, hooded, lateral lobe oblong, narrower. *Lateral staminode* absent. *Labellum* flabellate, spreading, slightly 3-lobed, ca. 2.5 by 2.5 cm, base clawed, apex round, margin wrinkle, white with narrowly pale reddish stripes along center. *Filament* oblong, flat and broad, ca. 8.0 by 3.0 mm, glabrous; anther ca 4.0 by 2.5 mm, dehiscing lengthwise, attach on the flat filament; anther crest hooded, entire, 4.0-5.0 by 3.0 mm, apex round, connect to filament, slightly recurved, creamy white. *Ovary* cylindric, 2.0-3.0 by 2.0 mm long, glabrous, with 6-longitudinal ridges, yellowish white; stigma broadly cup-shaped, unequal 2-lobed, edge hairy; stylode blunt, ca. 4.0 mm long. *Fruit* 1-2, ovoid, longitudinally 6-winged arrange in 3-paired, ca. 2.2 by 1.8 cm, apex acuminate, base round, black, fruit stalk ca. 3 mm long.

Phenology.— Flowering: April; Fruiting: May.

Thailand.— PENINSULAR: Pra Chuap Kiri Khun (La-U waterfall), Chumphon (Krom Luang Chumphon , North) (Appendix B5).

Ecology.— Dry evergreen or evergreen forest, under shady trees or light gaps, N 10° 55′ 51.6′′, E 99° 8′ 05.9′′, ca. 250 m.

Note.— *Amomum* sp.3 is similar to *Amomum* sp.2, differs in its fruit are longitudinal 6-wing arrange in 3-paired.

Specimen examined.— *Kaewsri 19*, 15 May 2003, Kaeng Krachan (BK, BKF); *Kaewsri 75,* 7 April 2004, Chumphon (BK, BKF).

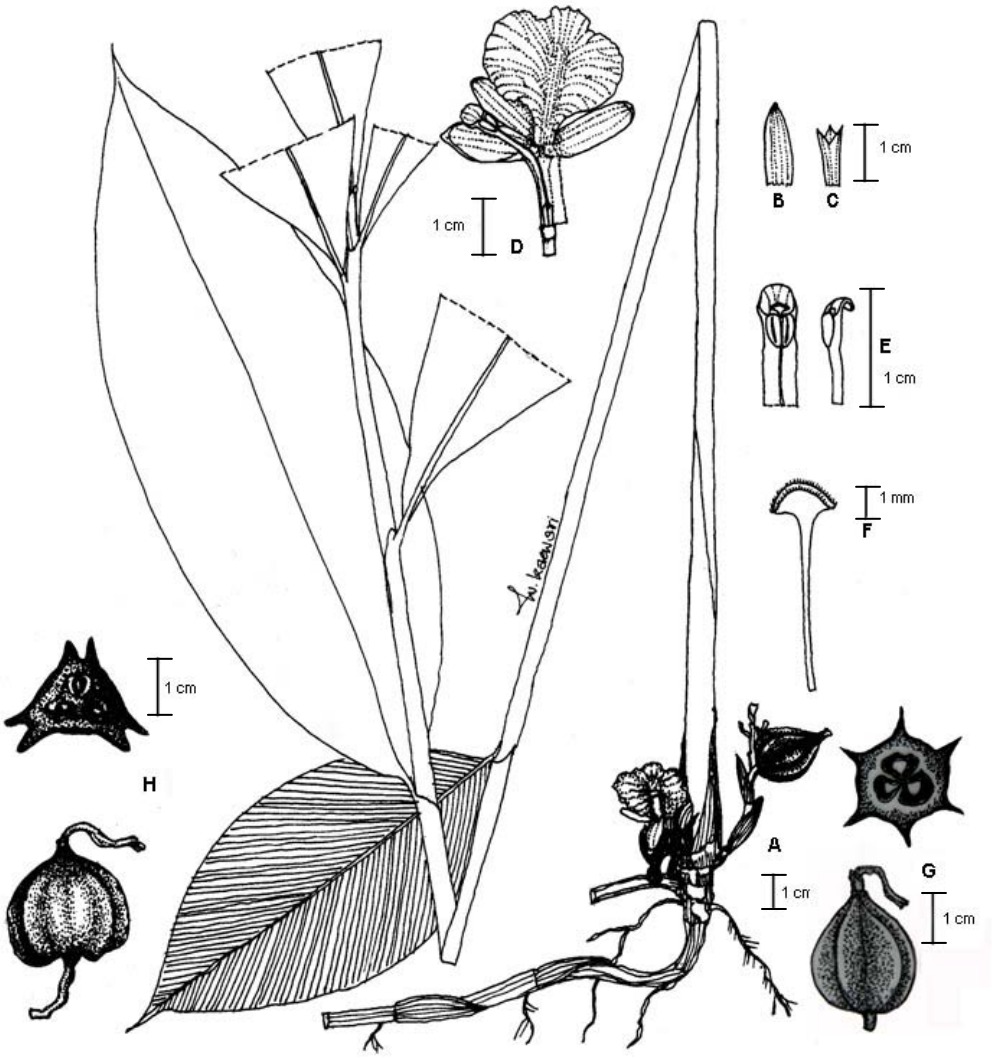

Figure 18 *Amomum* sp.2 and *Amomum* sp.3: A. inflorescence and infructescence; B. bract; C.calyx; D. flower, dissected; E. stamen, front and side views; F. stigma (drawn from Kaewsri-19); G. fruit of sp. 2, X-section (drawn from Kaewsri-139); H. fruit of sp.3 , X-section (drawn from Kaewsri-19).

17. Amomum sp.4. **Figure** 19. **Picture:** Appendix A17.

Rhizome short. *Leafy shoot* slender, 0.8-1.0 m tall. *Leaves* 10-12; sheath pale brown, pubescent; ligule 2-lobed, 0.5-1.0 mm long, fragile, margin ciliate; petiole sessile; lamina oblong-lanceolate, oblong or narrowly elliptic, 11.0-21.0 by 2.0-4.0 cm, upper surface glabrate, with brown hair along midvein, lower surface densely brown subtomentose, base attenuate or obtuse, apex acute, tip caudate, 2.0-3.0 cm. *Inflorescence* loose, obovoid or conical, ca. 4.8 by 2.6 cm; peduncle, ca. 2.5 cm long; peduncular bract deltoid , ca. 1.5 by 0.6 cm, apex acute, brown, subleathery, margin hairy. *Bract* lanceolate, ca. 1.5 by 0.6 cm, apex acute, outer surface with sparsely hair, margin ciliate, papery, reddish brown. *Bracteole* tubular, ca. 1.0 cm long including ovary, apex 2-fid, pale brown, outer surface sparsely pubescent. *Calyx* 1.5-2.1 cm long including ovary, apex 2-fid, pinkish brown, outer surface sparsely pubescent. *Corolla* pinkish white, tube equal to calyx, sparsely pubescent, dorsal lobe oblong, ca. 10.0 by 3.0 mm, apex acute, lateral lobe narrower. *Lateral staminode* minute, tooth-liked, ca 1.0 mm, creamy white with red spots at base. *Labellum* narrowly hooded, obovoid, ca. 1.5 by 0.9 cm, base attenuate, apex 2-fid, margin wrinkle, yellow with white blotchs from base along median band almost to apex, with scattered crimson dots inside the blotch and many crimson transversal stripes on each side. *Filament* linear, ca. 5.0 mm long; anther ca 5.0 by 2.0 mm, dehiscing lengthwise; anther crest 3-lobed, ca. 3.0 by 2.0 mm, pale yellow, central lobe biggest, apex round and emarginate, slightly reflex, lateral lobe auriculate, apex round. *Ovary* subellipsoid, 2.0 mm long, pubescent; stigma cup-shaped, glabrous; stylode blunt, ca. 2.0 mm long. *Fruit* 2-4 per infructescence, subglobose, covered with fine spines, pinkish red, ca. 1.2-1.5 cm dia.; seed angular, arillate, ca. 5.0 mm dia.

Phenology.— Flowering and fruiting during April - September.

Thailand.— SOUTH-WESTERN: Kanchanaburi (Thong Pha Phum, Sai Yok) (Appendix B6).

Ecology.— Dry evergreen to tropical rain forest, light gaps. 800-900 m.

Note.— *Amomum* sp.4 is similar to *A. rivale* Ridl., but differs in its smaller leafy stems, leaf surfaces densely covered with brown hairs and a yellow labellum. The species is a common herb in Thong Pha Phum National Park.

Specimen examined.— *Kaewsri 22*, 25 May 2004, Thong Pha Phum (BK, BKF)

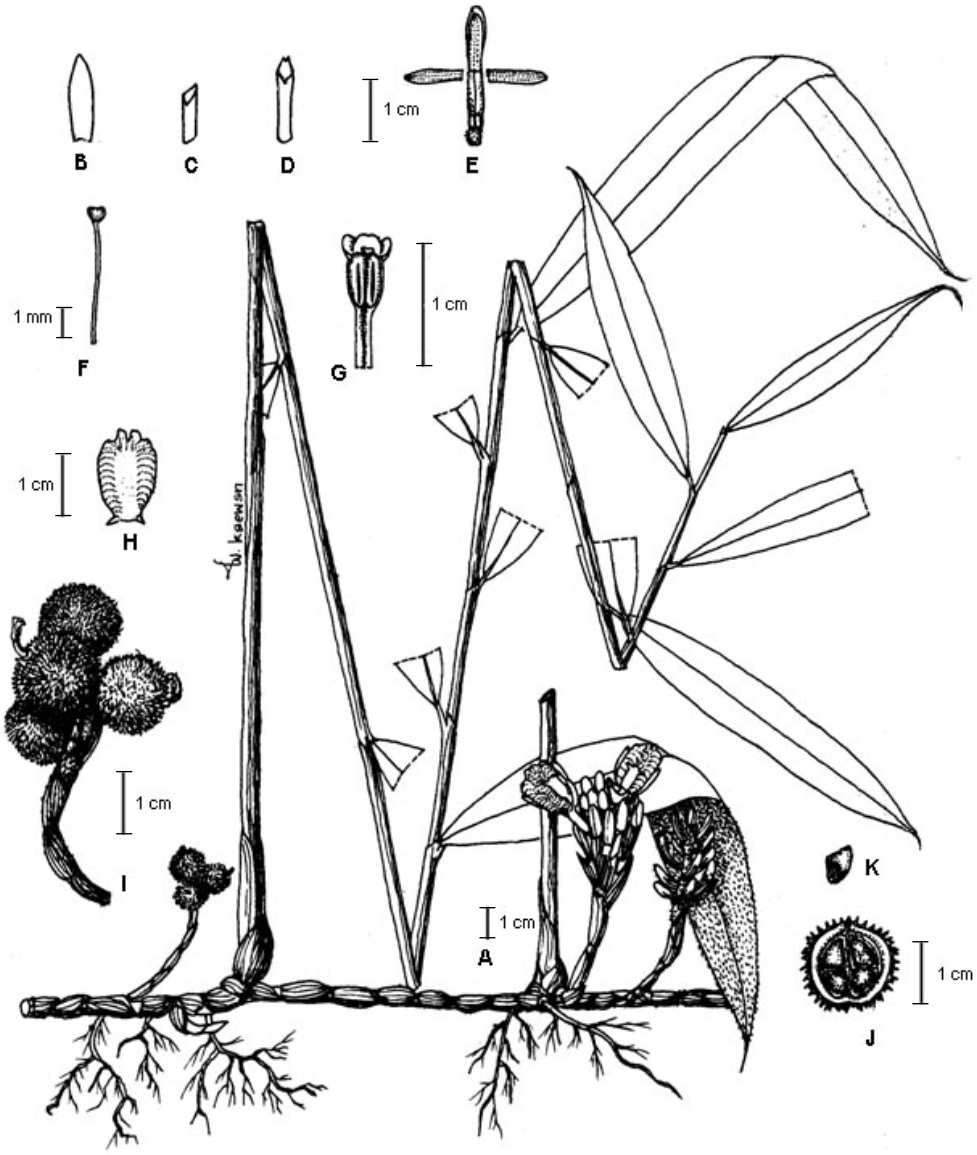

Figure 19 *Amomum* sp.4: A. habit; B. bract; C. bracteole; D. calyx; E. corolla, dissected; F. stigma; G. stamen; H. labellum; I. infructescence; J. fruit, L-section; K. seed (drawn from Kaewsri-22).

18. Amomum sp.5**. Figure** 20. **Picture:** Appendix A18.

Rhizome elongate. *Leafy shoot* slender, 1.4-1.5 m tall. *Leaves* ca. 25; ligule 2-lobed or round, dried papery, 0.5-1.3 cm long; petiole sessile; lamina oblong, 18.0-35.0 by 1.5-5.5 cm, base attenuate, apex acuminate, tip caudate, 2.0-5.0 cm. *Inflorescence* loose, obovate, 5.0-6.0 by 3.0-5.0 cm; peduncle 6.0-9.0 cm long; peduncular bract ovate-oblong, brown, glabrous, ca. 1.2 by 0.6 cm, apex round. *Bract* hooded, ovate-oblong, ca. 2.5 by 0.7 cm, soon decaying, submembranous, pale brown, outer surface brownish pubescent, apex acuminate or mucronate. *Bracteole* tubular, ca. 1.4 cm long , apex 2-fid, split ca. 6 mm on 1 side, pale brown, membranous, outer surface with fine pubescent. *Calyx* ca. 1.5 cm long, apex equally 3-fid, outer surface glabrous. *Corolla* creamy white, tube glabrous, ca. 1.3 cm long, dorsal lobe broadly oblong, apex blunt, hooded, ca. 1.3 by 0.6 cm, lateral lobes narrower. *Lateral staminode* absent. *Labellum* ovate, hooded, ca. 1.6 by 1.0 cm, base cuneate, apex 2-fid and reflex, white with pale yellow band along center and broader at apex, pale red veins on each side of band. *Filament* ca. 6.0 mm long, linear, glabrous; anther ca. 6.0 by 3.0 mm, dehiscing lengthwise, glabrous; anther crest 3-lobed, ca. 3.0 by 1.0 mm, white, central lobe ca. 1.0 by 1.0 mm , round, reflex, lateral lobe ca. 0.5 mm ong , small auriculate, erect. *Ovary* cylindric, ca. 3.0 by 2.0 mm, surface glabrous or glablate; stigma small bulbous, edge glabrous; stylode blunt, ca. 3 mm long. *Fruit* ca. 5-8 per infructescence, elliptic, ca. 2.0 by 1.2 cm, covered with slender spines, pinkish red, stalk 5.0-7.0 mm long.

Phenology.— Flowering and fruiting during April- July.

Thailand.— SOUTH-WESTERN: Kanchanaburi (Thong Pha Phum) (Appendix B6).

Ecology.— Dry evergreen forest, light gaps, ca. 950 m.

Note.— *Amomum* sp.5 is similar to *A. uliginosum* König ex Retz., but differs in its longer ligule, narrower leaves, looser inflorescence and smaller flower. The species is rare in Thong Pha Phum national park.

Specimen examined.— *Kaewsri 24*, 25 May 2003, Thong Pha Phum(BK, BKF*)*; *Kaewsri 147*, 29 May 2005, Thong Pha Phum (BK, BKF).

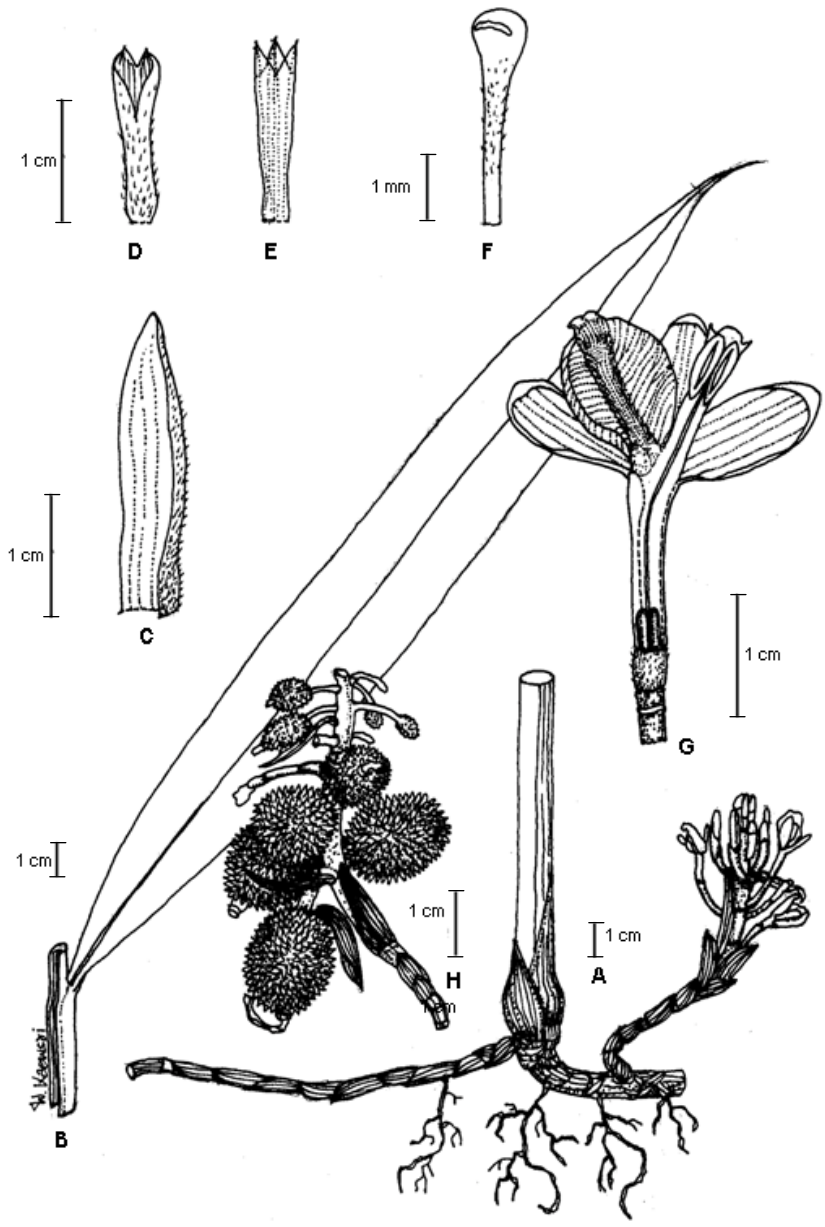

Figure 20 *Amomum* sp.5: A. inflorescence and rhizome; B. leaf; C. bract; D. bracteole; E. calyx; F. stigma; G. flower, dissected; H. infructescence (drawn from Kaewsri-24).

19. Amomum sp.6**. Figure** 21. **Picture:** Appendix A19.

Rhizome short. *Leafy shoot* usually slender, 0.4-0.8 m tall. *Leaves* 4-9; ligule 2-lobed, incrassate, 2.0-5.0 mm long, subleathery, pubescent along margin; petiole sessile or upto 10.0 cm long, glabrous; lamina elliptic, oblong to obovate-oblong, 10.0-35.0 by 2.5-8.5 cm, lower surface densely appressed silver pubescent, base cuneate to attenuate, apex acuminate to acute, tip caudate, 7- 10 mm. *Inflorescence* conical, ellipsoid, ovoid or suboblong, 3.5-6.0 by 1.8-3.0 cm; peduncle ca. 1.0-1.5 cm long; peduncular bract deltoid to ovate, 0.5-2.0 by 1.0 cm, reddish brown, outer surface glabrous, apex mucronate, subleathery. *Bract* sub-elliptic, oblong or lanceolate, 2.0-3.5 by 3.5-6 cm, outer surface glabrous, apex round with mucronate, pale brown. *Bracteole* tubular, ca. 2.2 cm including ovary, apex acuminate or obliqued acute, creamy white, outer surface glabrous or slightly pubescent. *Calyx* 3.0-4.0 cm long including ovary, apex 3-fid, shallowly split ca. 1.0 cm on 1 side, reddish cream, membranous, outer surface glabrous or slightly pubescent base. *Corolla* creamy white, glabrous, tube 2.5-3.5 cm long including ovary, dorsal lobe hooded, oblong, 2.0-3.0 by 0.9-1.5 cm, apex acuminate or apiculate, lateral lobes narrower, apex blunt, hooded. *Lateral staminode* subulate, 3-4 mm long, white. *Labellum* narrowly ovate, ovate or orbiculate, spreading, 2.5-4.0 by 1.8-2.4 cm, base attenuate, apex round, margin wrinkle, white with yellow blotches at base and paler upward, pinkish red spots radiate from base to margin, with sparsely whitish hair at the base. *Filament* 3.0-6.0 mm long, glabrous; anther 10.0-12.0 by 3.5 mm, dehiscing lengthwise, yellowish white, glabrous; anther crest entire, apex truncate or slightly 3-lobed, membranous, 10.0-12.0 by 3.5-4.0 mm, spreading, yellowish or creamy white. *Ovary* cylindric, 5.0-6.0 mm long, glabrous, with 11 longitudinal lines; stigma cup-shaped, the aperture narrowly transverse, edge hairy; stylode blunt, linear, 4.0-8.0 mm long, yellow. *Fruit* 1-4 per infructescence, globose, with longitudinal 11-winged, ca. 2.0 cm dia., bright green, glabrous, apex truncate with persistent calyx.

Phenology.— Flowering and fruiting during April- August.

Thailand.— NORTHERN: Tak (Um Phang), Chiang Mai (Mae lao-Mae Sae); SOUTH-WESTERN: Kanchanaburi (Thong Pha Phum) (Appendix B7).

Ecology.— Dry or hill evergreen forest, light gaps, N 15° 50′ 43.4′′, E 98° 42′ 11.6′′, 750-1,337 m.

Uses.— Young shoot edible.

Vernacular name.— Po Sor Si (โปซอซี) (Karen-Tak).

Note.— *Amomum* sp.6 is similar to *A.siamense* Craib, differs in its smaller leafy shoots and fruit are covered with 11 longitudinal wings.

Specimen examined.— *Kaewsri 25*, 25 May 2003, Thong Pha Phum (BK, BKF); *Kaewsri 89*, 20 April 2004, Um Phang (BK, BKF); *Kaewsri 113*, 21 May 2004, Chiang Mai (BK, BKF).

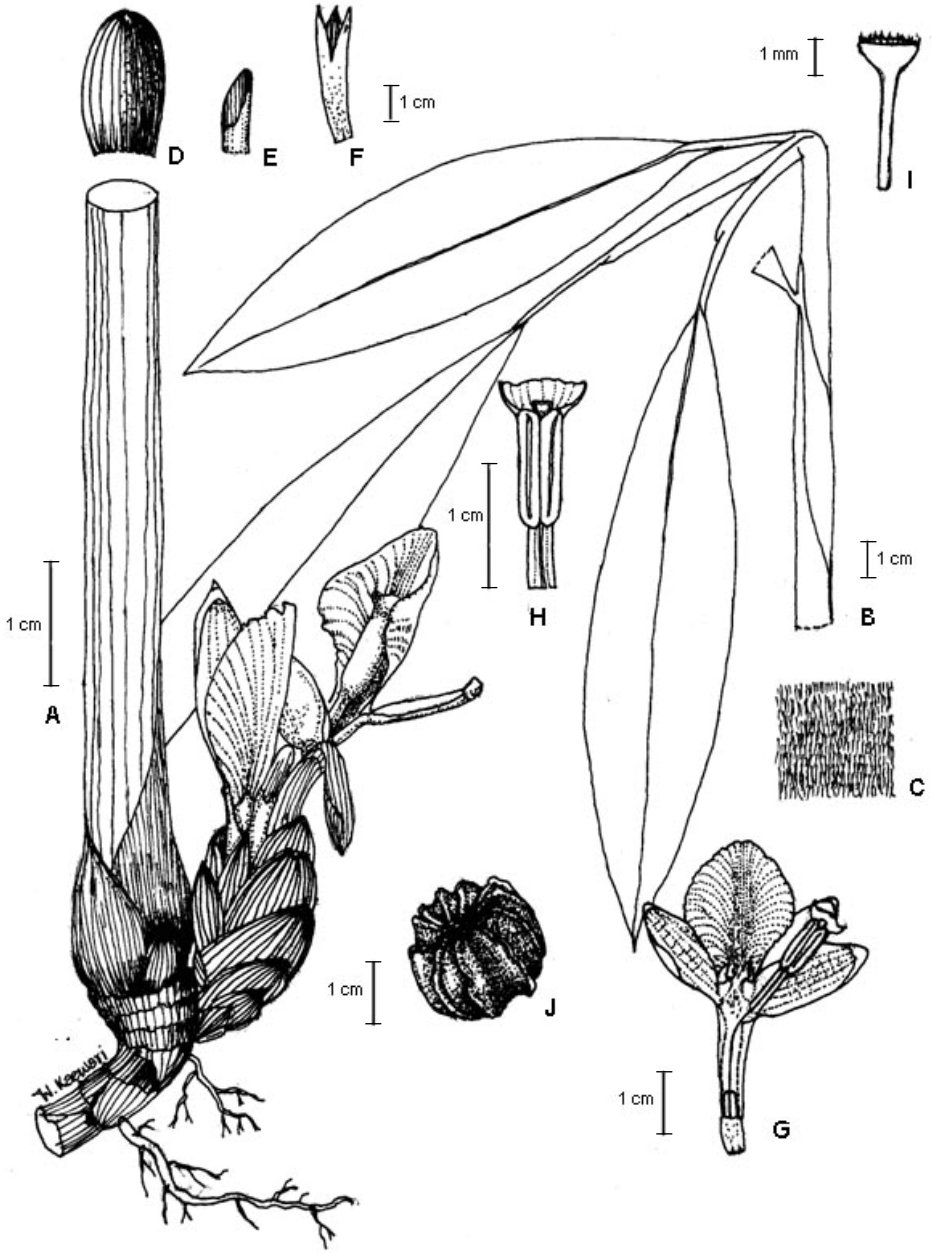

Figure 21 *Amomum* sp.6: A. inflorescence and stem base; B. leaf, C. leaf lower surface ; D. bract; E. bracteole; F. calyx; G. flower, dissected; H. anther, anther crest; I. stigma; J. fruit (drawn from Kaewsri-25).

20. Amomum sp.7. **Figure** 22. **Picture:** Appendix A20.

Rhizome elongate, yellow green. *Leafy shoot* slender, 1.2-1.7 m tall. *Leaves* 16-26; ligule 2-lobed, leathery, 1.0-2.0 mm long, with 2 transversal ridges and hairs axil; petiole sessile; lamina oblong, 15.0-32.0 by 6.0-7.5 cm, surfaces glabrous, base attenuate, apex acuminate, tip caudate, 1.5-2.0 cm. *Inflorescence* obovate, ca. 3.0-5.0 by 1.5-3.0 cm; peduncle 6.0-10.0 cm long; peduncular bract ovate, pale brown, 0.5-2.5 by 0.3-0.6 cm, apex hooded, acuminate. *Bract* hooded, ovate-oblong, ca. 2.0 by 0.7 cm, soon decaying, submembranous, pale brownish cream, apex acuminate or mucronate. *Bracteole* tubular, ca. 1.0 cm long including ovary, apex 2-fid, shallowly split on 1 side, creamy white, membranous, outer surface glabrous, base pubescent. *Calyx* ca. 1.5 cm long including ovary, apex 2-fid and shallowly split ca. 7.0 mm on 1 side, outer surface glabrous, pubescent base. *Corolla* creamy white, tube pubescent, ca. 2.5 cm long including ovary, dorsal lobe oblong, apex blunt, hooded, ca. 1.5 by 0.5 cm, lateral lobe narrower. *Lateral staminode* absent. *Labellum* spathulate, ca. 2.0 cm dia., base cuneate, apex 2-fid and reflex, white with yellow band along center and broader at apex, reddish veins on each side of band. *Filament* ca. 8.0 mm long, linear; anther ca. 5.0 by 3.0 mm, dehiscing lengthwise; anther crest 3-lobed, ca. 5.0 by 2.0 mm, white, central lobe ca. 3.0 by 2.0 mm , round and emarginate, reflex, lateral lobe ca. 1.0 by 1.0 mm, auriculate, erect. *Ovary* cylindric, ca. 3.0 by 3.0 mm, surface with white pubescent; stigma small bulbous, edge glabrous; stylode blunt, ca. 2 mm long. *Fruit* 3-5 per infructescence, globose, ca. 1.8 cm dia., covered with stout spines, bright green when young turning red when ripe, stalk ca. 2.0 mm long.

Phenology.— Flowering and fruiting: June.

Thailand.— SOUTH-WESTERN: Uthai Thani (Huai Kha Khaeng) (Appendix B7).

Ecology.— Dry evergreen forest, under shrubs or trees, ca. 215 m.

Note.— *Amomum* sp.7 is similar to *A. uliginosum* König ex Rezt., differs in its shorter leafy stem , inflorescence is less dense and lateral-staminodes are absent. The species is common in Huai Kha Khaeng (Mae Dee).

Specimen examined.— *Kaewsri 27*, 1 June 2004, Uthai Thani (BK, BKF).

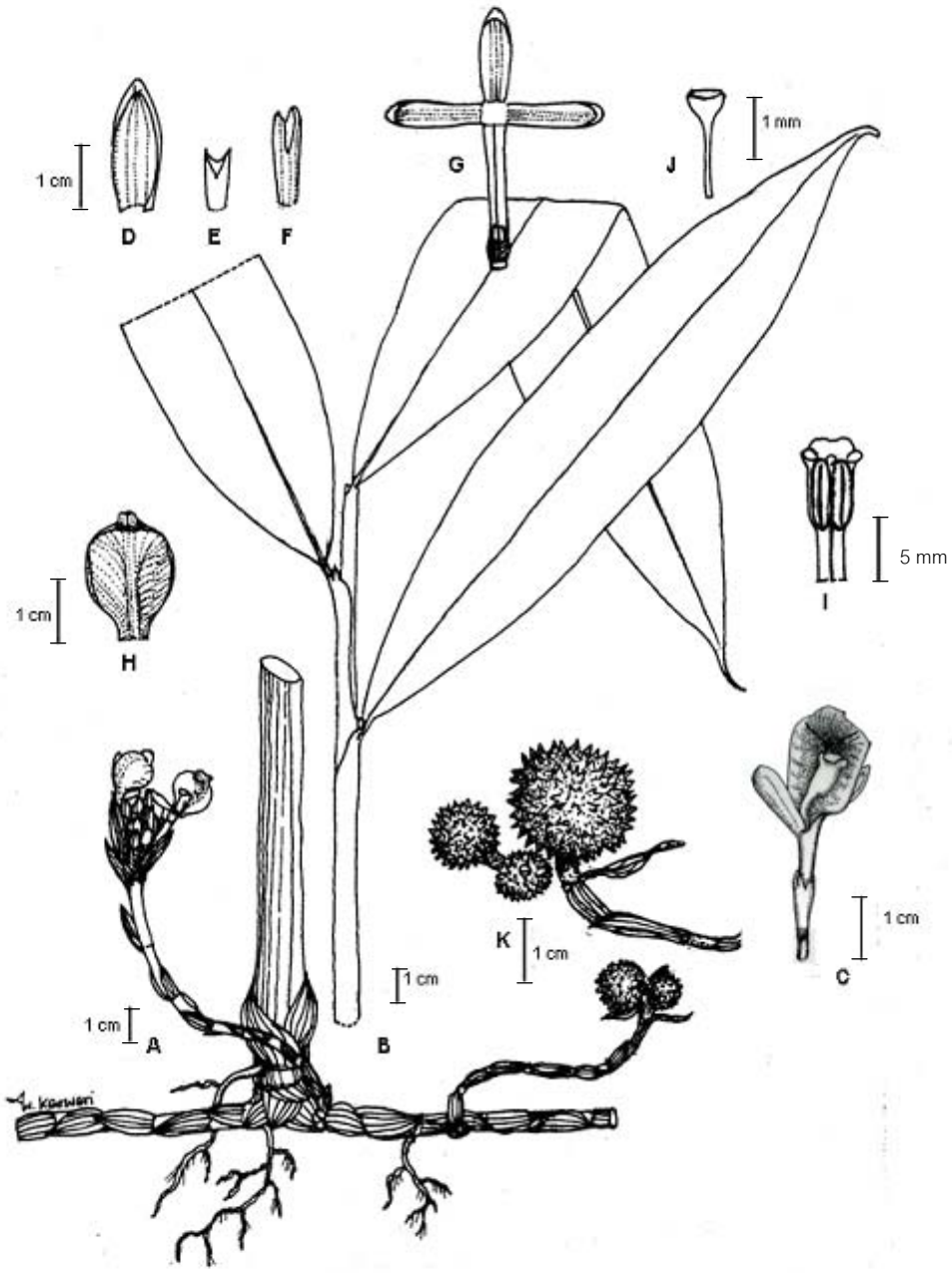

Figure 22 *Amomum* sp.7: A. inflorescence and infructescence; B. leaves; C. flower; D. bract; E. bracteole; F. calyx; G. corolla, dissected; H. labellum; I. stamen; J. stigma; K. fruit (drawn from Kaewsri-27).

21. Amomum sp. 8. **Figure** 23. **Picture:** Appendix A21.

Rhizome short. *Leafy shoot* slender, ca. 40.0 cm tall. *Leaves* 4-5; sheath reticulate, hairy; ligule 2-lobed, papery, ca. 2.0 mm long, margin ciliate; petiole sessile to 7 mm long; lamina narrowly oblong to elliptic-oblong, 18.0-21.0 by 5.0-6.5 cm, upper surface glabrous or glabrate, lower surface densely pubescent, base attenuate or cuneate, apex acuminate, tip caudate, 1.0-2.0 cm. *Inflorescence* not seen. *Fruit* globose, 1.0-1.5 cm dia., densely covered with slender spines, dark brown to blackish brown.

Phenology.— Fruiting: January.

Thailand.— PENINSULAR: Ranong (Khlong Naka) (Appendix B7).

Ecology.— Tropical rain forest, under shade of trees or shrubs and along streams, 55 m.

Vernacular name.— Pud Khee Maew (ปุดขี้แมว).

Note.— This species needs more specimens for examination especially flowering parts. The plants collected from Khlong Naka with only fruit were not enough to identify accurately. Considering its fruit, it is placed in the spiny group that is similar to *A.uliginosum*, but differs in its more rigid spines are more rigid and slender leafy stems.

Specimen examined.— *Kaewsri 35*, 10 January 2004, Khlong Naka (BK, BKF).

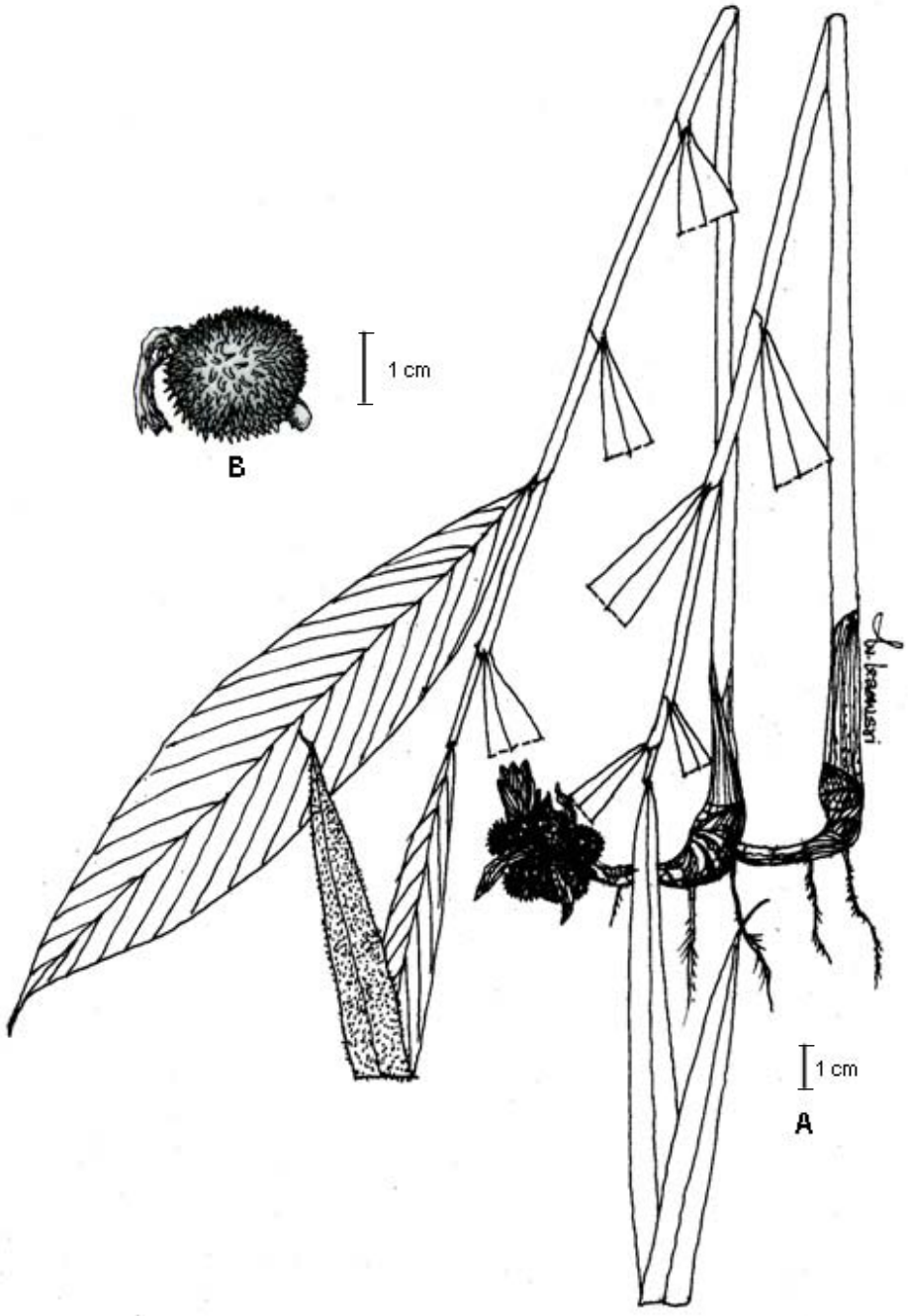

Figure 23 *Amomum* sp.8: A. habit; B. fruit (drawn from Kaewsri-35).

22. Amomum sp.9**. Figure** 24. **Picture:** Appendix A22.

Rhizome short. *Leafy shoot* slender, ca. 1.4 m tall, base swollen, ca. 2.0 cm dia. *Leaves* 19-23; ligule entire, apex truncate, ca. 2.0 mm long, hairs sparse at base, purplish green; petiole sessile; lamina oblong, 27.0-35.0 by 1.5-4.5 cm, base attenuate to obtuse, apex acuminate, tip caudate, 1.0-5.0 cm. *Inflorescence* not seen. *Fruit* ca. 6 per infructescence, globose, ca. 1.5 cm dia., densely covered with curved spines, bright red; peduncle procumbent.

Phenology.— Fruiting: January.

Thailand.— PENINSULAR: Ranong (Khlong Naka) (Appendix B8).

Ecology.— Tropical rain forest, under shady trees or shrubs, along the streams, 45 m.

Vernacular name.— Pud Ta Jong (ปุดตาจง).

Note.— *Amomum* sp.9 needs more specimens for examination. The parts of the flower are needed for identification. It is similar to *A. uliginosum* König ex Retz., but differs in its more slender leafy stem and cylindrical infructescence.

Specimen examined.— *Kaewsri 38*, 10 January 2004, Khlong Naka (BK, BKF).

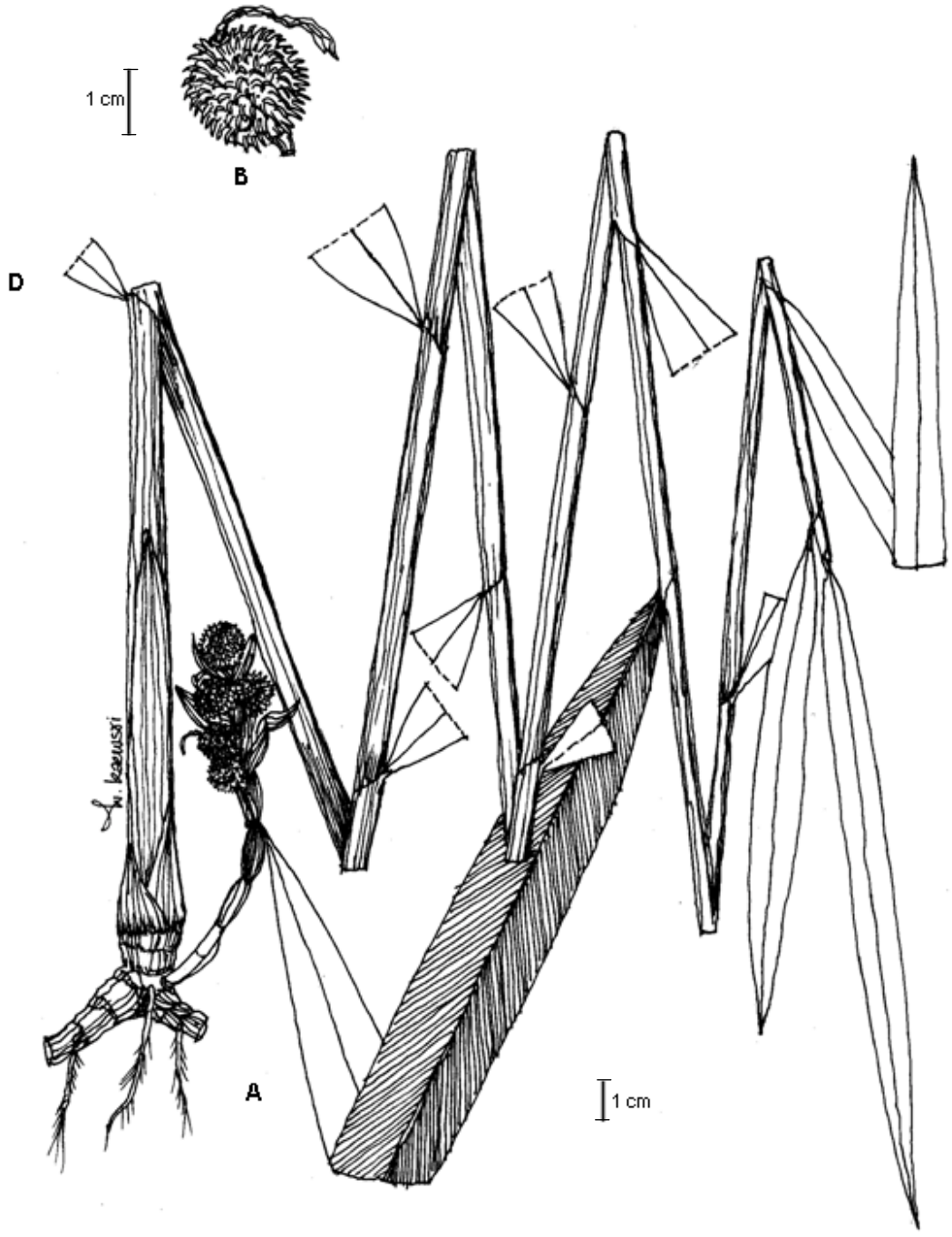

Figure 24 *Amomum* sp.9: A. habit; B. fruit (drawn from Kaewsri-38).

23. Amomum sp. 10. **Figure** 25. **Picture:** Appendix A23.

Rhizome elongate. *Leafy shoot* stout, 0.9-3.5 m tall, swollen and red at base. *Leaves* 18-24; sheath reticulate; ligule 2-lobed, membranous, 5.0-10.0 mm long, purplish red; petiole 5.0-10.0 mm long; lamina oblong, elliptic-oblong or ovate-oblong, 20.0-37.0 by 4.5-7.5 cm, base attenuate or obtuse, apex acuminate. *Inflorescence* obovoid, ca. 5.0 by 4.0 cm, ca. 16 flowers; peduncle ca. 10.0 cm long, procumbent; peduncular bract broadly ovate, pinkish green, apex round, hooded, apiculate. *Bract* ovate-oblong, hooded, ca. 2.3-3.0 by 1.0-1.7 cm, pinkish green, apex mucronate. *Bracteole* tubular, ca. 1.5-1.7 cm long including ovary, apex unequal 2-fid, shallowly split on 1 side, greenish cream, membranous, whitish pubescent base. *Calyx* 2.0-2.6 cm long including ovary, apex unequally 2-or 3-fid, shallowly split on 1 side, creamy white, membranous. *Corolla* creamy white, tube ca. 2.0 cm long including ovary, dorsal lobe oblong, apex acuminate, hooded, ca. 1.7 by 0.8 cm, lateral lobe narrower. *Lateral staminode* minute subulate, ca. 1.0-3.0 mm long, with crimson dot lines from base to apex. *Labellum* spreading, slightly 3-lobed, ca. 2.0-2.6 by 1.9-2.5 cm, base cordate and clawed, middle lobe apex round and emarginate, lateral lobes round, margin revolute and wrinkle, white with yellow blotchs along center and broader at apex, purplish red stripes on each side of blotch, hairy from base to middle. *Filament* 6.0-8.0 by 2.0 mm long, linear, glabrous, with 2 crimson dotted lines along center; anther ca. 8.0 by 3.5 mm, dehiscing lengthwise, pale yellow, sparsely pubescent; anther crest reniform, equally 3-lobed, hooded, white, central lobe rounded, ca. 5.0 by 3.0 mm, lateral lobe auriculate, ca. 3.0 by 3.0 mm, round. *Ovary* cylindric, 8.0 by 3.5 mm, surface densely brownish pubescent; stigma small cup-shaped, hairy edge; stylode blunt, ca. 2.0 by 2.0 mm. *Fruit* globose, ca. 2.5-2.7 cm dia., covered with rigid spines, purplish red, slightly aromatic.

Phenology.— Flowering and fruiting during April- August.

Thailand.— NORTH-EASTERN: Nong Khai (Phu Wua and Phu Tok Noi Wildlife Sanctuaries), Kalasin, Sakon Nakhon (Phu Phan), Nakhon Panom (Dong Bang-i); EASTERN: Nakhon Ratchasima (Khao Phrik); SOUTH-EASTERN: Chon Buri (Khao Kiew), Prachin Buri (Kao Hua Chang, Tab Lan), Sa Kaeo (Pang Si Da) (Appendix B8).

Ecology.— Dry evergreen forest, mostly disturbed areas in the moist deciduous forest, border of dry evergreen forest, ca. 300 m.

Vernacular name.— Neng Yai (แหน่งใหญ่), Maak Naeng (หมากแหน่ง), Maak Neng Kong (หมักเน่งโค่ง).

Note.— *Amomum* sp.10 is similar to *A. villosum* Lour., its difference includes spreading labellum and present of staminodes. The species should be the same as that collected from Phu Phan National Park by Yuktatat (1990) and Saensook (1998) but it was identified as *A. hastilabium* Ridl. In my opinion, their descriptions is quite different from *A. hastilabium* Ridl. especially in its fruit which covered with spines (vs. smooth) and *A. hastilabium* is common only in Southern Thailand.

Specimen examined.— *C. Niyomdham 5042*, 21 June 1997, Phutok Noi (BKF); *Kaewsri50*, 26 Febuary 2005, Sakon Nakhon (BK, BKF); *Kaewsri54*, 26 Febuary 2005, Sakon Nakhon (BK, BKF); *Kaewsri 104,* 6 May 2005, Buri Ram (BK, BKF); *Kaewsri 105,* 6 May 2005, Buri Ram (BK, BKF); *Kerr21477*, 15 May 1932, Nakhon Panom (BK); *Maxwell 75-421,* 11 April 1975, Khao Kiew (BK); *Maxwell 76-309*, 8 May 1976, Khao Phrik (BK); *Maxwell 01-492,* 19 September 2001, Khong Chiam(CMU); *Newman 955*, 2 August 1999, Phu Phan (BKF); *R. Pooma 1584,* 7 May 1997, Phu Wua (BKF); *Sakol 3207*, 27 March 1975, Kao Hua Chang (BK).

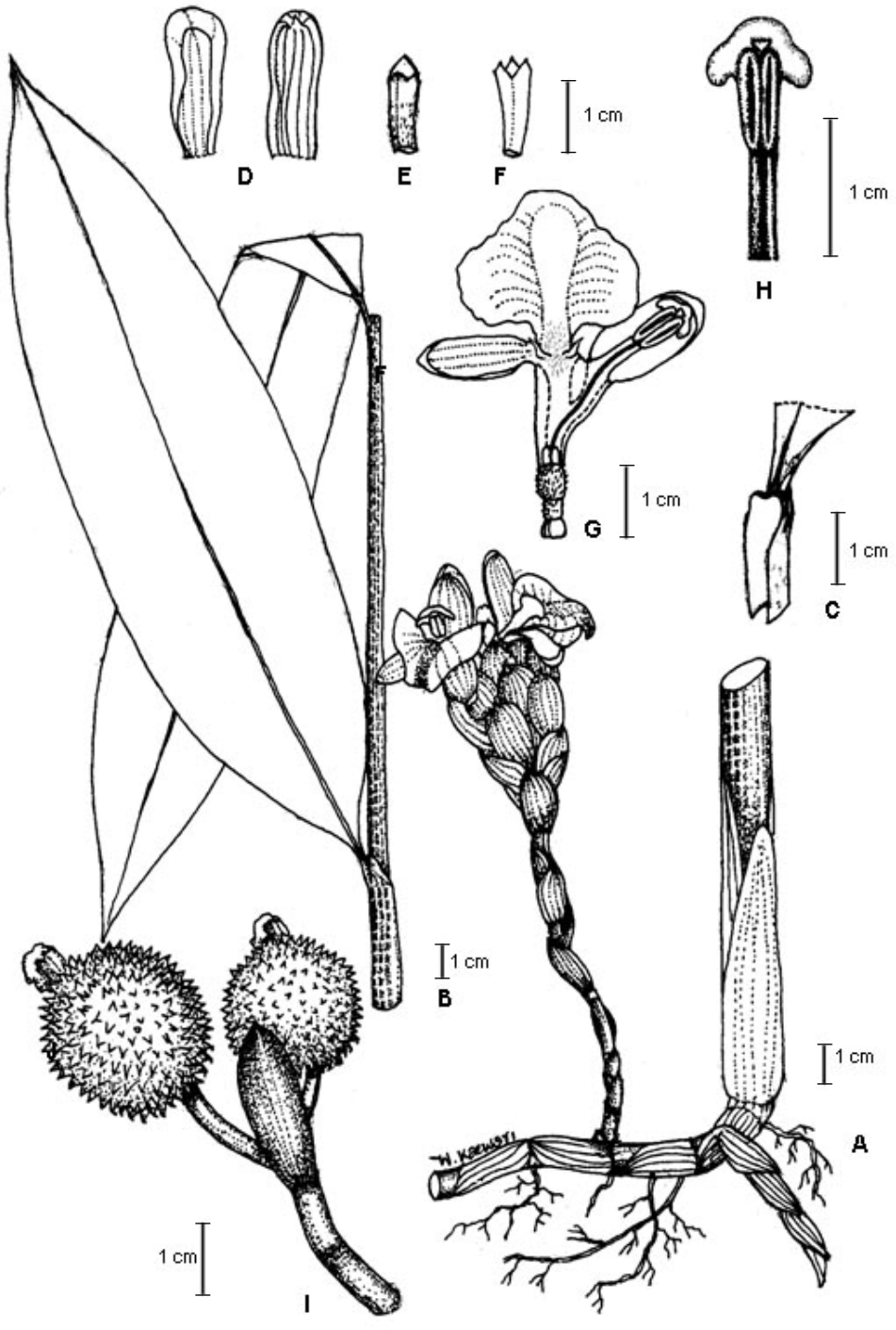

Figure 25 *Amomum* sp.10: A. inflorescence and rhizome; B. leaves; C.ligule; D. bract; E. bracteole; F. calyx; G. flower, dissected; H. stamen (drawn from Kaewsri-50); I. infructescence (drawn from Kaewsri-105).

24. Amomum sp.11. **Figure** 26. **Picture:** Appendix A24.

Rhizome elongate. *Leafy shoot* slender, 0.6-1.7 m tall. *Leaves* 17-31; sheath dark green; ligule 2-lobed, papery, 1.0-3.0 mm long; petiole 2.0-5.0 mm long; lamina oblong-lanceolate to narrowly oblong, 9.6-28.0 by 2.3-4.0 cm, paperly, base attenuate to obtuse, apex acuminate, tip caudate, 3.0-4.1 cm. *Inflorescence* obovate to conical, ca. 3.0 by 1.2 cm; peduncle 2.0-3.0 cm long; peduncular bract broadly ovate, pale brown, glabrous or sparsely pubescent, ca. 7 by 1 mm, apex acuminate. *Bract* ovate to deltoid, 1.8-2.0 by 1.5-2.0 cm, persistent, papery, pale brown with scattering dark brown spots, glabrous, apex mucronate. *Bracteole* tubular, ca. 1.5 cm long including ovary, apex 2-fid, pale brown, outer surface glabrous with pubescent base. *Calyx* ca. 2.5-4.0 cm long including ovary, apex 2-fid and shallowly split on 1 side, outer surface pale brown, base pubescent. *Corolla* white, tube 3.7-4.2 cm long including ovary, dorsal lobe oblong, ca. 1.6 by 0.8 cm, membranous, apex blunt, hooded, lateral lobe narrower. *Lateral staminode* narrowly subulate, ca. 5.0 mm. *Labellum* obovate and hooded, ca. 1.8 by 1.6 cm, base contracted and clawed, apex shallowly 2-fid, white with yellow band along center and crimson veins on each side of band. *Filament* ca. 6.0 by 1.5 mm, linear; anther ca. 4.0 by 3.0 mm, dehiscing lengthwise; anther crest 3-lobed, round, ca. 5.0 by 2.0 mm, whitish, central lobe 3.0-3.5 mm wide, emarginate, reflex, lateral lobe ca. 1.0 by 1.0 mm, spreading. *Ovary* cylindric, ca. 3.0 by 3.0 mm, hairy; stigma small bulbous, the aperture edge hairy; stylode blunt, ca. 5 mm long. *Fruit* 2-3 per infructescence, globose, ca. 1.7 by 1.5 cm dia., densely covered with rigid spines, white when young turning red when ripe.

Phenology.— Flowering and fruting during April-July.

Thailand.— PENINSULAR: Chumphon (Krom Luang Chumphon WS., North) (Appendix B8).

Ecology.— Tropical rain and hill evergreen forest, under shrubs and trees, N 10° 39′ 35.1′′, 98° 54′ 19.5′′, 215 m.

Note.— *Amomum* sp. 11 is similar to *A. uliginosum* Ridl. but differs in its smaller leafy stem and inflorescence, number of fruit are less and spines are stronger.

Specimen examined.— *Kaewsri 68*, 7 April 2004, Chumphon (BK, BKF); *Kaewsri 79*, 9 April 2004, Ranong (BK, BKF).

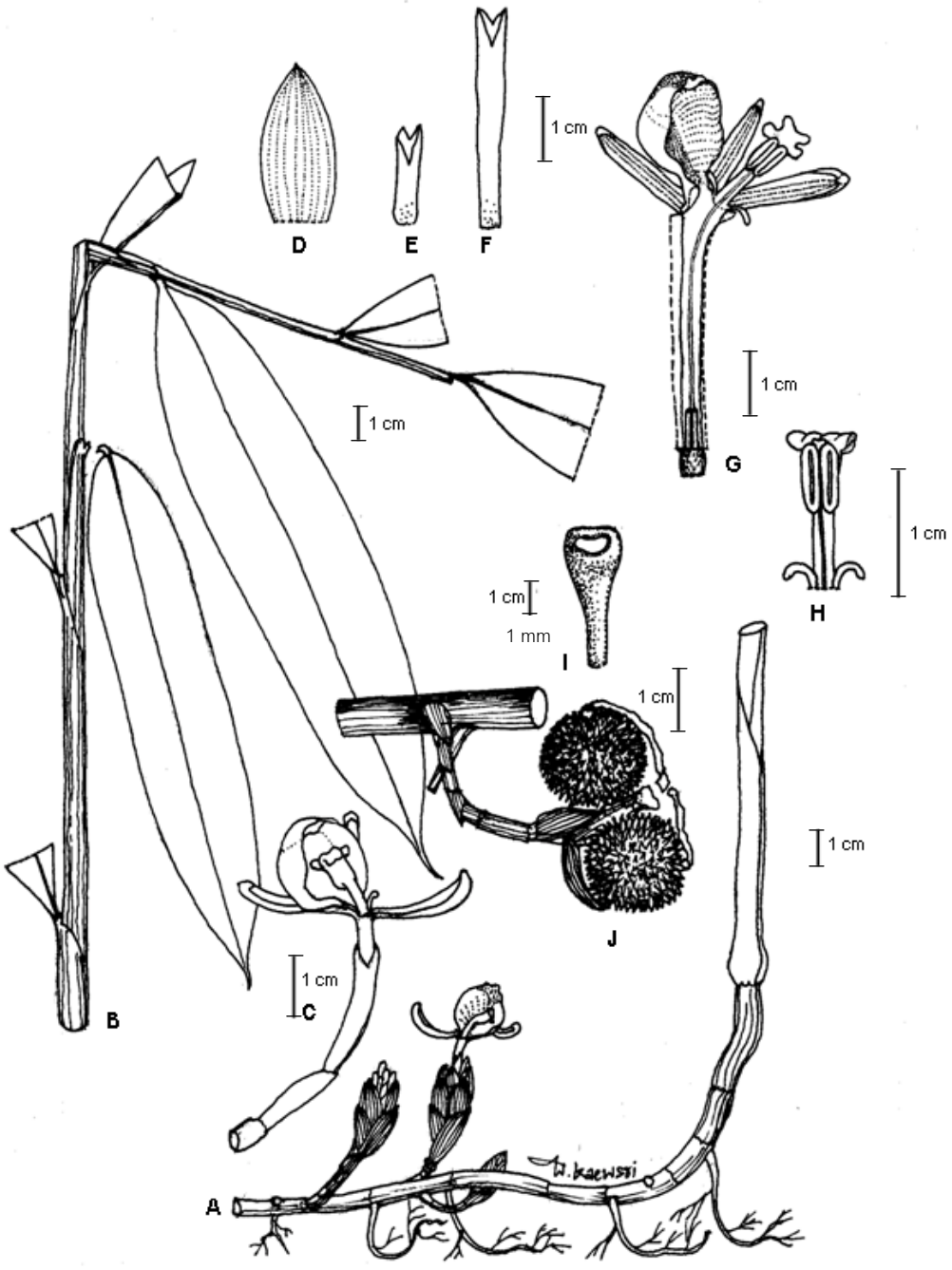

Figure 26 *Amomum* sp.11: A. inflorescences and rhizome; B. leaves; C. flower; D. bract; E. bracteole; F. calyx; G. flower, dissected; H. stamen, staminode; I. stigma; J. infructescence (drawn from Kaewsri-68).

25. Amomum sp.12. **Figure** 27. **Picture:** Appendix A25.

Rhizome short. *Leafy shoot* stout, 5.0-6.0 m tall. *Leaves* 46-54; sheath green, red at base; ligule 2-lobed, subleathery, margin pubescent, 8-12 mm long; petiole sessile; lamina ovate-oblong, narrowly oblong or lanceolate-oblong, 50.0-55.0 by 5.0-7.0 cm, base round or obliquely round, apex acuminate. *Inflorescence* clavate to cylindric , 17.0-24.0 by 5.0-8.0 cm; peduncle erect, stout, 75-121 cm long; peduncular bract ovate oblong, brown when dry, leathery, 4.0-10.5 by 2.5-3.0 cm. *Bract* ovate-oblong, ca.4.5 by 1.2 cm, brownish green, surfaces pubescent, apex acuminate. *Bracteole* tubular, ca. 2.3 cm long including ovary, apex 2-lobed, pale brown, outer surface with scattered pubescent. *Calyx* 2.2-2.5 cm long including ovary, apex 2-fid, shallowly split on 1 side, membranous, scattered pubescent base and margin. *Corolla* greenish cream, tube ca. 2.0 cm long including ovary, dorsal lobe elliptic or broad-elliptic, ca. 2.3 by 1.8 cm, membranous, apex mucronate, lateral lobe ca. 2.0 by 1.0 cm, apex blunt, hooded. *Lateral staminode* absent. *Labellum* slightly 3-lobed, transversly elliptic, convolute, ca. 2.5 by 2.0 cm, base attenuate, middle lobe slightly reflex, apex 2-cleft, pale yellow to pale green, with crimson dot lines radiate from base to margin. *Filament* ca. 2.0 mm long, flat, glabrous; anther ca. 15.0 by 5.0 mm, sparsely strigose, dehiscing lengthwise; anther crest reniform, 3-lobed, round, ca. 7.0 by 2.5 mm, greenish yellow, central lobe ca. 2.0 by 2.0 mm, lateral lobe ca. 2.5 by 2.5 mm. *Ovary* cylindric, ca. 7 mm, densely pubescent; stigma cup-shaped, aperture edge hairy; style with scattered hair, stylode blunt, ca. 5 mm long. *Fruit* not seen.

Phenology.— Flowering: April.- August.

Thailand.— PENINSULAR: Chumphon (Krom Luang Chumphon WS, North) (Appendix B9).

Ecology.— Tropical rain forest, 263-355 m.

Note.— *Amomum* sp. 12 is a rare species of Thailand. The species is similar to *A. aculeatum* Roxb., but differs in that the flower is smaller and pale yellow. Inflorescence is occasionally terminal on leafy shoot.

Specimen examined.— *Kaewsri 70*, 7 April 2004, Chumphon (BK, BKF).

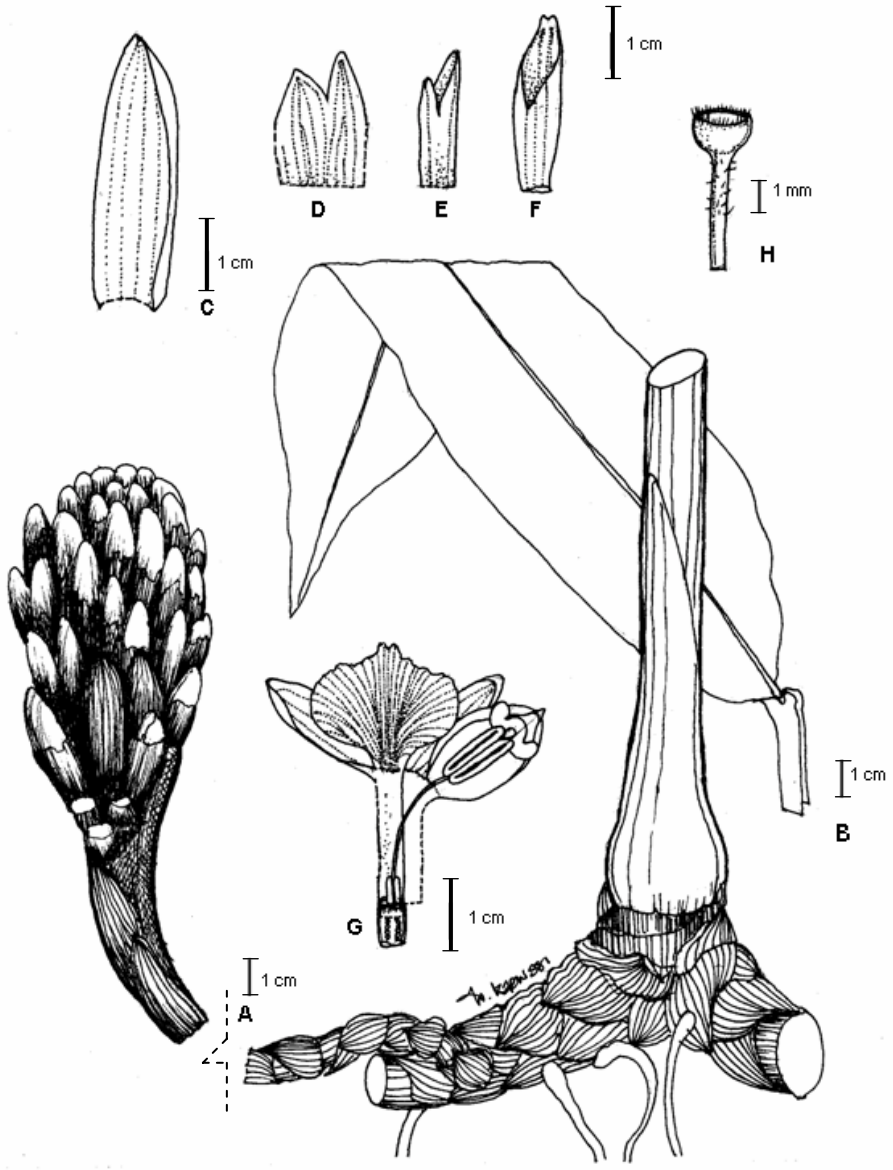

Figure 27 *Amomum* sp.12: A. inflorescence and stem base; B. leaf; C.bract; D-E. bracteole; F. calyx; G. flower, dissected; H. stigma (drawn from Kaewsri-70).

26. Amomum sp. 13. **Figure** 28. **Picture:** Appendix A26.

Rhizome short with stilt root. *Leafy shoot* slender, up to 1.6 m tall. *Leaves* 11-28; sheath brownish green, scattering hairs at base, reticulate; ligule 2-lobed, apex round, membranous, pale green, ca.3.0 mm long; petiole 4.0 mm long; lamina elliptic or oblong, 16.0-25.0 by 3.0-7.0 cm, base obtuse to cuneate, apex acuminate, tip caudate, 1-2 cm. *Inflorescence* obovoid, ca. 3.0 by 2.5 cm; peduncle ca. 1.5 cm long; peduncular bract ovate-deltoid, pale brown, papery, glabrate, ca. 5.0 by 5.0 cm. *Bract* oblong, ca.1.2 by 0.3 cm, pale brown, subpapery, hairs scattered at base, apex acuminate. *Bracteole* membranous, tubular, ca. 1.0 cm long, apex obscurely 2-lobed, pale brown, outer surface glabrous. *Calyx* ca. 1.5 cm long including ovary, apex 3-fid, shallowly split on 1 side almost to middle, creamy white, membranous, glabrous. *Corolla* creamy white, tube sparsely pubescent, ca. 1.5 cm long including ovary, dorsal lobe hooded oblong, ca. 10.0 by 4.0 mm, membranous, apex acuminate, lateral lobe ca. 8.0 by 4.0 mm, apex blunt, hooded. *Lateral staminode* fin-shaped, ca. 2 by 2 mm. *Labellum* hooded, elliptic, ca. 1.0 by 0.6 cm, apex slightly 2-fid, white with scattering crimson spots, with dark yellow blotchs at apex. *Filament* ca. 5.0 by 1.0 mm, glabrous; anther ca. 5.0 by 3.0 mm, glabrous, dehiscing lengthwise; anther crest reniform, 3-lobed, rounded, ca. 7.0 by 2.0 mm, creamy white, central lobe ca. 3.0 by 2.0 mm, lateral lobe ca. 2.0 by 2.0 mm. *Ovary* cylindric, ca. 3.0 by 2.0 mm, densely appressed pubescent; stigma clavate shaped, aperture narrowly transverse, glabrous; style glabrous, stylode blunt, ca. 3.0 by 1.0 mm, yellow. *Fruit* elliptic, densely covered with curve spines, ca. 2.3 by 2.0 cm, crimson- red; fruit stalk ca. 5.0 mm long.

Phenology.— Flowering and fruiting: April.

Thailand.— PENINSULAR: Ranong (Krom Luang Chumphon WS., North) (Appendix B9).

Ecology.— Tropical rain forest, under shrubs or trees on hill slopes, 263-355 m.

Note.— *Amomum* sp.13 is similar to *A. uliginosum* König ex Retz. but differs in its elevate leafy stem by stilt-roots, petioles are shorter, labellum and fruit are elliptic. This is a uncommon species found only in southern part of Thailand.

Specimen examined.— *Kaewsri 81,* 9 April 2004, Ranong (BK, BKF).

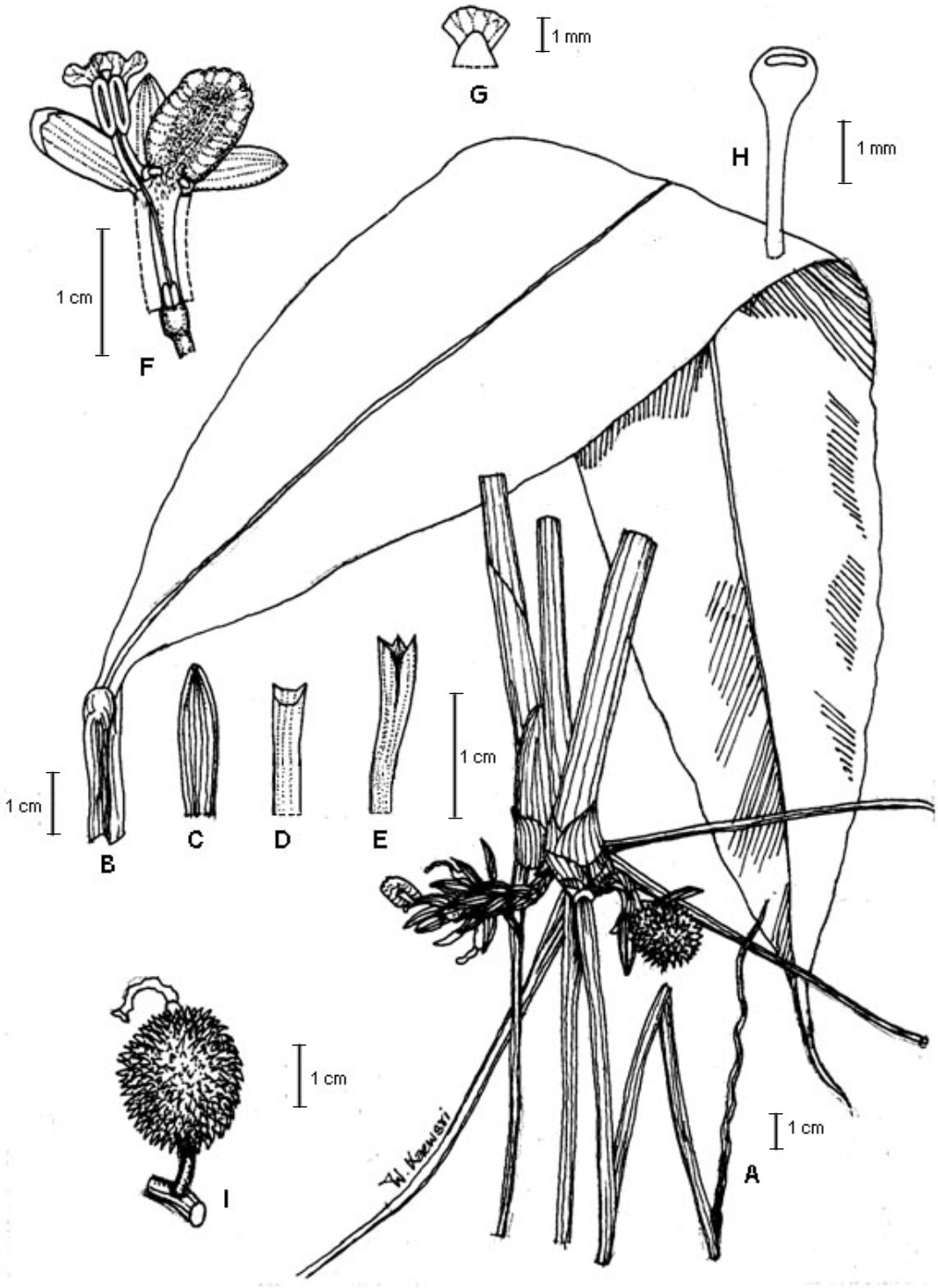

Figure 28 *Amomum* sp.13: A. habit; B. leaf; C. bract; D. bracteole; E. calyx; F. flower, dissected; G. lateral staminode; H. stigma; I. fruit (drawn from Kaewsri-81).

27. Amomum sp.14. **Figure** 29. **Picture:** Appendix A27.

Rhizome short. *Leafy shoot* slender, ca. 5.5 m high. *Leaves* 8-15; sheath green; ligule 2-lobed, papery, 1.0-2.0 mm long; petiole 3.0-6.0 mm long; lamina broadly elliptic to oblong, 10.0-14.0 by 5.0-6.8 cm, base attenuate or round, apex acuminate to round, tip caudate, 1.0-2.0 cm. *Inflorescence* conical or obovate, ca. 3.0 by 1.5 cm; peduncle ca. 1.5 cm long; peduncular bract ovate to oblong, densely pubescent, leathery, apex round. *Bract* ovate, ca. 1.8 by 0.9 cm, margin ciliate, outer surface with brownish pubescent, apex mucronate. *Bracteole* tubular, ca. 1.0 cm, apex 2-fid and split on 1 side, outer surface with brownish pubescent, margin ciliate. *Calyx* ca. 1.6 cm long, apex 3-fid and split to 5 mm on 1 side, outer surface brownish pubescent, margin ciliate. *Corolla* creamy white, tube glabrous, ca. 1.7 cm long including ovary, dorsal lobe hooded, broadly oblong to ovate-oblong, ca. 1.9 by 0.7 cm, apex apiculate, lateral lobe slightly smaller, apex blunt, hooded. *Lateral staminode* absent. *Labellum* broadly obovate, spreading, ca. 2.3 by 2.0 cm, base attenuate, apex obtuse and wrinkle, margin revolute, white with orange-yellow blotchs and spreading toward apex, reddish lateral stripes from base along middle, 2-ridged near apex, sparsely pubescent base. *Filament* ca. 6.0 by 2.5 mm, glabrous; anther 3-4 by 3 mm, dehiscing lengthwise; anther crest horn-liked, 3-lobed, ca. 4 by 4 mm, creamy white, central lobe slightly reflex, apex round, lateral lobes smaller, apex acute, spreading. *Ovary* cylindric, ca. 3 mm long, pubescent; stigma cup-shaped, aperture ciliate, ca. 2.5 mm wide, stylode blunt, ca. 3 mm long. *Fruit* not seen.

Phenology.—Flowering: April- July.

Thailand.—NORTHERN: Tak (Um Phang) (Appendix B9).

Ecology.— Dry evergreen forest, under shade of shrubs or trees, ca. 700 m.

Note.—*Amomum* sp.14 similar to *A.biflorum* Jack, differ in its broader leaves, larger inflorescence, more flowers, white labellum with orange-yellow midband. Its vegetative shoot similar to that of *Zingiber*.

Specimen examined.— *Kaewsri 93*, 21 April 2004, Um Phang (BK, BKF); *Kaewsri 94*, 21 April 2004, Um Phang (BK, BKF).

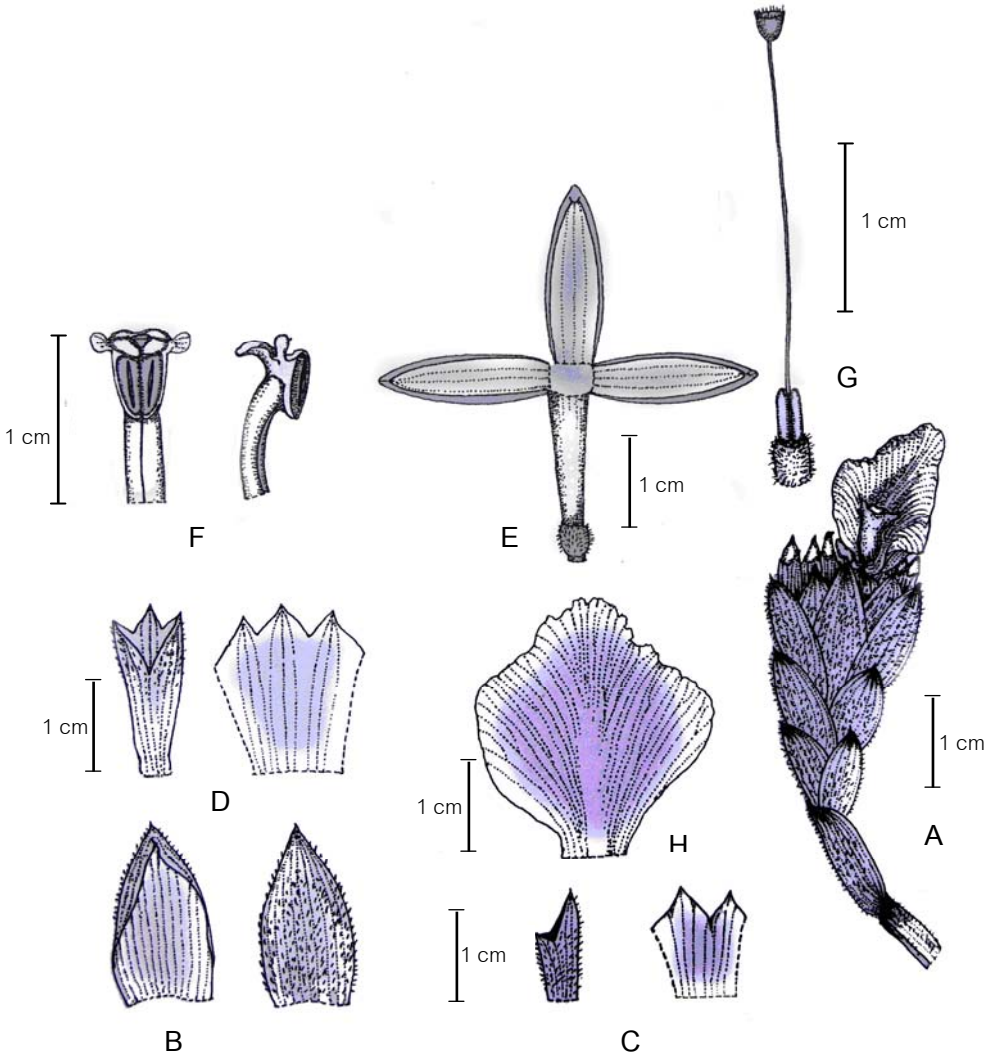

Figure 29 *Amomum* sp.14: A. inflorescence; B. bract; C. bracteole; D. calyx; E. corolla; F. stamen: G. stigma; H. labellum (drawn from Kaewsri-93).

28. Amomum sp.15**. Figure** 30. **Picture:** Appendix A28.

Rhizome short. *Leafy shoot* stout, 1.7-2.0 m tall. *Leaves* 5-8; sheath green; ligule 2-lobed, papery, ca. 5.0 mm long; petiole 2.0-7.5 cm long; lamina obovate-oblong, oblong or elliptic oblong, 26.0-65.0 by 5.0-11.0 cm, densely appressed silverly pubescent beneath, base attenuate or obtuse, apex acuminate. *Inflorescence* ovoid, obovoid or ellipsoid, 5.5-7.0 by 3.5-5.0 cm, reddish purple; peduncle 3.5-7.0 cm long; peduncular bract broadly ovate, 2.5-4.0 by 1.0-1.5 cm, papery, apex acuminate. *Bract* broadly ovate to ellipsoid, 2.0-5.0 by 2.0-3.0 cm, apex acuminate, reddish pink, soon disintegrate. *Bracteole* tubular, 1.6-2.5 cm including ovary, apex obliquely acute or round, shallowly split on 1 side, pink-cream. *Calyx* 4.1-4.5 cm long including ovary, apex 3-fid, creamy white. *Corolla* cream-white, tube 3.5-4.5 cm long including ovary, dorsal lobe hooded, oblong, 3.0-3.5 by 1.0 cm, apex apiculate, lateral lobes 2.7-3.0 by 0.6-0.9 cm, apex blunt, hooded. *Lateral staminode* subulate, 4.0-5.0 mm long. *Labellum* broadly ovate to orbiculate, spreading, 3.3-3.5 by 1.8-2.5 cm, base attenuate, apex round and slightly revolute, white with yellow blotchs along midband, with reddish stripes radiate from base to margin, base white pubescent. *Filament* ca. 5.0 mm long; anther ca. 1.5 cm long, dehiscing lengthwise; anther crest entire, apex truncate, spreading, 8.0-10.0 by 2.0-3.0 mm, cream-white. *Ovary* cylindric, ca. 6.0 mm long, smooth; stigma cup-shaped, aperture narrowly transverse, edge hairy; style glabrous, stylode blunt, ca. 6.0 mm long. *Fruit* ovoid or ellipsoid, with longitudinal 9-winged, ca. 1.5 by 1.3 cm, purple, glabrous, calyx remnant ca. 2.8 cm long at apex, fruit stalk ca. 1.5 cm long.

Phenology.— Flowering and fruiting: May.

Thailand.— NORTHERN: Tak (Doi Musur), Chiang Mai (Doi Inthanon) (Appendix B10).

Ecology.— Hill or dry evergreen forest , along the slope of mountain, light gaps. 550-1,300 m.

Vernacular.— Kuk (กุ๊ก), Chi Kuk (จี้กุ๊ก), Plee Kuk (ปลีกุ๊ก).

Uses.— Young inflorescence edible.

Note.— *Amomum* sp.15 is similar to *A. siamense* Craib., by differs on its fruit is red and 9-winged while fruit of *A. siamense* is green and 7-13-longitudinal ridged.

Specimen examined.— *Kaewsri 97*, 23 April 2004, Doi Musur (BK, BKF); *Kaewsri 108*, 17 May 2004, Doi Inthanon (BK, BKF); *TH.Wongprasert 009-12,* 17 Sep 2000, Fang Hot Spring NP.(BKF).

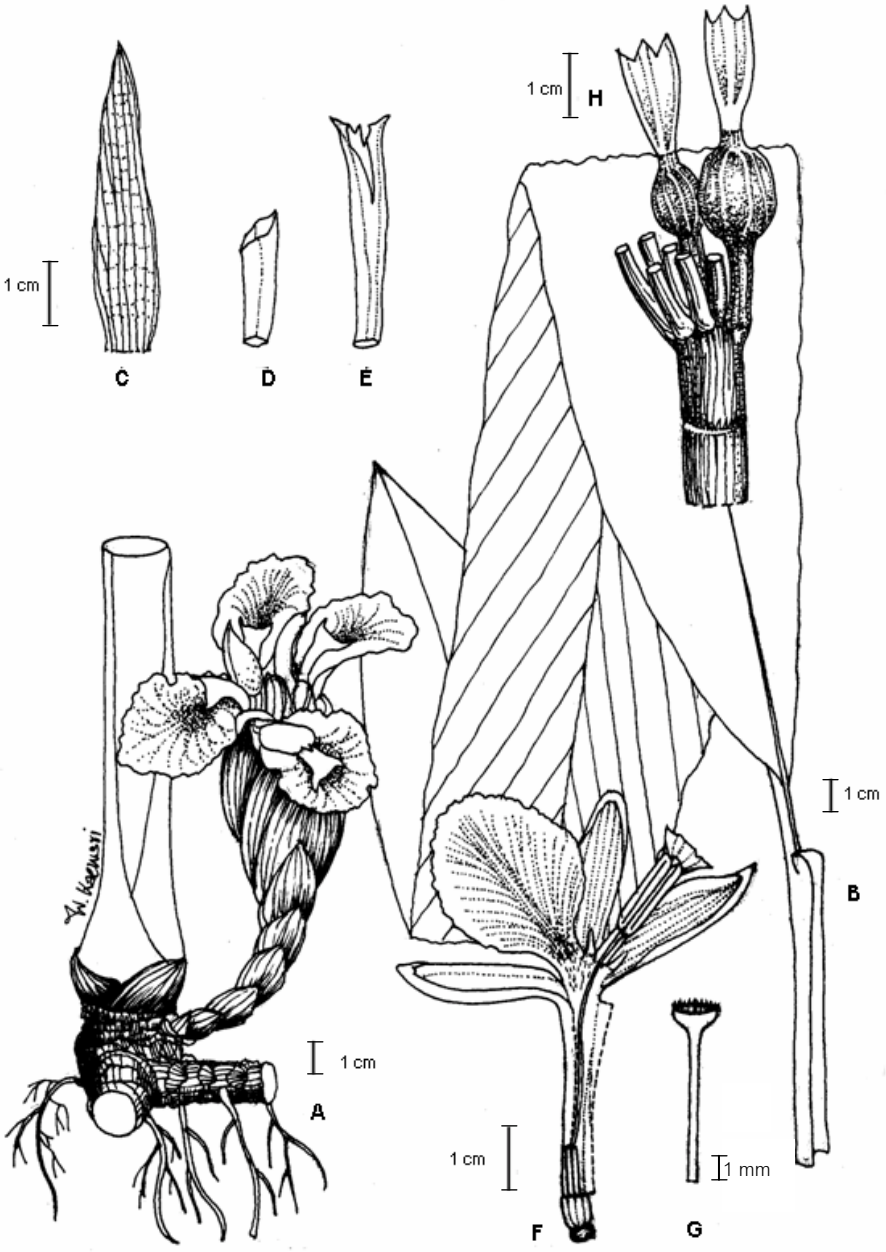

Figure 30 *Amomum* sp.15: A. inflorescence and stem base; B. leaf; C. bract; D. bracteole; E. calyx; F. flower, dissected; G. stigma; H. young fruit (drawn from Kaewsri-108).

29. Amomum sp.16**. Figure** 31. **Picture:** Appendix A29.

Rhizome short. *Leafy shoot* stout, 1.2-3.0 m tall. *Leaves* 12-14; sheath green, reddish-tinged at base; ligule entire, apex dried papery, 0.6-2.0 cm long; petiole 0.3-1.0 cm long; lamina oblong, ovate-oblong or elliptic-oblong, 20.0-68.0 by 3.0-18.0 cm, base attenuate or cuneate, apex acuminate. *Inflorescence* ovoid, cylindric or conical, emerge near base of pseudostem, 5.0-11.0 by 3.5-4.0 cm, purplish red; peduncle stout, 4.0-6.0 cm long; ; peduncular bract broadly ovate or orbicular, red, apex acuminate, 1.0-1.5 by 1.0-2.0 cm. *Bract* ovate to broadly ovate, 3.5-7.5 by 1.0-2.0 cm, apex acuminate, red. *Bracteole* tubular, 3.6-4.0 cm long, apex 2-lobed, shallowly split ca. 2 cm on 1 side, outer surface pubescent, pinkish white. *Calyx* ca. 4.0 cm long including ovary, apex shallowly 2-fid split on 1 side, pinkish white, glabrous. *Corolla* pinkish white, tube ca. 4.0 cm long including ovary, dorsal lobe hooded, oblong, ca. 2.5 by 1.0 cm, apex acuminate, lateral lobe narrower. *Lateral staminode* absent. *Labellum* elliptic or broadly ovate, spreading, ca. 3.7 by 1.5 cm, base attenuate, apex round, margin wrinkle, pale yellow, darker toward apex, pale red band from base to middle, lateral crimson lines along the band from base to middle, with crimson streak at both side of base, base white pubescent. *Filament* ca. 1.0 mm long; anther ca 1.3 by 0.3 cm, pale yellow, dehiscing lengthwise; anther crest entire, truncate-emarginate or slightly 3-lobed, lateral lobes distinct, the middle lobe usually disintegrate, spreading, 5.0 by 3.0 mm, pale yellow. *Ovary* cylindric, ca. 13 by 6.0 mm, smooth; stigma triangular, aperture narrowly transverse, edge hairy; stylode blunt, ca. 8 mm long. *Fruit* narrowly ovate or elliptic, smooth, 4.5-5 by 2.0-3.0 cm, pale green when young, fruit stalk 1.0-1.5 cm long; seeds many, angular, ca. 5.0 by 4.0 mm, brown.

Phenology.— Flowering and fruiting during May-September.

Thailand.— NORTHERN: Chiang Mai (Doi Suthep, Doi Inthanon), Lampang (Jae zon), Nan (Doi Phu Kha); NORTH-EASTERN: Loei (Naa Haew) (Appendix B10).

Ecology.— Hill evergreen and pine forest, under shade of trees or shrubs, moist area along stream, granite bedrock, N 18° 34′ 24.1′′, E 98° 28′ 3′′, 850-2,249 m.

Note.— *Amomum* sp.16 is common in the highlands of Northern Thailand. The species is similar to *A. coriandriodorum* S.Q. Tong & Y. M. Xia, but differs in its entire labellum (not lobed or auriculate) and the fruit without coriander smell.

Specimen examined.— *C. Phengklai et al 7183*, 28 July 1988, Doi Inthanon (BKF); *Dawid J. Middleton 155*, 2 September 1999, Tham Pha Toop (BKF); *Kaewsri 111*, 18 May 2004, Doi Inthanon (BK, BKF)**;** *Kaewsri-114*, 21 May 2004, Pang Sa Dej (BK, BKF); *Kaewsri 137*, 5 July 2004, Doi Phu Kha (BK, BKF); *Maxwell 05-451*, 16 July 2005, Doi Lohn, Chiang Mai (CMU); *Maxwell 88-604*, 8 May 1988, Doi Suthep (CMU); *Maxwell 88-1081*, 15 September 1988, Doi Suthep (CMU, BKF); *Maxwell 90-541*, 21 May 1990, Doi Suthep (CMU); *Maxwell 91-410*, 7 May 1991, Jom Tong (CMU); *Maxwell 91-557*, 16 June 1991, Jom Tong (CMU); *Maxwell 96-876*, 24 June 1996, Jae Sawn (CMU, BKF); *P. Srisanga & C. Maknoi 2057*, 22 August 2001, Doi Phu Kha (QBG); *S. Watthana 1395*, 8 July 2001, Mae Wong NP.(QBG); *W. Nanakorn*, 25 April 1994, Naa Haew (QBG).

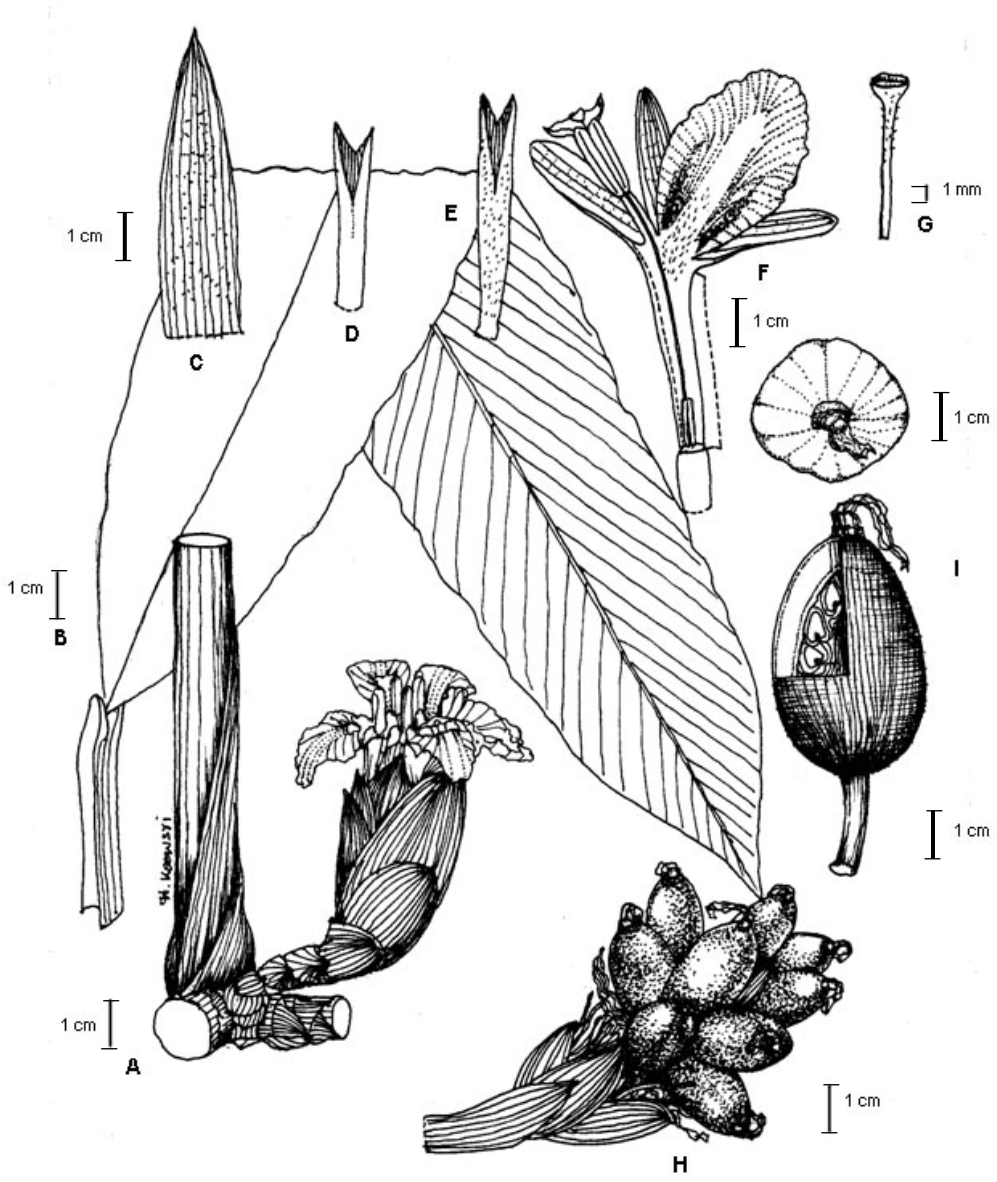

Figure 31 *Amomum* sp.16: A. Inflorescence and stem base; B. leaf; C. bract; D. bracteole; E. calyx; F. flower, dissected; G. stigma (drawn from Kaewsri-114); H. infructescence, I. fruit, dissected (drawn from Kaewsri-137).

30. Amomum sp.17**. Figure** 32. **Picture:** Appendix A30.

Rhizome short. *Leafy shoot* stout, 0.8-4.0 m tall. *Leaves* 3-9; sheath purplish green, glabrous; ligule 2-lobed, membranous, apex dry at maturity, 1.5-2 cm long; petiole 14.0-28.5 cm long; lamina ovate-oblong, 47.0-95.0 by 7.5-22.0 cm, lower surface pale green, velvet, densely appressed white pubescent, base attenuate, apex acuminate. *Inflorescence* ovoid, paniculate, 8.0-12.0 by 5.0-10.0 cm, pinkish green; peduncle 8.0-20.0 cm long; peduncular bract oblong, brown, outer surface with pubescent, apex round or acuminate, ca. 3.0 by 1.0 cm. *Bract* oblong, ca. 1.5 by 1.2 cm, outer surface pubescent, apex round or apiculate, pale brown. *Bracteole* absent. *Calyx* ca. 1.4-1.9 cm long, apex 3-fid, shallowly split ca. 8.0 mm on 1 side, outer surface pubescent. *Corolla* creamy white, tube ca. 1.3 cm long including ovary, dorsal lobe hooded, membranous, oblong , ca. 12.0 by 6.0 mm, apex apiculate or round, lateral lobe narrower, apex blunt, hooded. *Lateral staminode* subulate, ca. 1.0 mm long. *Labellum* obovate, 3-lobed, spreading, 1.5-2.2 by 1.0-1.5 cm, middle lobe apex round and revolute, lateral lobe larger, margin slightly revolute, base attenuate, white with pale yellow blotchs from base along center, with red streak on both sides at base. *Filament* ca. 2.0 mm long; anther 5.0-6.0 mm long, dehiscing lengthwise, pale yellow; anther crest slightly 3-lobed, membranous, ca. 6.0-7.0 by 2.0 mm, spreading, round, creamy white, central lobe ca. 3.0 by 2.0 mm, slightly reflex, lateral lobe ca. 1.5 by 1.5 mm. *Ovary* elliptic or oblong, ca. 3.0 by 2.5 mm long, elevated by fruit stalk ca. 4 mm long, smooth, with 9-longitudinally ridged; stigma cup-shaped, aperture narrowly transverse, edge hairy; style glabrous, stylode blunt, ca. 3.0 mm long. *Fruit* globose, with longitudinal 9-winged, ca. 2.3-3.0 cm dia., yellowish green when young turning pink at maturity, glabrous, apex with persistent calyx 1.0-1.5 cm long, fruit stalk 5.0-8.0 mm long; seed ca. 4.0 by 3.0 mm irregularly polyhedral, white aril.

Phenology.— Flowering and fruiting during April-July.

Thailand.— NORTHERN: Tak (Mae Sot-Umphang, N 16° 14′ 56′′, E 098° 59′ 46′′),
Nan (Doi Phukha, N 19° 2′ 32′′, E 101° 5′ 56′′) (Appendix B10).

Ecology.— Hill evergreen forest, light gaps, 900-1,500 m.

Note.— *Amomum* sp.17 is similar to *A. mengtzense* H.T. Tsai et P.S. Chen, differs in its shorter puduncles, fruit is globose and glabrous.

Specimen examined.— *A. Kostermans 64,* 25 April 1946, near Wangka (BK); *Kaewsri 134*, 5 July 2005, Doi Phu Kha (BK, BKF); *Kaewsri 135*, 5 July 2005, Doi Phu Kha (BK, BKF); *M. Newman 913*, 15 July 1990, Tak (BKF); *Srisanga 1451*, 27 May 2000, Doi Phu Kha (QBG).

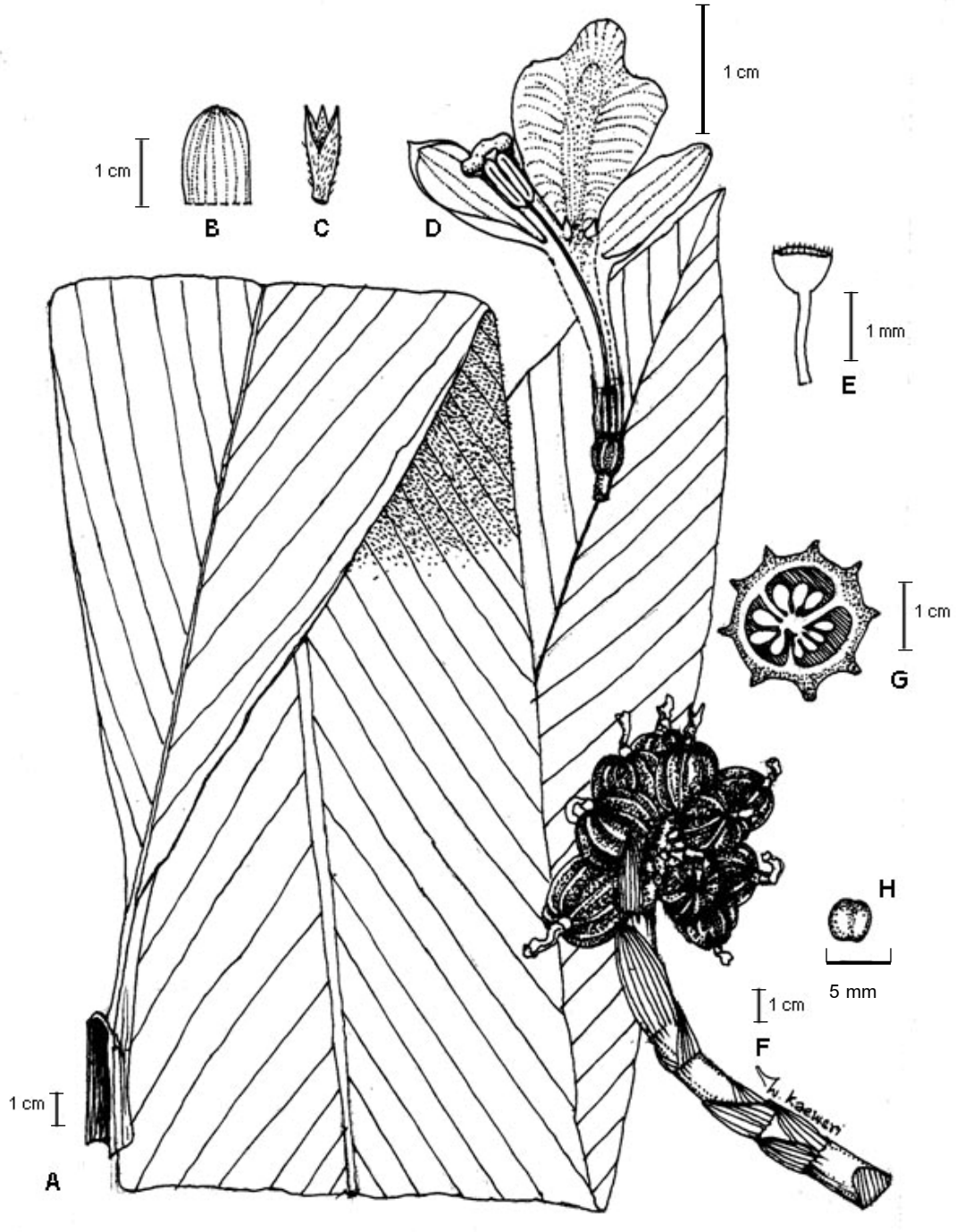

Figure 32 *Amomum* sp.17: A. leaf; B. bract; C. calyx; D. flower, dissected; E. stigma; F. infructescence; G. fruit, X-section; H. seed (drawn from Kaewsri-134).

31. **Amomum** sp.18**. Figure** 33. **Picture:** Appendix A31.

Rhizome short, stem base elevated to ca. 30 cm above ground by brownish stilt-root. *Leafy shoot* slender, ca. 0.9-1.2 m tall. *Leaves* 14-16; sheath brown when dried; ligule shallowly 2-lobed, apex round, papery, ca. 2.0 mm long; petiole sessile; lamina oblong or ovate-oblong, 8.0-20.0 by 2.0-4.0 cm, glabrous, base attenuate, apex acute, tip caudate, 1.0-2.5 cm. *Inflorescence* narrowly conical, 3.0-5.0 by 1.0-2.0 cm, brown; peduncle 2.0-3.5 cm long; peduncular bract deltoid, ca 1.0 by 0.6 cm, brown, subleathery, brownish pubescent, apex acuminate. *Bract* lanceolate-oblong, ca. 1.5 by 0.4 cm, apex acute, outer surface brown pubescent. *Flower* not seen. *Fruit* globose, covered with fine spines, dark green, ca. 1.0-1.3 cm dia, fruit stalk ca. 5 mm long, infructescence of ca. 15 fruits; seed angular, arillate, ca. 2.0 mm dia.

Phenology.— Fruting: June–August.

Thailand.— SOUTH-WESTERN: Kanchanaburi (Thong Pha Phum) (Appendix B10).

Ecology.— Dry evergreen forest, along jungle trails and under shady trees, ca. 950 m.

Note.— This species is rare in Thong Pha Phum National Park. We can not identify it because no flowers are available. The species is distinguished by a slender leafy stem, a stilt-root with raised stem base above ground, many fruits per head, and fruit is covered with greenish spines.

Specimen examined.— *Kaewsri 151*, 29 June 2005, Thong Pha Phum (BK, BKF).

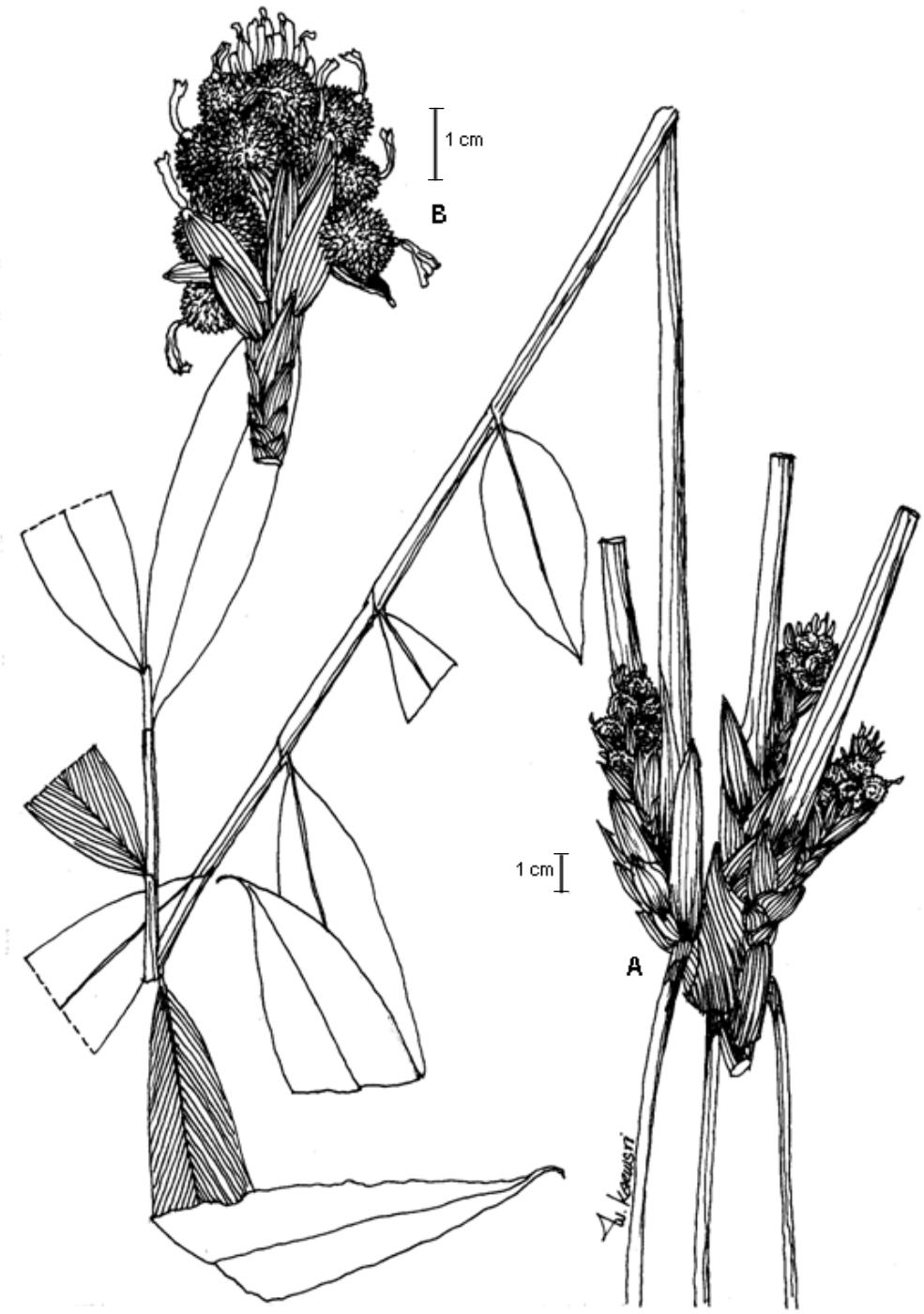

Figure 33 *Amomum* sp.18: A. habit; B. infructescence (drawn from Kaewsri-151).

32**. A. hirticalyx** Schumm., in J. Schmidt, Flora of Koh Chang. 1916.

Leafy shoot slender, ca. 0.90 m tall. *Leafsheath* light yellowish green; ligule obtuse, 2 mm long, ciliate; petiole sessile to 8 cm long; lamina linear or linear-oblanceolate, base attenuate, 25 by 3.5 cm, glabrous. *Inflorescence* narrowly ellipsoid, ca. 7 cm long, peduncle evenly shorter. *Bract* oblong, apiculate, pubescent. *Bracteole* 2-lobed, pubescent, or subtomentose, ca. 3.2 cm. long. *Calyx* 4.5 cm. long, apex 3-lobed, puberulous. *Corolla* tube 3.5 cm long, lobes ca. 2 cm long. *Labellum* base expanded, margin entire, ca. 3.5 cm long. *Anther* subglabrous, ca. 6 mm long. *Filament* as long as anther.

Thailand.— SOUTH-EASTERN: Trat (Jungle near Khlong Son, Koh Chang)

Distribution.— Thailand.

Ecology.— Tropical rain forest, under shady trees or shrubs.

Notes.— The description is taken and modified from Schumann (1902).

33. **A. lappaceum** Ridl., J. Str. Br. Roy. Asiat. Soc. 32: 134, 1899; *A. perakense* Ridl., J. Str. Br. Roy. Asiat. Soc. 32: 135, 1899; **Lectotype:** SBG.

Rhizome short. *Leafy shoot* stout, often supported on short stout stilt roots, 1.8-3 m tall. *Leaves* oblong lanceolate, acuminate, cuspidate, somewhat narrow at base, 45 by 10 cm; petiole sessile. *Inflorescence* numerous-flowered, gradually elongating to 40 cm long, cylindrical, rachis stout covered with brown tomentum. *Bracts* oblong 2-fid, apex round, red, ca. 4.75 cm long. *Bracteole* 3-fid, apex pink. *Calyx* tubular 2.5 cm long, apex equally 3-fid, acute, red. *Corolla* tube as long as the calyx, lobes linear, upper lobe broader, oblong, ca. 1.25 cm long, ochre yellow. *Labellum* obovate, round, narrowly 2-lobed. *Staminode* absent. *Stamen* rather short, anther 1.25 cm long, anther crest absent. *Ovary* pubescent. *Fruit* ca. 3.5 by 2.5 cm, covered with conic subulate spines; fruit stalk 1.25-2 cm long, stout.

Phenology. — Flowering and fruiting: April.

Thailand.— PENINSULAR: Narathiwat (Ban Bala, Waeng Dist.).

Distribution.— Thailand, Malay Peninsula.

Ecology.— Tropical rain forest, on sandy or acidic soil.

Notes.— The description is taken and modified from Holttum (1950).

Specimens examined.— *Supee S. Larsen et al. 45667*, 16 August 1995, Narathiwat (BKF).

34. **A. maximum** Roxb., As. Res. Xi:344. 1810. *non vidi*; in Fl. Indica : 41-42, 1820; Baker in J.D. Hooker, Fl. British India 6: 239, 1892; Valeton, Bull. Jard. Bot. Buitenzorg ser. 3, 2:355, 1920; K. Schumann in Engler, Das Pflanzenreich. 4(46):255; Heyne, De Nutt. Plant. Ned. Ind.: 486, 1927; Bakhuizen in Backer & Bakhuizen, Flora of Java 3:53, 54, 1968; D. L. Wu & K. Larsen, Flora of China 24:354, Figure 399, 2000. **Type**: CAL, or K?.

Rhizome short. *Leafy shoot* stout, 2-3 m tall. *Leaves* sheath light yellowish green; ligule 2-cleft, 12-20 mm long, sparsely white pubescent; petiole sessile to 8 cm long; lamina ovate or oblong, 30-90 by 10-20 cm, upper surface glabrous, lower surface, green and lighter, softly pubescent , base decurrent, unequal, apex acute, margin undulate. *Inflorescence* bunched around bases of leafy shoots, ca. 7 cm long; peduncle 8-9 cm long. *Bract* ovate, brown. *Bracteole* not persistent. *Calyx* tubular, to 1.5 cm long, creamy white or pink, tips 3-dentate. *Corolla* white. *Lateral staminode* subulate. *Labellum* broad, obovate, 3 cm wide, margin crenulate, with golden yellow to brownish red patch under the anther, and radial translucent lines toward margin. *Filament* short, anther linear, 1-1.2 cm, anther crest horned, crescent-shaped, 5 mm wide, white, apex slightly revolute. *Ovary* ridged. *Fruit* ovoid, 9-winged, glabrescent, 2.5-3 by 1.8-2.4 cm, light green or purplish green turning brown, with stigma remains at the apex, seed reddish brown.

Phenology.— Flowering: May-Jun and fruiting: Jun-August.

Thailand.— PENINSULAR: Yala (Betong, Wang Sai). Cultivated plants at Hala-Bala.

Distribution.— Malay Peninsula, India, Sri Langa, China, Myanmar, Vietnam?, Thailand.

Ecology.— Tropical rain forest, on sandy and acidic soil. 400- 800 m.

Notes.— The description is taken and modified from Wu and Larsen (2002).

Specimen examined.— *C. Niyomdham 6183*, 2001/2002, Yala(BKF)**.**

35. **A. spiceum** Ridl., J.S.B.R.A.S. 86:309. 1922; Ridl., Fl. Mal. Pen.4:263, 1924.

Leafy shoots close together, 1-2 m tall. *Leaves* narrow linear-oblong to about 60 cm by 2.5-4 cm (to 8 cm), apex acuminate, base attenuate; ligule oblong, round, margin ciliate, ca. 7 mm long. *Inflorescence* elongate to ca. 20 cm, slender, ca. 5 cm dia; peduncle 2.5-5 cm (to 20) long, short-hairy. *Bract* apparently reddish, to about 6 by 1-1.7 cm, elliptic, papery, the veins slightly raised, glabrous or short-hairy towards the base, the edges, ± fringed with hairs when young. *Bracteole* not tubular, ca. 4 cm long, edges fringed with hairs. *Calyx* 2.5 cm long, hairy. *Corolla* tube as long as calyx, lobes dull red, ca. 2.5 cm long, the upper one 1 cm wide or wider, hooded at the apex, at a small angle to the labellum, lateral lobe narrower. *Labellum* a little longer than corolla-lobe, broadly obovate, hardly lobed, the sides towards the base incurved and touching the dorsal corolla-lobe, the apex somewhat reflex, yellow, with small red marks on either side of the middle near the base. *Filament* about 8 mm long; anther 1 cm long, narrow, with a curve, narrow horn-like appendage ca. 6 mm long, on either side at the apex and a short rounded crest, hooded over the stigma. *Staminode* absent. *Ovary* densely hair. *Fruit* not seen.

Phenology. — Flowering and fruiting: April.

Thailand.— PENINSULAR: Yala (Khao Pisat).

Distribution.— Thailand, Malay Peninsula.

Ecology.— Tropical rain forest, on sandy and acidic soil, 1,000-1,250 m.

Notes.— The description is taken and modified from Ridley (1924).

Specimens examined.—*C. Niyomtham and P. Puudjaa 5453*, 30 April 1998, Yala (BKF); *C. Niyomtham and P. Puudjaa 5507*, 30 April 1998, Yala (BKF); *C. Niyomtham and P. Puudjaa 5514*, 30 April 1998, Yala (BKF).

36. **A. squarrosum** Ridl., J.S.B.R.A.S. 57:104. 1910; Ridl., Flora Malay Peninsula 4:265. 1924.

Rhizome supported on stout stilt roots to 15 cm long. *Leafy shoot* close together, 1-4 m tall. *Leaves* sheath yellowish, reddish at extreme base of stem; ligule apex entire, usually short-hairy, to about 1 cm long; petiole sessile to 2.0 cm long; lamina oblong to linear-oblong, ca. 58.0 by 3.0-6.0 cm, upper surface glabrous, lower surface, green and lighter, softly pubescent, base cuneate or attenuate, apex acut, caudate tip ca. 1.0-2.0 cm. *Inflorescence* 10-12 cm long; peduncular sheath ca. 3.5 cm dia. at flowering, peduncle ca. 30.0 cm long. *Bract* persistent, firm but thin, green with broad membranous edge, to ca. 2 by 1.3 cm, apex acute, sometimes reflex, fringed with hairs towards the base. *Bracteole* tubular, funnel-shaped, nearly 2 cm long, 3-lobed, short-appressed hairy all over. *Calyx* ca. 1.4 cm long, including ovary, funnel-shaped, thin, glabrous, with 3 rather large unequal lobes, pale pink. *Corolla* tube shorter than calyx; dorsal lobe, concave, ca. 1.5 by 1.2 cm, apex slightly 3-lobed, white tipped with pink, lateral lobe ca. 7 mm wide, white. *Lateral staminode* a small triangular lobe at base of labellum, ca. 2 mm long. *Labellum* white with a broad median longitudinal yellow band edged with red and with short red lines spreading laterally, distinctly 3-lobed, nearly 2 cm wide, the lateral lobes broadly rounded and spreading, erect towards the base, midlobe entire, round, ca. 7 mm wide and 5 mm long. *Filament* short and broad; anthers ca. 8 mm long; anther crest 3-lobed, lateral lobes spreading, ca. 1 mm wide, middle lobe short, round, ca. 2 by 1 mm, the whole anther creamy-white. *Stigma* cup-shaped, the aperture a narrowly transverse elliptic, glabrous. *Fruit* enclosed by the more or less persistent bracts, round, smooth, or with slight longitudinal ridges towards the apex, about 1.3 cm dia., thin wall, crown with the persistent calyx.

Phenology. — Flowering and fruiting: April.

Thailand.— PENINSULAR: Narathiwat (Hala-Bala, Sukirin).

Distribution.— Thailand, Malay Peninsula.

Ecology.— Tropical rain forest, on sandy and acidic soil.

Notes.— The description is taken and modified from Ridley (1924) and Holttum (1950).

Specimen examined.—*C. Niyomtham and P. Puudjaa 4999*, 12 April 1997, Narathiwat (BKF).

6. Morphological Characteristic Analysis

A cluster analysis of 58 morphological characteristics (Table 2) based on similarity matrix (Table 6) was performed. A similarity coefficient at 58% separated Thai *Amomum* into 3 major groups: A, B and C while *Alpinia nigra* and *Siamanthus siliquosus* were grouped together in a separate cluster (Figure 34).

Group A. The 10 taxa in this group form a clade in which species complex are clearly grouped at similarity coefficient support of 60%. The group consists of *A. aculeatum*, *Amomum* sp.12, *A.koenigii*, *Amomum* sp.10, *A.uliginosum*, *A.*cf. *villosum*, *Amomum* sp.8, *Amomum* sp.11, *Amomum* sp.5 and *A.pierreanum*. Regard to their morphology, most species in this group have tri-lobed anther crest and spiny fruit. Only *A.koenigii* possesses smooth fruit but is otherwise consistent in this group. This result agrees with Xia (2004) where work strongly support the placement of *A.koenigii* in *A.villosum* group, even though its fruit is smooth. Numerous spots found on the fruit's surface of *A.koenigii* distinguish it from the "Tsao-ko type".

Group B. This group comprises 11 species of *Amomum* and 1 outgroup (*Etlingera littoralis* (König) Giseke). Group B consists of *A.dealbatum*, *Amomum* sp.17, *A.siamense*, *Amomum* sp.15, *Amomum* sp.16, *Amomum* sp.6, *A.hastilabium*, *A.repoense*, *A.testaceum*, *Amomum* sp.2 and *Amomum* sp.3. The group is defined by the following features: fruit are winged, ridged or smooth, tri-lobed or entire anther crest. These results do not support classification by using anther crest character as proposed by Schumann (1904). It does tend to group by fruit character. Regard to the outgroup genus, *Etlingera littoralis* is clustered in this group. The result is supported by the earlier work of *Xia* et *al.* (2000) who placed it in *A. villosum* group. One possible explanation is both *Amomum* and *Etlingera* had ever been placed in the same, genus *Amomum* complex by Baker (1892) which consisted 5 sections: *Geanthus*, *Euamomum*, *Achasma*, *Hornstedtia* and *Cenolophon*, respectively. The similar characteristic between *Amomum* and *Etlingera* are dense inflorescence, conical shape and overlapping bract. This result confirms their close relationship.

Group C. This group contains 13 accessions of 6 species. The members in the group consist of: *A.biflorum*, *Amomum* sp.1, *A.micranthum*, *A.rivale*, *Amomum* sp.4 and *Amomum* sp.13. The group is characterized by spiny fruit, tri-lobed anther crest and slender pseudostem (usually less than 1.5 m in height). The result showed that the species in this group were separate from those in Group A. Although they have the same fruit and anther crest types, they differ in psuedostem size. Thus, within the spiny fruit type, a division into 2 subgroups based on leafy stem size is necessary.

7. Morphology and classification of Thai *Amomum*

The result derived from morphological study generated Thai *Amomum* into three major groups: *A. aculeatum*, *A. dealbatum* and *A. biflorum* groups.

A. aculeatum group. This group consists 9 species of *Amomum*: *A. aculeatum*, *A.koenigii*, *Amomum* sp.10, *A.uliginosum*, *A.*cf. *villosum*, *Amomum* sp.8, *Amomum* sp.11, *Amomum* sp.5 and *A.pierreanum*. This group have tri-lobed anther crest, spiny or smooth fruit and robust pseudostem.

A. dealbatum group. The group comprises 11 species of *Amomum*: *A.dealbatum*, *Amomum* sp.17, *A.siamense*, *Amomum* sp.15, *Amomum* sp.16, *Amomum* sp.6, *A.hastilabium*, *A.repoense*, *A.testaceum*, *Amomum* sp.2 and *Amomum* sp.3. The group is defined by the following features: fruits are winged, ridged or smooth; tri-lobed or entire anther crest.

A. biflorum group. The members in the group consist of 6 species of *Amomum*: *A.biflorum*, *Amomum* sp.1, *A.micranthum*, *A.rivale*, *Amomum* sp.4 and *Amomum* sp.13. The group is characterized by spiny fruit, tri-lobed anther crest and slender pseudostem that usually less than 1.5 m in height.

Table 6 Similarity index of 53 accessions of *Amomum* and 3 outgroup taxa based on morphological characteristics by simple matching coefficient.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
1. A.aculeatum 4	1.00																										
2. *A.aculeatum* 3	1.00	1.00																									
3. A.aculeatum 2	0.98	0.98	1.00																								
4. A.aculeatum 1	1.00	1.00	0.98	1.00																							
5. A.biflorum 2	0.56	0.56	0.58	0.56	1.00																						
6. A.biflorum 1	0.58	0.58	0.59	0.58	0.98	1.00																					
7. A.dealbatum	0.59	0.59	0.58	0.59	0.56	0.58	1.00																				
8. *A.hastilabium*	0.59	0.59	0.58	0.59	0.61	0.63	0.73	1.00																			
9. *A.koenigii* 3	0.71	0.71	0.69	0.71	0.58	0.59	0.61	0.56	1.00																		
10. *A.koenigii* 2	0.71	0.71	0.69	0.71	0.58	0.59	0.64	0.58	0.97	1.00																	
11. *A.koenigii* 1	0.73	0.73	0.71	0.73	0.56	0.58	0.63	0.56	0.98	0.98	1.00																
12. *A.micranthum* 2	0.64	0.64	0.66	0.64	0.75	0.76	0.54	0.64	0.59	0.63	0.61	1.00															
13. *A.micranthum* 1	0.61	0.61	0.63	0.61	0.78	0.80	0.51	0.66	0.59	0.59	0.58	0.97	1.00														
14. *A.pierreanum*	0.61	0.61	0.59	0.61	0.56	0.58	0.61	0.64	0.58	0.61	0.59	0.63	0.61	1.00													
15. *A.repoense* 1	0.56	0.56	0.54	0.56	0.53	0.54	0.66	0.71	0.61	0.61	0.59	0.64	0.64	0.56	1.00												
16. *A.repoense* 2	0.56	0.56	0.54	0.56	0.53	0.54	0.66	0.71	0.61	0.61	0.59	0.64	0.64	0.56	1.00	1.00											
17. *A.repoense* 3	0.54	0.54	0.53	0.54	0.51	0.53	0.64	0.69	0.59	0.59	0.58	0.63	0.63	0.54	0.98	0.98	1.00										
18. *A.rivale* 3	0.47	0.47	0.46	0.47	0.71	0.73	0.51	0.59	0.49	0.49	0.47	0.66	0.69	0.58	0.58	0.58	0.56	1.00									
19. *A.rivale* 2	0.46	0.46	0.44	0.46	0.69	0.71	0.53	0.58	0.47	0.47	0.46	0.64	0.68	0.56	0.56	0.56	0.54	0.98	1.00								
20. *A.rivale* 1	0.47	0.47	0.46	0.47	0.71	0.73	0.51	0.59	0.49	0.49	0.47	0.66	0.69	0.58	0.58	0.58	0.56	1.00	0.98	1.00							
21. *A.siamense* 3	0.59	0.59	0.58	0.59	0.53	0.54	0.80	0.68	0.64	0.64	0.63	0.58	0.58	0.54	0.63	0.63	0.61	0.51	0.53	0.51	1.00						
22. *A.siamense* 2	0.59	0.59	0.58	0.59	0.53	0.54	0.80	0.68	0.64	0.64	0.63	0.58	0.58	0.54	0.63	0.63	0.61	0.51	0.53	0.51	1.00	1.00					
23. *A.siamense* 1	0.61	0.61	0.59	0.61	0.51	0.53	0.81	0.68	0.63	0.66	0.64	0.59	0.56	0.56	0.61	0.61	0.59	0.49	0.51	0.49	0.98	0.98	1.00				
24. *A. testaceum* 1	0.68	0.68	0.69	0.68	0.61	0.63	0.68	0.64	0.63	0.66	0.64	0.69	0.69	0.63	0.68	0.68	0.66	0.59	0.61	0.59	0.64	0.64	0.66	1.00			
25. *A.testaceum* 2	0.66	0.66	0.68	0.66	0.63	0.64	0.63	0.66	0.61	0.61	0.63	0.68	0.68	0.64	0.69	0.69	0.68	0.58	0.59	0.58	0.63	0.63	0.64	0.92	1.00		
26. *A.testaceum* 3	0.61	0.61	0.63	0.61	0.61	0.63	0.68	0.63	0.59	0.59	0.58	0.66	0.66	0.64	0.78	0.78	0.76	0.59	0.61	0.59	0.61	0.61	0.59	0.86	0.88	1.00	
27. *A.uliginosum* 1	0.68	0.68	0.66	0.68	0.61	0.63	0.51	0.61	0.63	0.66	0.64	0.76	0.73	0.63	0.54	0.54	0.53	0.56	0.54	0.56	0.58	0.58	0.59	0.66	0.61	0.56	1.00

Table 6 (continued)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
28. *A.uliginosum* 2	0.68	0.68	0.66	0.68	0.61	0.63	0.51	0.61	0.63	0.66	0.64	0.76	0.73	0.63	0.54	0.54	0.53	0.56	0.54	0.56	0.58	0.58	0.59	0.66	0.61	0.56	1.00
29. *A.uliginosum* 3	0.68	0.68	0.66	0.68	0.61	0.63	0.51	0.61	0.63	0.66	0.64	0.76	0.73	0.63	0.54	0.54	0.53	0.56	0.54	0.56	0.58	0.58	0.59	0.66	0.61	0.56	1.00
30. *A.uliginosum* 4	0.66	0.66	0.68	0.66	0.63	0.64	0.49	0.59	0.61	0.64	0.63	0.78	0.75	0.61	0.53	0.53	0.51	0.54	0.53	0.54	0.56	0.56	0.58	0.68	0.63	0.58	0.98
31. *A.uliginosum* 5	0.68	0.68	0.66	0.68	0.61	0.63	0.51	0.61	0.63	0.66	0.64	0.76	0.73	0.63	0.54	0.54	0.53	0.56	0.54	0.56	0.58	0.58	0.59	0.66	0.61	0.56	1.00
*32. A.*cf. *villosum*	0.61	0.61	0.63	0.61	0.64	0.66	0.54	0.61	0.59	0.63	0.61	0.69	0.69	0.59	0.54	0.54	0.56	0.46	0.47	0.46	0.61	0.61	0.63	0.69	0.68	0.59	0.80
33. *Amomum* sp.1a	0.58	0.58	0.59	0.58	0.81	0.80	0.51	0.63	0.63	0.63	0.61	0.80	0.83	0.58	0.61	0.61	0.59	0.66	0.64	0.66	0.54	0.54	0.53	0.69	0.75	0.73	0.63
34. *Amomum* sp.1b	0.59	0.59	0.61	0.59	0.83	0.81	0.53	0.61	0.61	0.61	0.59	0.78	0.81	0.56	0.59	0.59	0.58	0.68	0.66	0.68	0.56	0.56	0.54	0.68	0.73	0.71	0.61
35. *Amomum* sp.2	0.51	0.51	0.53	0.51	0.61	0.63	0.61	0.53	0.59	0.59	0.58	0.63	0.66	0.54	0.61	0.61	0.59	0.56	0.54	0.56	0.61	0.61	0.59	0.66	0.64	0.69	0.53
36. *Amomum* sp.3	0.51	0.51	0.53	0.51	0.61	0.63	0.61	0.53	0.59	0.59	0.58	0.63	0.66	0.54	0.61	0.61	0.59	0.56	0.54	0.56	0.61	0.61	0.59	0.66	0.64	0.69	0.53
37. *Amomum* sp.4	0.54	0.54	0.53	0.54	0.58	0.59	0.44	0.53	0.46	0.46	0.44	0.59	0.63	0.54	0.54	0.54	0.56	0.66	0.68	0.66	0.47	0.47	0.46	0.56	0.54	0.56	0.56
38. *Amomum* sp.5	0.64	0.64	0.66	0.64	0.54	0.56	0.47	0.54	0.56	0.59	0.58	0.73	0.69	0.49	0.61	0.61	0.63	0.46	0.47	0.46	0.58	0.58	0.59	0.66	0.64	0.59	0.76
39. *Amomum* sp.6b	0.64	0.64	0.63	0.64	0.58	0.59	0.71	0.68	0.73	0.76	0.75	0.56	0.56	0.54	0.54	0.54	0.53	0.53	0.51	0.53	0.71	0.71	0.73	0.63	0.58	0.56	0.59
40. *Amomum* sp.6a	0.61	0.61	0.59	0.61	0.61	0.63	0.68	0.66	0.73	0.73	0.71	0.56	0.59	0.51	0.58	0.58	0.56	0.56	0.54	0.56	0.71	0.71	0.69	0.59	0.54	0.56	0.56
41. *Amomum* sp.7	0.63	0.63	0.64	0.63	0.63	0.64	0.46	0.58	0.68	0.68	0.66	0.64	0.68	0.49	0.49	0.49	0.47	0.44	0.42	0.44	0.53	0.53	0.51	0.58	0.56	0.51	0.78
42. *Amomum* sp.10c	0.76	0.76	0.75	0.76	0.63	0.64	0.66	0.66	0.75	0.78	0.76	0.64	0.61	0.68	0.59	0.59	0.58	0.54	0.53	0.54	0.63	0.63	0.64	0.68	0.63	0.61	0.71
43. *Amomum* sp.10b	0.78	0.78	0.76	0.78	0.64	0.66	0.68	0.68	0.76	0.80	0.78	0.66	0.63	0.69	0.61	0.61	0.59	0.56	0.54	0.56	0.64	0.64	0.66	0.69	0.64	0.63	0.73
44. *Amomum* sp.10a	0.76	0.76	0.75	0.76	0.63	0.64	0.66	0.66	0.75	0.78	0.76	0.64	0.61	0.68	0.59	0.59	0.58	0.54	0.53	0.54	0.63	0.63	0.64	0.68	0.63	0.61	0.71
45. *Amomum* sp.11	0.59	0.59	0.58	0.59	0.66	0.68	0.53	0.58	0.71	0.71	0.69	0.71	0.75	0.56	0.56	0.56	0.54	0.58	0.56	0.58	0.59	0.59	0.58	0.61	0.56	0.51	0.81
46. *Amomum* sp.12	0.80	0.80	0.81	0.80	0.54	0.56	0.54	0.59	0.64	0.64	0.66	0.58	0.56	0.73	0.58	0.58	0.56	0.46	0.44	0.46	0.51	0.51	0.53	0.69	0.73	0.66	0.58
47. *Amomum* sp.13	0.54	0.54	0.56	0.54	0.61	0.63	0.54	0.66	0.56	0.56	0.54	0.66	0.69	0.58	0.61	0.61	0.59	0.59	0.58	0.59	0.54	0.54	0.53	0.63	0.61	0.59	0.66
48. *Amomum* sp.14	0.56	0.56	0.58	0.56	0.81	0.80	0.56	0.58	0.63	0.63	0.61	0.78	0.80	0.64	0.61	0.61	0.59	0.63	0.61	0.63	0.56	0.56	0.54	0.68	0.69	0.69	0.61
49. *Amomum* sp.15	0.68	0.68	0.66	0.68	0.51	0.53	0.81	0.68	0.66	0.69	0.68	0.56	0.53	0.59	0.61	0.61	0.59	0.53	0.54	0.53	0.85	0.85	0.86	0.76	0.71	0.69	0.63
50. *A.*momum sp.16a	0.59	0.59	0.61	0.59	0.63	0.64	0.76	0.66	0.61	0.64	0.63	0.64	0.61	0.68	0.69	0.69	0.68	0.54	0.56	0.54	0.73	0.73	0.75	0.75	0.73	0.75	0.58
51. *A.*momum sp.16b	0.59	0.59	0.61	0.59	0.63	0.64	0.76	0.66	0.61	0.64	0.63	0.64	0.61	0.68	0.69	0.69	0.68	0.54	0.56	0.54	0.73	0.73	0.75	0.75	0.73	0.75	0.58
52. *A.*momum sp.16c	0.58	0.58	0.59	0.58	0.64	0.66	0.75	0.64	0.63	0.66	0.64	0.66	0.63	0.66	0.68	0.68	0.66	0.53	0.54	0.53	0.75	0.75	0.76	0.73	0.71	0.73	0.59
53. *Amomum* sp.17	0.71	0.71	0.69	0.71	0.51	0.53	0.81	0.61	0.66	0.69	0.68	0.59	0.56	0.63	0.68	0.68	0.66	0.53	0.54	0.53	0.78	0.78	0.80	0.76	0.71	0.76	0.53
54. *Alpinia nigra*	0.46	0.46	0.47	0.46	0.58	0.56	0.53	0.53	0.54	0.58	0.56	0.51	0.49	0.51	0.51	0.51	0.53	0.54	0.53	0.54	0.56	0.56	0.58	0.53	0.54	0.47	0.51
55. *Siamanthus siliquosus*	0.56	0.56	0.58	0.56	0.46	0.47	0.63	0.59	0.54	0.54	0.56	0.51	0.47	0.54	0.61	0.61	0.59	0.46	0.44	0.46	0.53	0.53	0.54	0.63	0.66	0.63	0.53
56. *Etlingera littoralis*	0.46	0.46	0.47	0.46	0.44	0.46	0.58	0.56	0.51	0.51	0.49	0.53	0.54	0.54	0.61	0.61	0.59	0.41	0.42	0.41	0.59	0.59	0.58	0.51	0.53	0.59	0.42

Table 6 (continued)

	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56
28.*A.uliginosum*2	1.00																												
29.*A.uliginosum*3	1.00	1.00																											
30.*A.uliginosum*3	0.98	0.98	1.00																										
31.*A.uliginosum4*	1.00	1.00	0.98	1.00																									
*32.A.*cf.*villosum*	0.80	0.80	0.81	0.80	1.00																								
33.*Amomum*sp.1a	0.63	0.63	0.64	0.63	0.63	1.00																							
34.*Amomum*sp.1b	0.61	0.61	0.63	0.61	0.61	0.98	1.00																						
35.*Amomum* sp.2	0.53	0.53	0.54	0.53	0.63	0.69	0.68	1.00																					
36.*Amomum* sp.3	0.53	0.53	0.54	0.53	0.63	0.69	0.68	1.00	1.00																				
37.*Amomum* sp.4	0.56	0.56	0.54	0.56	0.59	0.63	0.64	0.53	0.53	1.00																			
38.*Amomum* sp.4	0.76	0.76	0.78	0.76	0.76	0.66	0.64	0.49	0.49	0.66	1.00																		
39.*Amomum* sp.6b	0.59	0.59	0.58	0.59	0.59	0.59	0.61	0.66	0.66	0.42	0.46	1.00																	
40.*Amomum* sp.6a	0.56	0.56	0.54	0.56	0.56	0.63	0.64	0.69	0.69	0.46	0.46	0.97	1.00																
41.*Amomum* sp.7	0.78	0.78	0.80	0.78	0.78	0.68	0.66	0.58	0.58	0.61	0.75	0.61	0.61	1.00															
42.*Amomum* sp.10c	0.71	0.71	0.69	0.71	0.68	0.61	0.59	0.58	0.58	0.44	0.54	0.71	0.68	0.63	1.00														
43.Amomum sp.10b	0.73	0.73	0.71	0.73	0.69	0.63	0.61	0.59	0.59	0.46	0.56	0.73	0.69	0.64	0.98	1.00													
44.Amomum sp.10a	0.71	0.71	0.69	0.71	0.68	0.61	0.59	0.58	0.58	0.44	0.54	0.71	0.68	0.63	1.00	0.98	1.00												
45.Amomum sp.11	0.81	0.81	0.80	0.81	0.75	0.71	0.69	0.64	0.64	0.58	0.68	0.61	0.64	0.83	0.69	0.71	0.69	1.00											
46.Amomum sp.12	0.58	0.58	0.59	0.58	0.64	0.61	0.59	0.54	0.54	0.51	0.61	0.54	0.51	0.61	0.69	0.71	0.69	0.51	1.00										
47.Amomum sp.13	0.66	0.66	0.68	0.66	0.63	0.69	0.68	0.66	0.66	0.73	0.66	0.53	0.56	0.71	0.58	0.59	0.58	0.71	0.54	1.00									
48.Amomum sp.14	0.61	0.61	0.63	0.61	0.64	0.90	0.88	0.73	0.73	0.56	0.61	0.56	0.59	0.64	0.63	0.64	0.63	0.71	0.63	0.66	1.00								
49.Amomum sp.15	0.63	0.63	0.61	0.63	0.63	0.53	0.54	0.63	0.63	0.46	0.59	0.83	0.80	0.51	0.68	0.69	0.68	0.54	0.59	0.53	0.51	1.00							
50.Amomum sp.16c	0.58	0.58	0.59	0.58	0.64	0.58	0.56	0.61	0.61	0.44	0.61	0.64	0.61	0.49	0.63	0.64	0.63	0.53	0.64	0.54	0.63	0.78	1.00						
51.Amomum sp.16b	0.58	0.58	0.59	0.58	0.64	0.58	0.56	0.61	0.61	0.44	0.61	0.64	0.61	0.49	0.63	0.64	0.63	0.53	0.64	0.54	0.63	0.78	1.00	1.00					
52.Amomum sp.16a	0.59	0.59	0.61	0.59	0.66	0.59	0.58	0.63	0.63	0.46	0.59	0.66	0.63	0.51	0.64	0.66	0.64	0.54	0.63	0.56	0.64	0.76	0.98	0.98	1.00				
53.Amomum sp.17	0.53	0.53	0.51	0.53	0.56	0.59	0.61	0.66	0.66	0.53	0.59	0.66	0.63	0.47	0.68	0.69	0.68	0.54	0.63	0.56	0.61	0.80	0.78	0.78	0.76	1.00			
54.*Alpinia nigra*	0.51	0.51	0.53	0.51	0.56	0.53	0.51	0.53	0.53	0.46	0.51	0.51	0.47	0.54	0.61	0.63	0.61	0.54	0.53	0.56	0.56	0.51	0.59	0.59	0.61	0.51	1.00		
55. *Siamanthus siliquosus*	0.53	0.53	0.54	0.53	0.58	0.46	0.44	0.59	0.59	0.39	0.47	0.54	0.51	0.53	0.58	0.59	0.58	0.46	0.66	0.49	0.53	0.59	0.61	0.61	0.59	0.58	0.59	1.00	
56. *Etlingera littoralis*	0.42	0.42	0.44	0.42	0.46	0.56	0.54	0.63	0.63	0.47	0.53	0.54	0.58	0.47	0.53	0.54	0.53	0.51	0.54	0.54	0.54	0.58	0.63	0.63	0.64	0.64	0.56	0.53	1.00

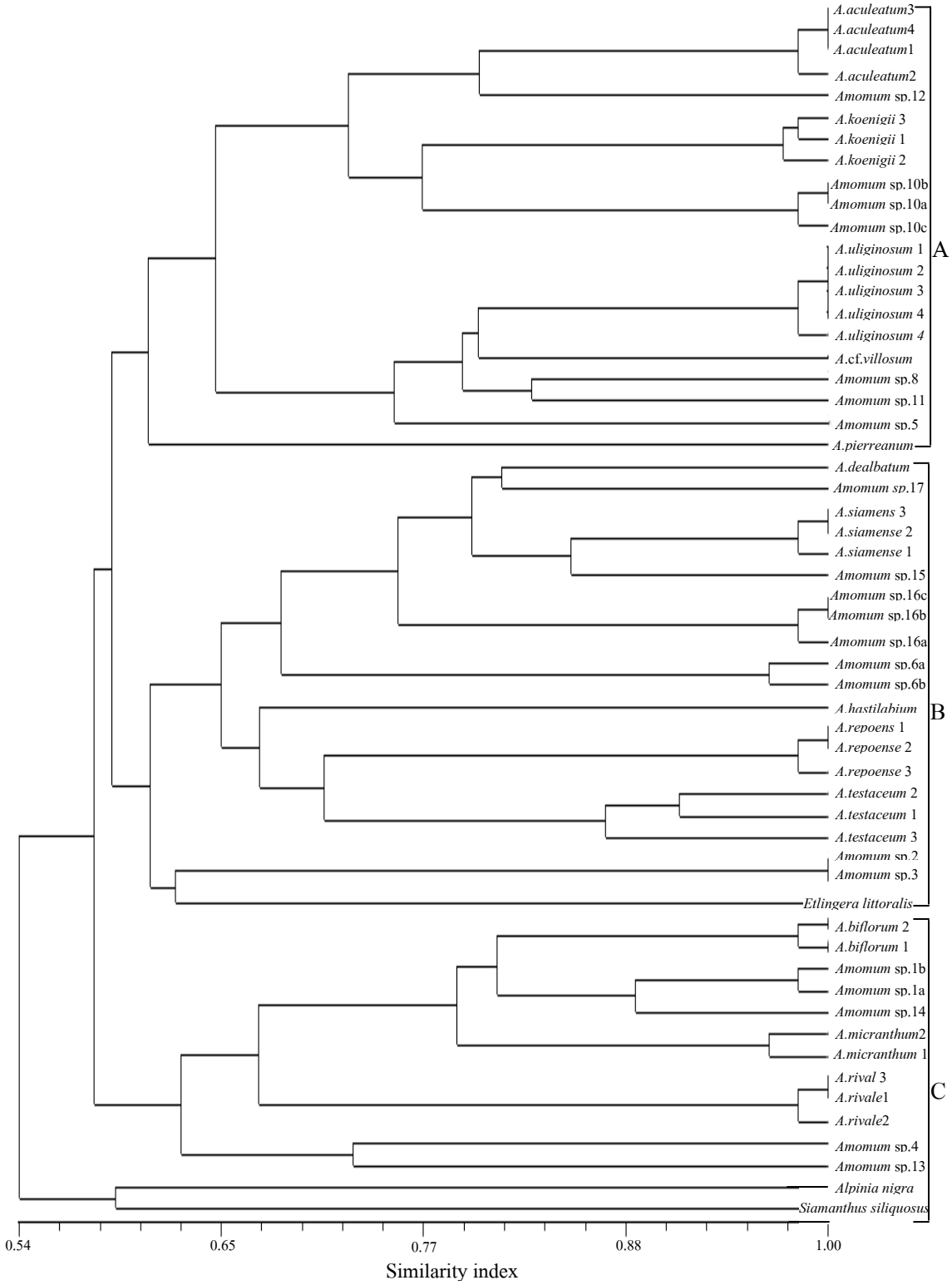

Figure 34 Dendogram depicting the phenetic relationship among 53 *Amomum* accessions and 3 outgroup taxa based on morphological characteristics**,** using similarity coefficient by SM (Sneath and Sokal, 1973), clustering with UPGMA (Sokal and Michener, 1958).

Amplified Fragmented Length Polymorphism study

1. Primer combination

Five informative AFLP primer combinations generated a total of 364 reproducible amplification fragments across all species of *Amomum*, among which 122 bands were polymorphic (Table 7, Figure 35-39). The number of amplified AFLP bands per primer pair varied from 66 to 81 with an average of 72.8 bands. The average number of polymorphic bands detected was 24.4 per primer combination. The fragment sizes were determined by comparing each one with the standard DNA ladder, ranging from about 140 to 726 base pairs (bp). Two primer combinations: E-AGG, M-CAA and E-ACC, M-CAA produced 30 polymorphic bands, a relatively higher numbers of polymorphisms compare to the other primers used in this study.

Table 7 AFLP primer pairs and their number of selected and polymorphic bands for phylogenetic study of Thai *Amomum*.

Primer combinations (*Eco*RI+3/*Mse*I+3)	**Selected bands**	**No. of polymorphic bands**
E-AGG, M-CAA	81	30
E-ACC, M-CTA	73	17
E-ACC, M-CAA	66	30
E-AGC, M-CTC	74	25
E-AGG, M-CTC	70	20
Total	364	122
Mean	72.8	24.4

2. Cluster analysis

In this study, 40 accessions of Thai *Amomum* species were fingerprinted including 5 outgroup taxa. One hundred twenty two polymorphic AFLP markers were produced from five primer combinations. UPGMA cluster analysis (Rohlf, 1997) with genetic similarity of 57%

separated *Amomum* into 2 main clusters: A consists of C and D groups and B consists of E and F groups (Figure 40).

Regarding the C group, *A. koenigii* 1 and *A.koenigii* 2 were collected from Kanchanaburi and Nakhon Nayok provinces, respectively. It is clear that both collections are closely related (74%), even though the peduncular lengths vary greatly. The plants from Nakhon Nayok have a much shorter peduncle than those found in Kanchanaburi. The variation in phenotype could be caused by differences in their respective habitats. The placement of this species is similar to morphological analysis that placed it in spiny fruit group. This result is confirmation of the paraphyletic relationship between *A.koenigii* and the spiny fruit species (*A. uliginosum* and *A. aculeatum*). *A.aculeatum* and *Amomum* sp.12 are placed together at 90% GS. These closely related species are similar in leafy stem but differ in peduncular length, colour and size of labellum. From the results, the species *Amomum* sp.12 should be established as a new variety. However, this is difficult to decide from only a single plant. More collections are needed to solve this problem.

D group is divided into two subgroups (I and II). Subgroup D (I) consists of *A. testaceum* 1, *A. testaceum* 2, *A. testaceum* 3 and *Amomum* cf. *testaceum*. Regarding *A. testaceum* species complex, the dendogram suggests that this species can be separated into at least three varieties; especially *A. testaceum* 4 which was isolated from the group. The placement of *A. testaceum* is rather close to the spiny fruit species (*Amomum* sp.1 and *Amomum* sp.14). This result does agree with Xia et *al*. (2004) whose work was based on ITS and *Mat*K genes. They placed *A.testaceum* among the spiny fruit species of *A.villosum* group. A possible explanation for this was a paraphyletic origin of *A. testaceum* complex. Although its morphological characteristics are different, its genotype is close to spiny fruit species. The *Amomum* cf. *testaceum* that was collected from Chumphon is also placed in this group. Its leafy stem is similar to *A. testaceum* but differs in its hairiness on the lower surface of leaves.

Subgroup D (II) consists of *A. testaceum* 4, *A.* cf. *villosum*, *Amomum* sp.5, *Amomum* sp.7, *A. uliginosum* 2, *Amomum* sp.11, *A. uliginosum* 3, *A. villosum* 1, *A. rivale* 1, *A. micranthum*,

A. rivale 2, *A.* cf. *rivale*, *Amomum* sp.8, *Amomum* sp.4 and *Amomum* sp.13. All members have spiny fruit and leafy stem less than 1.50 m tall. Regarding *uliginosum* 2 and 3 which were collected from Tak province, they were separated from *A. uliginosum* 1 and 4 (from Nakhon Nayok and Ranong provinces, respectively). Their morphological characteristics differ from the ones in C group in its shorter leafy stem and smaller inflorescence. A possible explanation for this is that their morphological characteristics were the result of long time adaptation in the surrounding habitats which resulted in two ecotypes of *A. uliginosum.*

B cluster consists of E and F groups. It is characterized by smooth, ridged or winged fruit (rarely spiny fruit).

E and F groups include *Amomum* sp.16, *Amomum* sp.3, *Amomum* sp.2, *Amomum* sp.17a, *A. siamense*, *Amomum* sp.6b, *Amomum* sp.6a, *Amomum* sp. 17b, *A. dealbatum*, *Amomum* sp. 15, *Amomum* sp. 10, *Elettaria cardamomum*, *Alpinia nigra*, *Amomum* sp. 1, *Amomum* sp.14, *A. repoense* and *Etlingera pavieana*.

The dendogram suggests the placement of smooth fruit (*Amomum* sp.16) between spiny and winged fruit. Similar to the result of *Amomum* sp.1 and 10 both of which are spiny fruit but were placed among winged fruit species. *Amomum* sp.17a and 17b from Nan province are similar in their morphology but were placed in different clusters. More study is needed to properly identify the position of these species. *A.siamense* with fruit longitudinally ridged is also placed in this group. This species should be closely related to winged fruit species. Although the cluster is not completely separated from the others, all winged fruit species are clearly placed. Therefore, the results have the tendency to be consistent with the *A.maximum* group of Xia et *al.* (2004).

The outgroup taxa (*Alpinia, Elettaria, Etlingera* and *Geostachys*) are placed among *Amomum* species. The result indicates a closer relationship among them and the spiny fruit species of *Amomum*. This result is similar to Xia et *al.* (2004) who found that *Etlingera littoralis* was placed in the clade of *A.villosum* group. The results then confirmed that *Etlingera* is related

to the genus *Amomum*. Furthermore, some species of *Alpinia*, *Elettaria* and *Geostachys* are also closely related to the genus *Amomum*.

3. Classification of Thai *Amomum* by AFLP

Twenty-six representives of Thai *Amomum* can be classified into 3 groups by using AFLP evidence: *A. aculeatum*, *A. biflorum* and *A. dealbatum* groups.

The *A. aculeatum* group consists of 4 species: *A. koenigii, A. uliginosum, A. aculeatum* and *Amomum* sp. 12. Species in this group have smooth and spotted or spiny fruit, anther crest 3 lobes, leafy stem stout and usually more than 1.5 m tall.

The *A. biflorum* group contains 10 species: *A. testaceum*, *Amomum* cf. *villosum, Amomum* sp.4*, Amomum* sp.5, *Amomum* sp.7, *Amomum* sp.8, *A.rivale*, *A. micranthum*, *Amomum* sp.11 and *Amomum* sp.13. All members of this group are defined by smooth or spiny fruit. Most species of this group are spiny fruit. In the case of smooth fruit, its fruit shape is usually globular and fruit colour is white or pale brown. The leafy stem is usually slender and shorter than 1.5 m.

The *A. dealbatum* group contains 12 species of *Amomum*: *A. dealbatum, A. repoense*, *A. siamense*, *Amomum* sp.1, *Amomum* sp.2, *Amomum* sp.3, *Amomum* sp.6, *Amomum* sp.10, *Amomum* sp.14, *Amomum* sp.15, *Amomum* sp.16 and *Amomum* sp.17. The species in this group are characterized by winged, ridged or smooth fruit (rarely spiny fruit and 3 lobes) and entire, round or truncate anther crest.

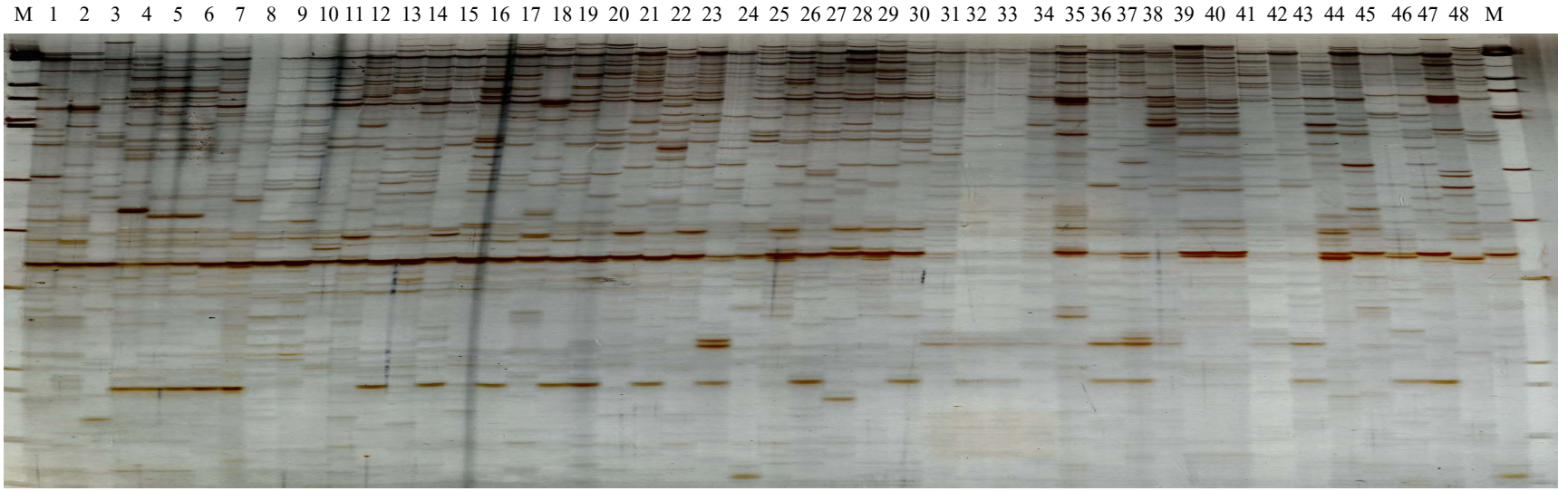

Figure 35 AFLP fingerprint of Thai *Amomum* species and out-groups using E-AGG, M-CAA primer pair. 1. *A. koenigii*1 , 2. *A. koenigii* 2, 3. *Amomum* sp.16, 4. *A. testaceum*1, 5. *A. testaceum* 2, 6. *A. testaceum* 3, 7. *A. testaceum* 4, 8. *Amomum* sp.1, 9. *A. aculeatum* Roxb., 10. *Amomum* sp.12, 11. *A. rivale*1, 12. *A. rivale*2, 13. *A.*cf. *villosum*1, 14. *A.* cf. *villosum*2, 15. *Amomum* sp.4, 16. *Amomum* sp.5, 17. *Amomum* sp.7, 18. *A. uliginosum*1, 19. *A. uliginosum*2, 20. *A. uliginosum*3, 21. *A Amomum* cf. *rivale.*, 22. *Amomum* sp.17a, 23. *Amomum* sp.8, 24. *Amomum* sp.10, 25. *A. biflorum* Jack , 26. *A. micranthum* Ridl., 27. *Amomum* sp.11, 28. *Amomum* sp.13, 29. none use, 30. none use, 31. *A. siamense* Craib,32. .*Amomum* sp.3, 33. *Amomum* sp.2, 34. *Amomum* sp.6b, 35. *A. uliginosum4*, 36. *Amomum* sp.17b, 37. *A. repoense* Gagnep., 38. *Amomum* sp.6a, 39. none use, 40. *Amomum* sp.14, 41. *Amomum* sp.15, 42. *A. dealbatum* Roxb., 43. *Elettaria cardamomum*, 44. *Etlingera littoralis*, 45. *Etlingera pavieana*, 46. *Alpinia nigra*, 47. *Geostachys* sp., 48.*Amomum* cf. *testaceum* and M = ϕX*Hin*fI

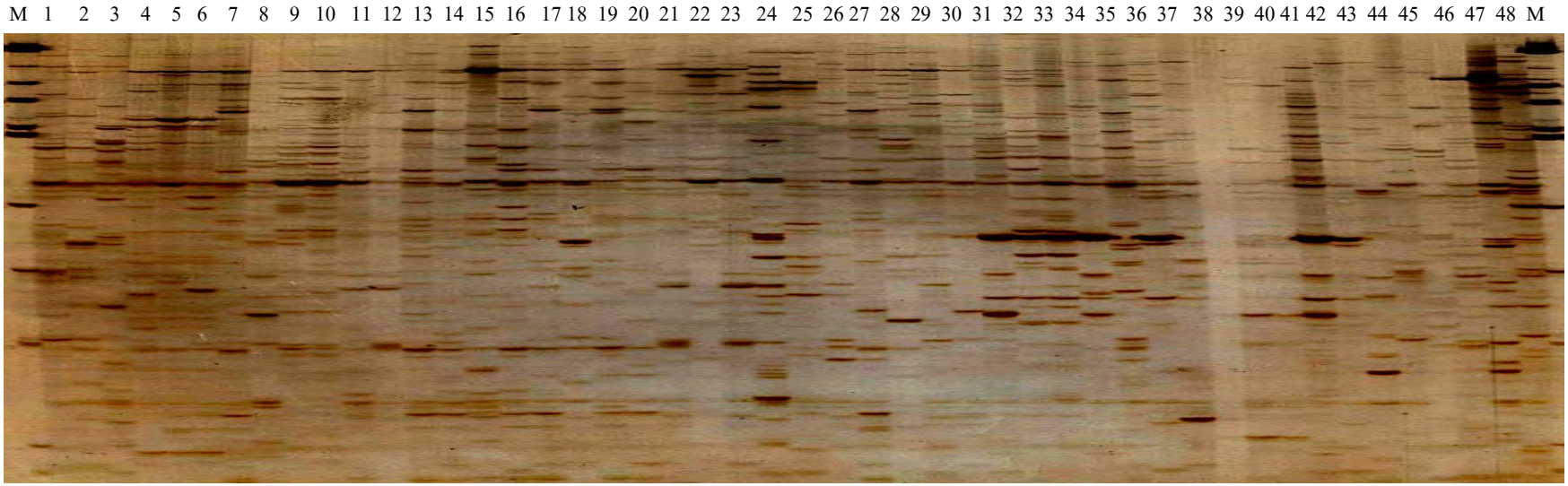

Figure 36 AFLP fingerprint of Thai *Amomum* species and out-groups using E-ACC, M-CTA primer pair. 1. *A. koenigii*1 , 2. *A. koenigii* 2, 3. *Amomum* sp.16, 4. *A. testaceum*1, 5. *A. testaceum* 2, 6. *A. testaceum* 3, 7. *A. testaceum* 4, 8. *Amomum* sp.1, 9. *A. aculeatum* Roxb., 10. *Amomum* sp.12, 11. *A. rivale*1, 12. *A. rivale*2, 13. *A.*cf. *villosum*1, 14. *A.* cf. *villosum*2, 15. *Amomum* sp.4, 16. *Amomum* sp.5, 17. *Amomum* sp.7, 18. *A. uliginosum*1, 19. *A. uliginosum*2, 20. *A. uliginosum*3, 21. *A Amomum* cf. *rivale.*, 22. *Amomum* sp.17a, 23. *Amomum* sp.8, 24. *Amomum* sp.10, 25. *A. biflorum* Jack , 26. *A. micranthum* Ridl., 27. *Amomum* sp.11, 28. *Amomum* sp.13, 29. none use, 30. none use, 31. *A. siamense* Craib,32. .*Amomum* sp.3, 33. *Amomum* sp.2, 34. *Amomum* sp.6b, 35. *A. uliginosum4*, 36. *Amomum* sp.17b, 37. *A. repoense* Gagnep., 38. *Amomum* sp.6a, 39. none use, 40. *Amomum* sp.14, 41. *Amomum* sp.15, 42. *A. dealbatum* Roxb., 43. *Elettaria cardamomum*, 44. *Etlingera littoralis*, 45. *Etlingera pavieana*, 46. *Alpinia nigra*, 47. *Geostachys* sp., 48.*Amomum* cf. *testaceum* and M = ϕX*Hin*fI

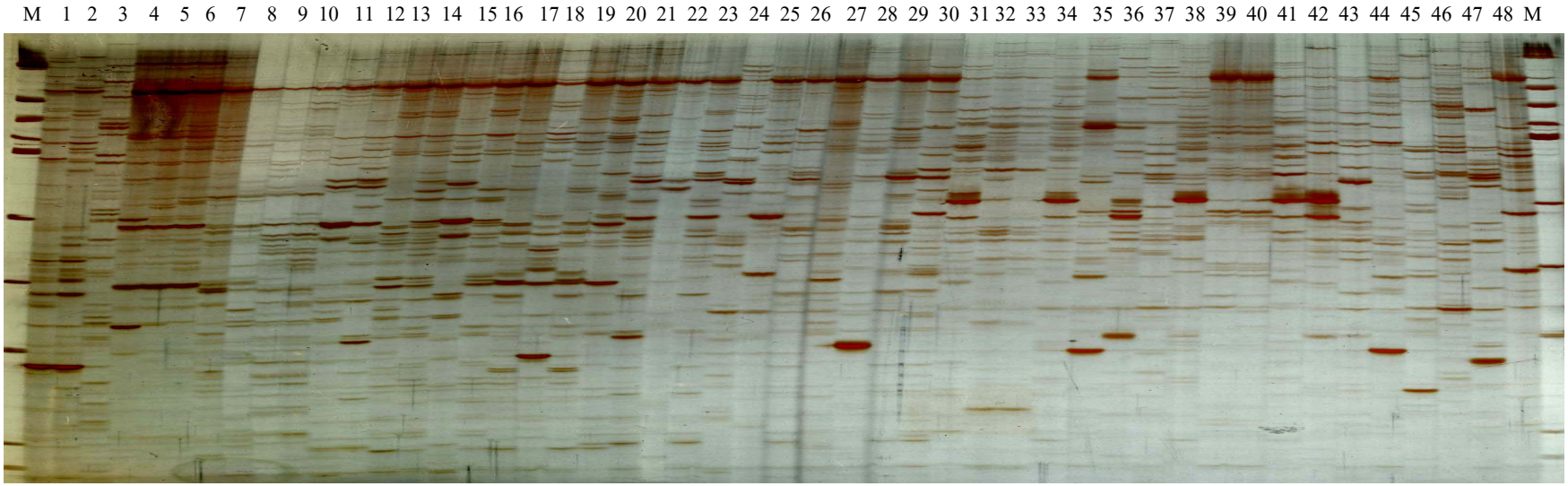

Figure 37 AFLP fingerprint of Thai *Amomum* species and out-groups using E-ACC, M-CAA primer pair. 1. *A. koenigii*1 , 2. *A. koenigii* 2, 3. *Amomum* sp.16, 4. *A. testaceum*1, 5. *A. testaceum* 2, 6. *A. testaceum* 3, 7. *A. testaceum* 4, 8. *Amomum* sp.1, 9. *A. aculeatum* Roxb., 10. *Amomum* sp.12, 11. *A. rivale*1, 12. *A. rivale*2, 13. *A.*cf. *villosum*1, 14. *A.* cf. *villosum*2, 15. *Amomum* sp.4, 16. *Amomum* sp.5, 17. *Amomum* sp.7, 18. *A. uliginosum*1, 19. *A. uliginosum*2, 20. *A. uliginosum*3, 21. *A Amomum* cf. *rivale.*, 22. *Amomum* sp.17a, 23. *Amomum* sp.8, 24. *Amomum* sp.10, 25. *A. biflorum* Jack , 26. *A. micranthum* Ridl., 27. *Amomum* sp.11, 28. *Amomum* sp.13, 29. none use, 30. none use, 31. *A. siamense* Craib,32. .*Amomum* sp.3, 33. *Amomum* sp.2, 34. *Amomum* sp.6b, 35. *A. uliginosum4*, 36. *Amomum* sp.17b, 37. *A. repoense* Gagnep., 38. *Amomum* sp.6a, 39. none use, 40. *Amomum* sp.14, 41. *Amomum* sp.15, 42. *A. dealbatum* Roxb., 43. *Elettaria cardamomum*, 44. *Etlingera littoralis*, 45. *Etlingera pavieana*, 46. *Alpinia nigra*, 47. *Geostachys* sp., 48.*Amomum* cf. *testaceum* and M = ϕX*Hin*fI

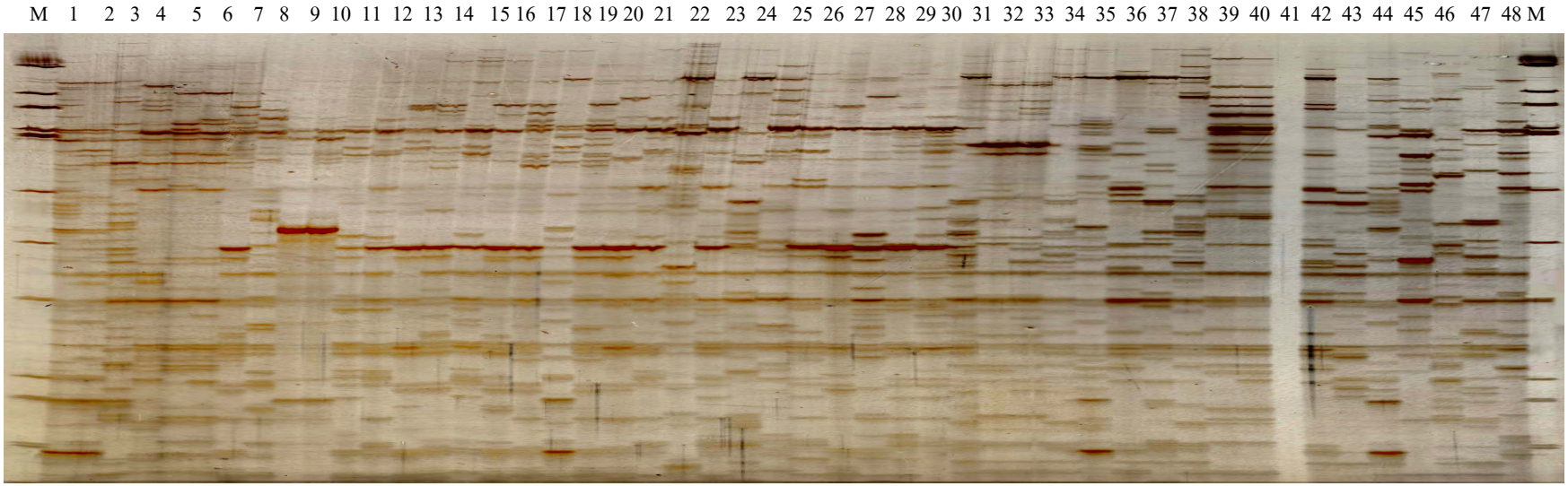

Figure 38 AFLP fingerprint of Thai *Amomum* species and out-groups using E-AGC, M-CTC primer pair. 1. *A. koenigii*1 , 2. *A. koenigii* 2, 3. *Amomum* sp.16, 4. *A. testaceum*1, 5. *A. testaceum* 2, 6. *A. testaceum* 3, 7. *A. testaceum* 4, 8. *Amomum* sp.1, 9. *A. aculeatum* Roxb., 10. *Amomum* sp.12, 11. *A. rivale*1, 12. *A. rivale*2, 13. *A.*cf. *villosum*1, 14. *A.* cf. *villosum*2, 15. *Amomum* sp.4, 16. *Amomum* sp.5, 17. *Amomum* sp.7, 18. *A. uliginosum*1, 19. *A. uliginosum*2, 20. *A. uliginosum*3, 21. *A Amomum* cf. *rivale.*, 22. *Amomum* sp.17a, 23. *Amomum* sp.8, 24. *Amomum* sp.10, 25. *A. biflorum* Jack , 26. *A. micranthum* Ridl., 27. *Amomum* sp.11, 28. *Amomum* sp.13, 29. none use, 30. none use, 31. *A. siamense* Craib,32. .*Amomum* sp.3, 33. *Amomum* sp.2, 34. *Amomum* sp.6b, 35. *A. uliginosum4*, 36. *Amomum* sp.17b, 37. *A. repoense* Gagnep., 38. *Amomum* sp.6a, 39. none use, 40. *Amomum* sp.14, 41. *Amomum* sp.15, 42. *A. dealbatum* Roxb., 43. *Elettaria cardamomum*, 44. *Etlingera littoralis*, 45. *Etlingera pavieana*, 46. *Alpinia nigra*, 47. *Geostachys* sp., 48.*Amomum* cf. *testaceum* and M = ϕX*Hin*fI

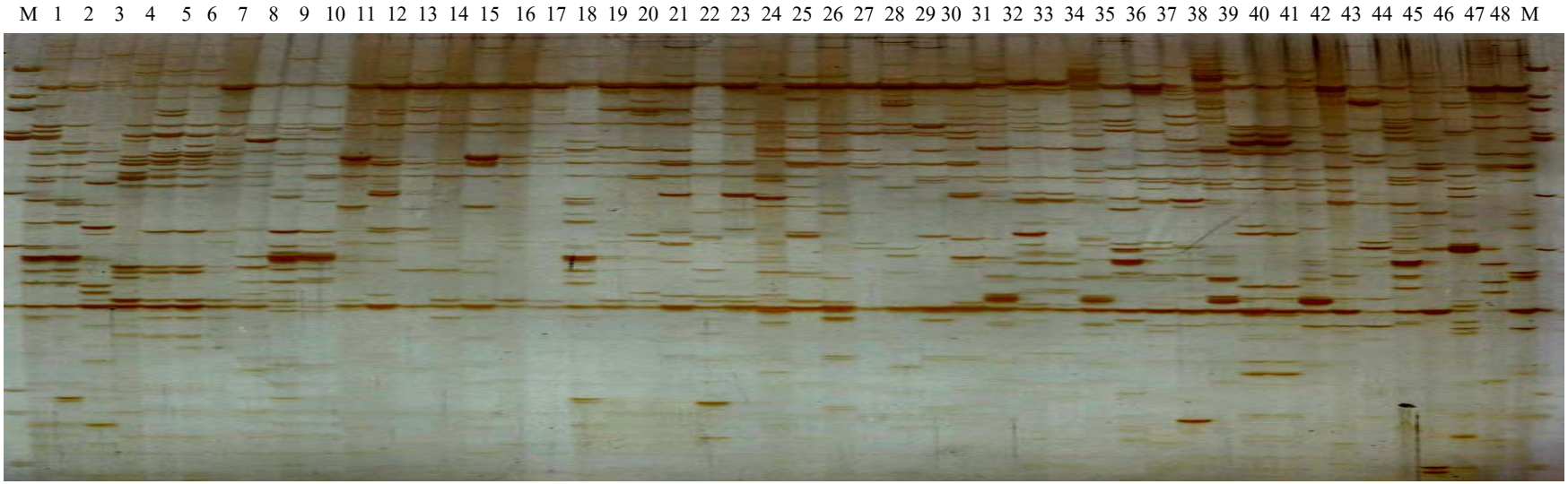

Figure 39 AFLP fingerprint of Thai *Amomum* species and out-groups using E-AGG, M-CTC primer pair. 1. *A. koenigii*1 , 2. *A. koenigii* 2, 3. *Amomum* sp.16, 4. *A. testaceum*1, 5. *A. testaceum* 2, 6. *A. testaceum* 3, 7. *A. testaceum* 4, 8. *Amomum* sp.1, 9. *A. aculeatum* Roxb., 10. *Amomum* sp.12, 11. *A. rivale*1, 12. *A. rivale*2, 13. *A.*cf. *villosum*1, 14. *A.* cf. *villosum*2, 15. *Amomum* sp.4, 16. *Amomum* sp.5, 17. *Amomum* sp.7, 18. *A. uliginosum*1, 19. *A. uliginosum*2, 20. *A. uliginosum*3, 21. *A Amomum* cf. *rivale.*, 22. *Amomum* sp.17a, 23. *Amomum* sp.8, 24. *Amomum* sp.10, 25. *A. biflorum* Jack , 26. *A. micranthum* Ridl., 27. *Amomum* sp.11, 28. *Amomum* sp.13, 29. none use, 30. none use, 31. *A. siamense* Craib,32. .*Amomum* sp.3, 33. *Amomum* sp.2, 34. *Amomum* sp.6b, 35. *A. uliginosum4*, 36. *Amomum* sp.17b, 37. *A. repoense* Gagnep., 38. *Amomum* sp.6a, 39. none use, 40. *Amomum* sp.14, 41. *Amomum* sp.15, 42. *A. dealbatum* Roxb., 43. *Elettaria cardamomum*, 44. *Etlingera littoralis*, 45. *Etlingera pavieana*, 46. *Alpinia nigra*, 47. *Geostachys* sp., 48.*Amomum* cf. *testaceum* and M = ϕX*Hin*fI

Table 8 Similarity index estimated by DICE from AFLP fingerprints of 40 accessions of *Amomom* and 5 outgroup taxa.

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	*A. koenigii* 1	1.00																					
2	*A. koenigii* 2	0.71	1.00																				
3	*Amomum* sp.16	0.58	0.57	1.00																			
4	*A. testaceum* 1	0.56	0.54	0.45	1.00																		
5	*A. testaceum* 2	0.56	0.51	0.47	0.78	1.00																	
6	*A. testaceum* 3	0.57	0.57	0.51	0.78	0.88	1.00																
7	*A. testaceum* 4	0.50	0.55	0.47	0.59	0.62	0.64	1.00															
8	*Amomum* sp.1	0.64	0.60	0.60	0.50	0.53	0.57	0.60	1.00														
9	*A. aculeatum*	0.59	0.65	0.60	0.66	0.63	0.64	0.56	0.61	1.00													
10	*Amomum* sp.12	0.58	0.63	0.57	0.64	0.62	0.60	0.60	0.64	0.90	1.00												
11	*A. rivale* 1	0.63	0.63	0.61	0.65	0.67	0.68	0.61	0.68	0.65	0.61	1.00											
12	*A. rivale* 2	0.57	0.59	0.65	0.57	0.55	0.63	0.65	0.67	0.60	0.59	0.76	1.00										
13	*A.* cf. *villosum* 1	0.54	0.56	0.51	0.57	0.52	0.52	0.64	0.52	0.61	0.57	0.65	0.60	1.00									
14	*A.* cf. *villosum* 2	0.50	0.53	0.43	0.53	0.53	0.53	0.73	0.53	0.58	0.59	0.56	0.64	0.75	1.00								
15	*Amomum* sp.4	0.61	0.63	0.58	0.68	0.68	0.71	0.64	0.60	0.67	0.64	0.80	0.74	0.71	0.62	1.00							
16	*Amomum* sp.5	0.57	0.60	0.53	0.60	0.58	0.60	0.65	0.57	0.66	0.65	0.64	0.67	0.77	0.83	0.68	1.00						
17	*Amomum* sp.7	0.53	0.55	0.52	0.62	0.68	0.64	0.69	0.59	0.60	0.66	0.67	0.67	0.65	0.70	0.75	0.71	1.00					
18	*A. uliginosum* 1	0.67	0.83	0.61	0.57	0.56	0.59	0.53	0.60	0.68	0.64	0.63	0.60	0.60	0.51	0.63	0.64	0.55	1.00				
19	*A. uliginosum* 2	0.53	0.57	0.47	0.65	0.68	0.65	0.69	0.57	0.62	0.64	0.64	0.67	0.71	0.74	0.77	0.74	0.94	0.58	1.00			
20	*A. uliginosum* 3	0.53	0.52	0.57	0.57	0.56	0.54	0.63	0.62	0.56	0.58	0.67	0.64	0.67	0.64	0.69	0.65	0.75	0.58	0.74	1.00		
21	*Amomum* cf.*rivale*	0.55	0.57	0.69	0.59	0.57	0.62	0.63	0.64	0.62	0.58	0.72	0.85	0.62	0.64	0.78	0.68	0.66	0.61	0.67	0.67	1.00	
22	*A.momum* sp.17a	0.53	0.52	0.58	0.53	0.51	0.48	0.53	0.56	0.60	0.60	0.63	0.56	0.60	0.48	0.60	0.53	0.60	0.50	0.57	0.58	0.60	1.00

Table 8 (Continued)

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
23	*Amomum* sp.8	0.55	0.57	0.66	0.57	0.57	0.59	0.61	0.62	0.59	0.55	0.77	0.85	0.65	0.62	0.77	0.67	0.63	0.61	0.66	0.69	0.92	0.60	1.00
24	*Amomum* sp.10	0.55	0.50	0.63	0.54	0.53	0.48	0.57	0.59	0.57	0.58	0.60	0.57	0.60	0.53	0.60	0.51	0.53	0.58	0.58	0.61	0.63	0.61	0.66
25	*A. biflorum* Jack	0.58	0.58	0.61	0.65	0.65	0.68	0.61	0.65	0.60	0.61	0.71	0.71	0.59	0.56	0.69	0.64	0.67	0.64	0.67	0.67	0.71	0.55	0.71
26	*A. micranthum* Ridl.	0.53	0.54	0.62	0.61	0.60	0.63	0.71	0.63	0.63	0.62	0.73	0.75	0.63	0.63	0.64	0.61	0.64	0.57	0.64	0.67	0.76	0.56	0.74
27	*Amomum* sp.11	0.50	0.54	0.51	0.64	0.69	0.64	0.71	0.60	0.55	0.57	0.62	0.67	0.61	0.67	0.68	0.71	0.81	0.59	0.81	0.73	0.70	0.53	0.65
28	*Amomum* sp.13	0.54	0.67	0.65	0.67	0.61	0.63	0.60	0.60	0.66	0.64	0.73	0.75	0.60	0.60	0.71	0.61	0.68	0.64	0.68	0.70	0.78	0.56	0.78
29	*A. siamense* Craib	0.54	0.62	0.57	0.58	0.60	0.57	0.54	0.55	0.60	0.64	0.70	0.57	0.58	0.55	0.62	0.58	0.59	0.64	0.59	0.64	0.60	0.60	0.65
30	*Amomum* sp.3	0.52	0.53	0.61	0.53	0.51	0.53	0.55	0.64	0.56	0.52	0.63	0.51	0.51	0.48	0.60	0.47	0.57	0.55	0.55	0.61	0.53	0.52	0.57
31	*Amomum* sp.2	0.50	0.53	0.66	0.51	0.51	0.50	0.57	0.67	0.51	0.49	0.60	0.56	0.48	0.47	0.57	0.43	0.53	0.53	0.50	0.58	0.57	0.50	0.55
32	*Amomum* sp.6b	0.58	0.60	0.58	0.54	0.53	0.51	0.53	0.60	0.57	0.58	0.67	0.60	0.57	0.60	0.63	0.60	0.60	0.57	0.58	0.64	0.63	0.64	0.64
33	*A. uliginosum*4	0.59	0.67	0.65	0.58	0.58	0.58	0.60	0.57	0.63	0.62	0.65	0.64	0.60	0.58	0.67	0.64	0.62	0.74	0.62	0.62	0.68	0.57	0.67
34	*Amomum* sp.17b	0.57	0.56	0.60	0.57	0.63	0.58	0.62	0.69	0.63	0.60	0.68	0.64	0.63	0.52	0.65	0.60	0.60	0.62	0.62	0.59	0.64	0.64	0.67
35	*A. repoense* Gagnep.	0.53	0.52	0.58	0.50	0.54	0.54	0.55	0.70	0.56	0.52	0.58	0.59	0.57	0.54	0.57	0.51	0.52	0.52	0.55	0.63	0.63	0.64	0.63
36	*Amomum* sp.6a	0.59	0.54	0.60	0.50	0.47	0.47	0.45	0.55	0.60	0.57	0.59	0.53	0.50	0.43	0.53	0.49	0.56	0.51	0.54	0.51	0.54	0.60	0.54
37	*Amomum* sp.14	0.53	0.53	0.57	0.55	0.57	0.53	0.64	0.67	0.57	0.60	0.65	0.66	0.57	0.61	0.57	0.61	0.59	0.56	0.57	0.60	0.64	0.48	0.62
38	*Amomum* sp.15	0.57	0.54	0.56	0.57	0.58	0.55	0.56	0.57	0.61	0.57	0.70	0.66	0.66	0.55	0.65	0.58	0.54	0.54	0.59	0.62	0.67	0.68	0.70
39	*A. dealbatum* Roxb.	0.61	0.64	0.57	0.56	0.57	0.62	0.52	0.70	0.60	0.53	0.63	0.60	0.64	0.54	0.67	0.57	0.55	0.64	0.60	0.60	0.66	0.60	0.67
40	*Elettaria cardamomum*	0.65	0.56	0.60	0.44	0.52	0.53	0.51	0.74	0.57	0.62	0.62	0.58	0.53	0.50	0.51	0.50	0.56	0.57	0.54	0.59	0.53	0.62	0.56
41	*Etlingera littoralis*	0.69	0.63	0.64	0.56	0.56	0.59	0.52	0.60	0.59	0.60	0.60	0.62	0.60	0.57	0.60	0.64	0.58	0.71	0.58	0.60	0.63	0.57	0.64
42	*Etlingera pavieana*	0.58	0.58	0.57	0.54	0.57	0.54	0.57	0.71	0.64	0.63	0.67	0.54	0.51	0.47	0.61	0.50	0.58	0.55	0.58	0.61	0.55	0.61	0.53
43	*Alpinia nigra*	0.52	0.55	0.55	0.53	0.53	0.50	0.60	0.56	0.56	0.50	0.61	0.50	0.62	0.56	0.61	0.56	0.55	0.52	0.60	0.58	0.55	0.49	0.58
44	*Geostachys* sp.	0.57	0.60	0.59	0.55	0.57	0.53	0.60	0.64	0.69	0.65	0.64	0.57	0.61	0.58	0.65	0.61	0.59	0.67	0.62	0.65	0.65	0.60	0.62
45	*Amomum* cf. *testaceum*	0.53	0.49	0.61	0.70	0.70	0.68	0.58	0.57	0.60	0.60	0.63	0.67	0.47	0.53	0.63	0.56	0.53	0.49	0.53	0.55	0.67	0.57	0.66

Table 8 (Continued)

		24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
24	*Amomum* sp.10	1.00																					
25	*A. biflorum* Jack	0.60	1.00																				
26	*A. micranthum* Ridl.	0.62	0.67	1.00																			
27	*Amomum* sp.11	0.57	0.73	0.63	1.00																		
28	*Amomum* sp.13	0.64	0.74	0.75	0.64	1.00																	
29	*A. siamense* Craib	0.65	0.57	0.58	0.57	0.64	1.00																
30	*Amomum* sp.3	0.69	0.58	0.57	0.51	0.64	0.60	1.00															
31	*Amomum* sp.2	0.66	0.58	0.57	0.53	0.60	0.57	0.88	1.00														
32	*Amomum* sp.6b	0.69	0.55	0.60	0.53	0.65	0.82	0.63	0.58	1.00													
33	*A. uliginosum4*	0.59	0.65	0.66	0.57	0.74	0.64	0.60	0.57	0.62	1.00												
34	*Amomum* sp.17b	0.70	0.70	0.58	0.67	0.63	0.63	0.62	0.64	0.65	0.52	1.00											
35	*A. repoense* Gagnep.	0.71	0.61	0.68	0.57	0.60	0.54	0.61	0.58	0.60	0.54	0.62	1.00										
36	*Amomum* sp.6a	0.62	0.56	0.57	0.52	0.60	0.67	0.57	0.57	0.71	0.52	0.66	0.56	1.00									
37	*Amomum* sp.14	0.54	0.70	0.66	0.61	0.64	0.52	0.60	0.64	0.47	0.61	0.60	0.59	0.43	1.00								
38	*Amomum* sp.15	0.67	0.65	0.67	0.57	0.64	0.60	0.54	0.53	0.65	0.58	0.72	0.64	0.69	0.55	1.00							
39	*A. dealbatum* Roxb.	0.64	0.63	0.54	0.56	0.59	0.59	0.61	0.63	0.64	0.59	0.74	0.66	0.60	0.57	0.70	1.00						
40	*Elettaria cardamomum*	0.60	0.57	0.63	0.49	0.53	0.66	0.59	0.59	0.68	0.55	0.61	0.67	0.69	0.53	0.61	0.59	1.00					
41	*Etlingera littoralis*	0.55	0.67	0.54	0.57	0.59	0.62	0.55	0.57	0.60	0.71	0.62	0.58	0.53	0.60	0.53	0.69	0.60	1.00				
42	*Etlingera pavieana*	0.64	0.63	0.59	0.56	0.59	0.60	0.63	0.63	0.57	0.54	0.67	0.69	0.59	0.64	0.60	0.63	0.57	0.52	1.00			
43	*Alpinia nigra*	0.67	0.55	0.56	0.54	0.59	0.56	0.61	0.57	0.58	0.54	0.54	0.61	0.54	0.54	0.53	0.60	0.51	0.49	0.64	1.00		
44	*Geostachys* sp.	0.70	0.64	0.64	0.57	0.64	0.67	0.65	0.62	0.70	0.63	0.71	0.62	0.57	0.60	0.64	0.62	0.64	0.54	0.64	0.57	1.00	
45	*Amomum* cf. *testaceum*	0.60	0.64	0.65	0.62	0.65	0.51	0.53	0.60	0.55	0.54	0.59	0.63	0.53	0.54	0.65	0.57	0.53	0.55	0.57	0.44	0.54	1.00

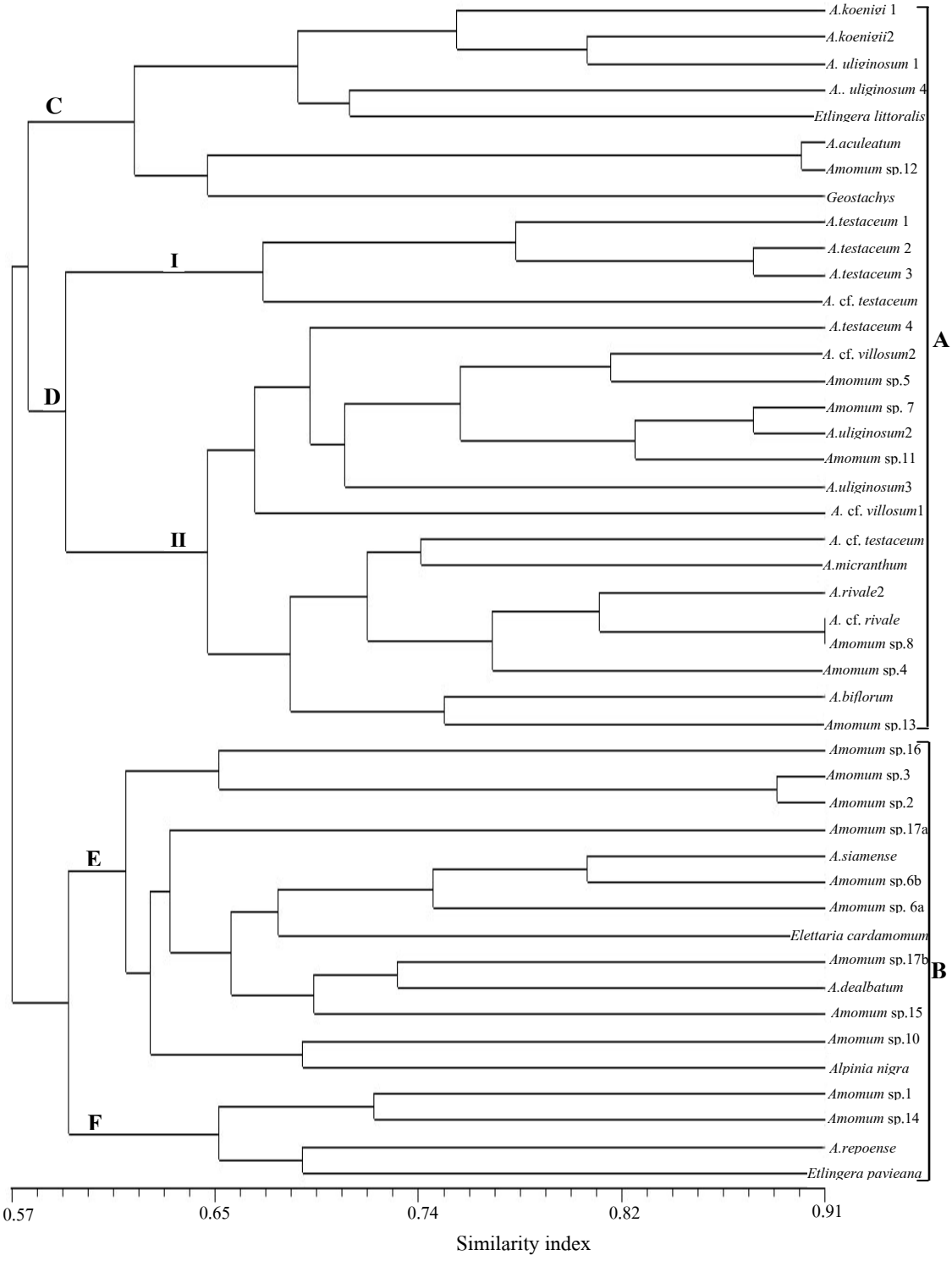

Figure 40 Dendogram depicts the genetic relationship of 45 accessions of *Amomum* based on AFLP fingerprint, using similarity coefficient by DICE, clustering with UPGMA.

Palynological study

1. Palynological analysis

The results from SEM technique revealed that the pollen grains of Thai *Amomum* are spherical to sub-spherical, only some grains of *A.rivale* Ridl. are ovoid, 30-70 μm in diameter. The intine layer is 1-7 μm thick. These results agree with Mangaly and Nayar (1990) which reported that the pollen shape of *Amomum hypoleucum* Thw. and *A. pterocarpum* Thw. are sub-spheroidal to ovoid and spheroidal, the diameter varies from 30-90 and 35-75 μm, respectively. The intine layer is 1.25-2.5 μm thick in *Amomum hypoleucum* Thw. Our results revealed that the pollen can be divided into two groups either by intine thickness: less than 4 μm thick and 4 μm thick or more or by exine sculpturing: echinate and psilate (Table 9) (Figure 41). Our results do not coincide with the classification by previous authors, in particular, Schumann (1904) who subdivided the genus (section *Euamomum*) into two series, 1. ser. *Lobulatae* (anther crest with two or three lobes) and 2. ser. *Integrae* anther crest margin with entire lobe). Our study reveals that most pollen grains are echinate sculpturing which was consistent in both series and are of less use in classification.

2. Pollen characteristics of Thai *Amomum*

General description of pollen morphology: grains monads, inaperturate; spherical, subspherical or ovoid; 30-70 μm in diameter; exine echinate or psilate (reticulate), spine sharp or blunt apex; intine 1-7 μm thick. (Table 9)

Table 9 Pollen morphology of Thai *Amomum* species.

Species	Shape and size (dia.)	Intine thickness	Exine sculpturing
1. *A. aculeatum*	Spherical, 46-60 µm.	3 µm	Echinate; spine uniformly distributed, sharp apex, having collared base, 1.5-3 µm tall, 2-3 µm thick at base.
2. *A. biflorum*	Spherical, 35-46 µm.	1-2 µm	Echinate; spine uniformly distributed, usually sharp apex, having collared base, 2.5-3 µm tall, 3-3.5 µm thick at base.
3. *A. dealbatum*	Spherical, 52-58 µm.	3 µm	Echinate; spine uniformly distributed, blunt and interrupted by sharp apex, 3-3.5 µm tall, 3 µm thick at base.
4. *A. rivale*	Subspherical or ovoid, ca. 60 µm.	1 µm	Psilate, exine 0.5 µm thick
5. *A. siamense*	Spherical, 43-53 µm.	5 µm	Echinate; spine uniformly distributed, sharp apex, 2.5-3 µm tall, 3 µm thick at base, surface reticulate.
6. *A. testaceum*	Spherical to subspherical, 60 µm.	2 µm	Psilate, exine 1 µm thick.
7. *A. uliginosum*	Spherical, 30-35 µm.	1-2 µm	Echinate; spine irregularly distributed, blunt interupted by sharp apex, having collared base, 1 µm tall, 2 µm thick at base.
8. *Amomum* sp.3	Spherical, 63-70 µm.	4-5 µm	Echinate; spine uniformly distributed, sharp and interrupted by blunt apex, 4 µm tall, 6 µm thick at base.
9. *Amomum* sp.4	Spherical or subspherical, 50-58 µm.	1 µm	Echinate; spine uniformly distributed, sharp or blunt apex, having collared base, ca. 2 µm tall, 3 µm thick at base.
10. *Amomum* sp.6	Spherical to subsperical, 45-50 µm.	4-5 µm	Echinate; spine uniformly distributed, blunt and interrupted by sharp apex, 2-2.5 µm tall,2-3 µm thick at base.
11. *Amomum* sp.11	Spherical, 56-60 µm.	4-7 µm	Echinate; spine uniformly distributed, sharp apex, having collared base, 3 µm tall, 3 µm thick at base.
12. *Amomum* sp.12	Spherical, 60-64 µm.	1 µm	Echinate; spine uniformly distributed, sharp apex, 3-4 µm tall, 2-2.3 µm thick at base.
13. *Amomum* sp.15	Spherical, 50-60 µm.	1 µm	Echinate; spine uniformly distributed, sharp apex, 4 µm tall, 3.5 µm thick at base.
14. *Amomum* sp.16	Spherical, 60-63 µm.	2-3 µm	Echinate; spine uniformly distributed, sharp apex, 4 µm tall, 4 µm thick at base.

3. Pollen characteristics and classification of Thai *Amomum*

The results from palynological study are not useful for classification. Most data from pollen shapes and size characteristics are apparently homoplasious although exine sculpture can divide the species into two groups: echinate and psilate.

Echinate group, the groups consisted *A. aculeatum, A. biflorum, A. dealbatum, A. siamense, A. uliginosum, Amomum* sp.3, *Amomum* sp.4, *Amomum* sp.6, *Amomum* sp.11, *Amomum* sp.12, *Amomum* sp.15, *Amomum* sp.16.

Psilate group, this group contains 2 species: *A. rivale* and *A. testaceum.*

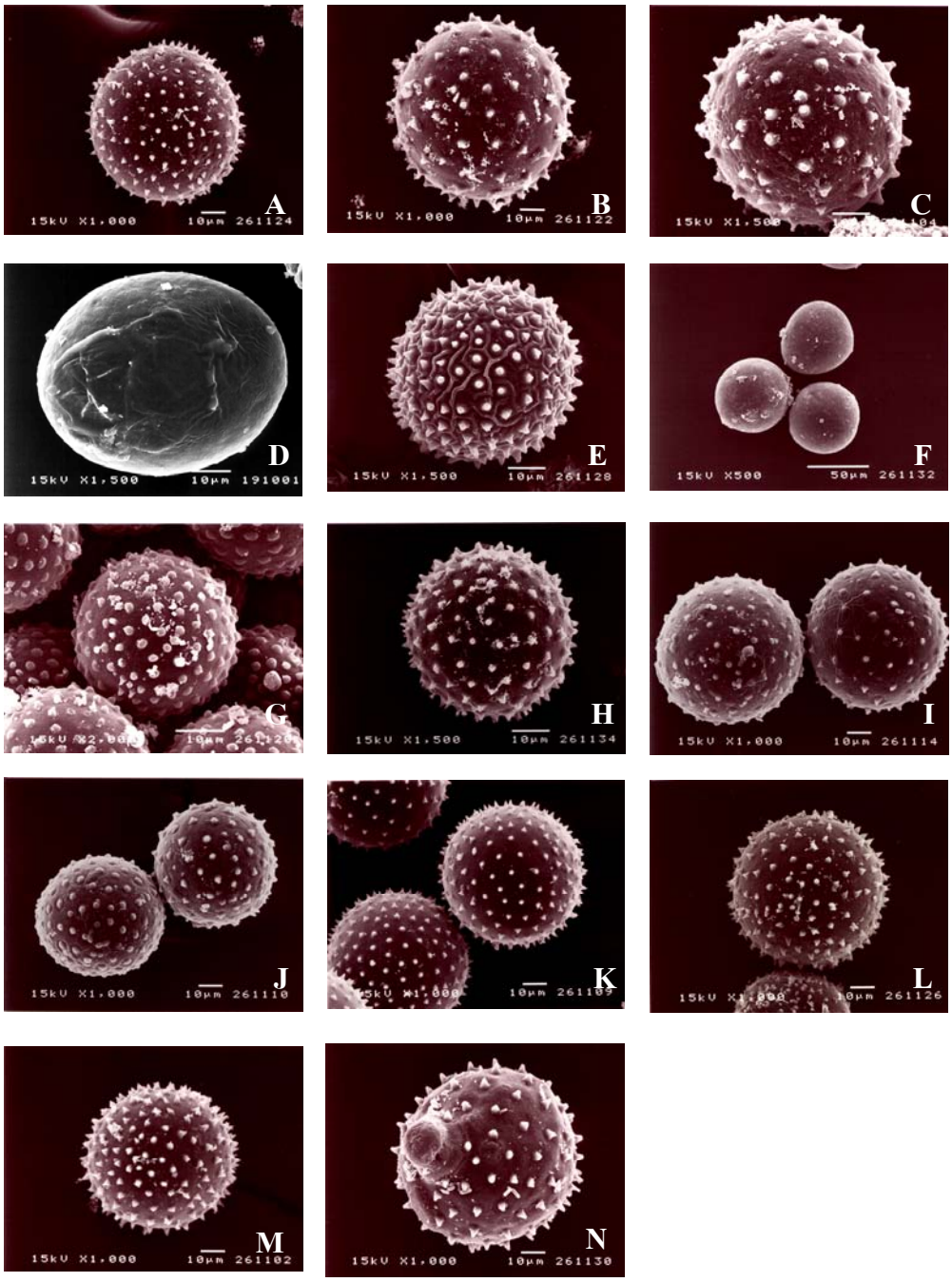

Figure 41 Scaning electron micrographs of pollen grains of Thai *Amomum*: (A) *Amomum aculeatum* (B) *A. biflorum* (C) *A. dealbatum* (D) *A. rivale* (E) *A. siamense* (F) *A. testaceum* var. *testaceum* (G) *A. uliginosum* (H) *Amomum* sp.3 (I) *Amomum* sp.4 (J) *Amomum* sp.6 (K) *Amomum* sp.11 (L) *Amomum* sp.12 (M) *Amomum* sp.15 (N) *Amomum* sp.16

CONCLUSION

1. This study found 36 species of Thai *Amomum*, 31 species are contained in our collection. Five species previously recorded were not collected during our field expedition. With regard to the collections, 13 species were identified, the rest are being proposed as new species.

2. Regarding AFLP marker, all *Amomum* species were separated into three groups which agree with morphological study. These groups corresponds to the fruit and leafy stem characteristics. Thai *Amomum* were divided into 3 groups: *A. aculeatum* group is characterized by fruit spiny or smooth and leafy stem stout, such as *A. koenigii* and *A. aculeatum*, *A. biflorum* group is defined by smooth or spiny fruit and leafy stem is usually slender such as *A. testaceum* and *A. biflorum*, *A. dealbatum* group is characterized by winged, ridged or smooth fruit such as *A. dealbatum*and *A. siamense*.

3. The pollen grains of Thai *Amomum* are spherical to subspherical, inaperturate. Exine sculpture echinate or psilate. Pollen characteristics agree with the previous reports but do not correspond with previous classification based on both morphological characteristics or molecular evidence. Therefore, the pollen morphology is less useful for subgeneric classification of Thai *Amomum*.

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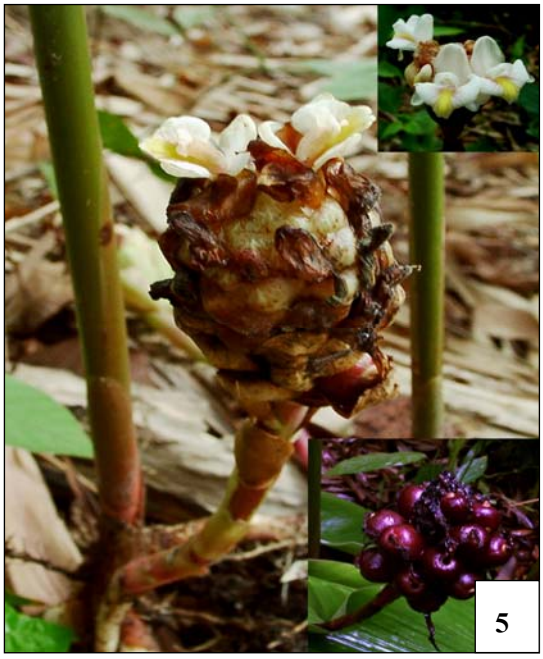
APPENDIX

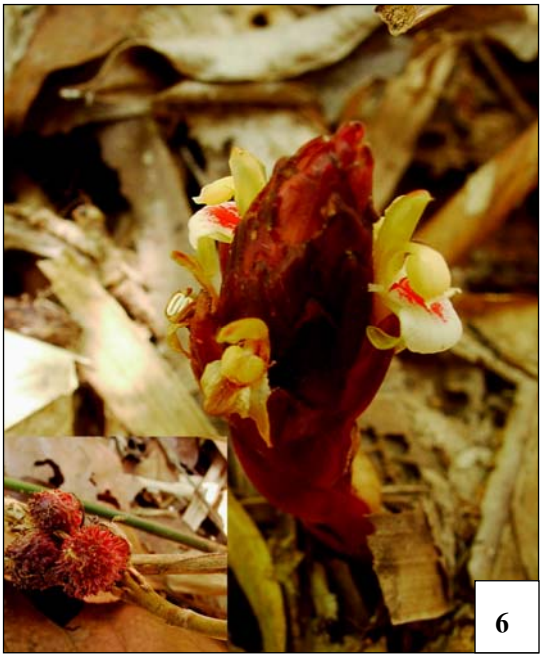
APPENDIX A

Illustrations of *Amomum* species

Appendix A Pictures of collected *Amomum*.

1. *A. aculeatum* Roxb.
2. *A. biflorum* Jack
3. *A. dealbatum* Roxb.
4. *A. hastilabium* Ridl.





Appendix A (continued)

5. *A.koenigii* Gmelin.
6. *A. micranthum* Ridl.
7. *A. pierreanum* Gagnep.
8. *A. repoense* Pierre ex Gagnep.

Appendix A (continued)

9. *A. rivale* Ridl.
10. *A. siamense* Craib
11. *A. testaceum* Ridl.
12. *A. uliginosum* König ex Retz.


13


14


15


16

Appendix A (continued)

13. *Amomum* cf. *villosum*
14. *Amomum* sp.1
15. *Amomum* sp.2
16. *Amomum*sp.3

17

18

19

20

Appendix A (continued)

17. *Amomum* sp.4
18. *Amomum* sp.5
19. *Amomum* sp.6
20. *Amomum* sp.7


21


22


23


24

Appendix A (continued)

21. *Amomum* sp.8
22. *Amomum* sp.9
23. *Amomum* sp.10
24. *Amomum* sp.11


25


26


27


28

Appendix A (continued)

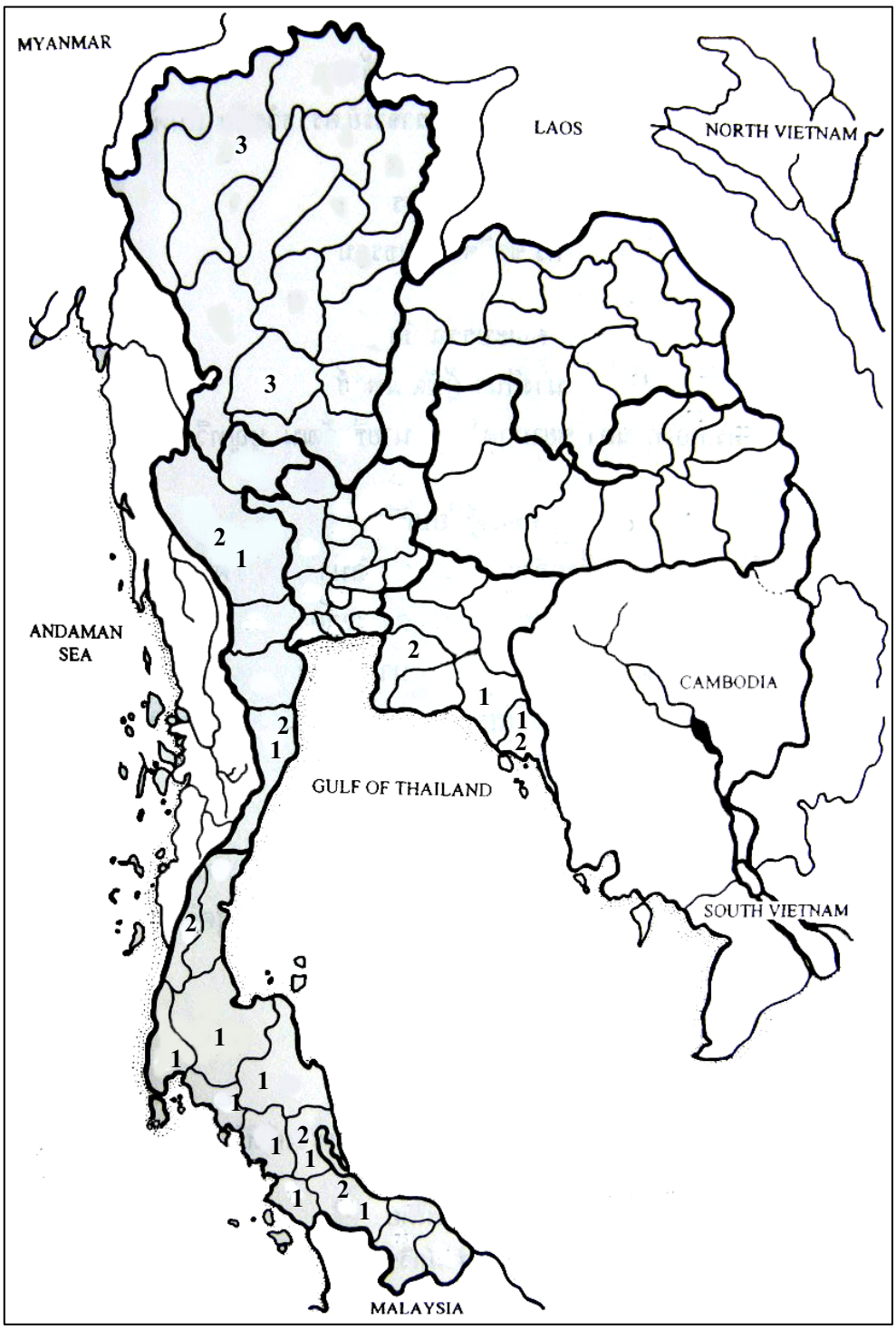
25. *Amomum* sp.12
26. *Amomum* sp.13
27. *Amomum* sp.14
28. *Amomum* sp.15

Appendix A (continued)

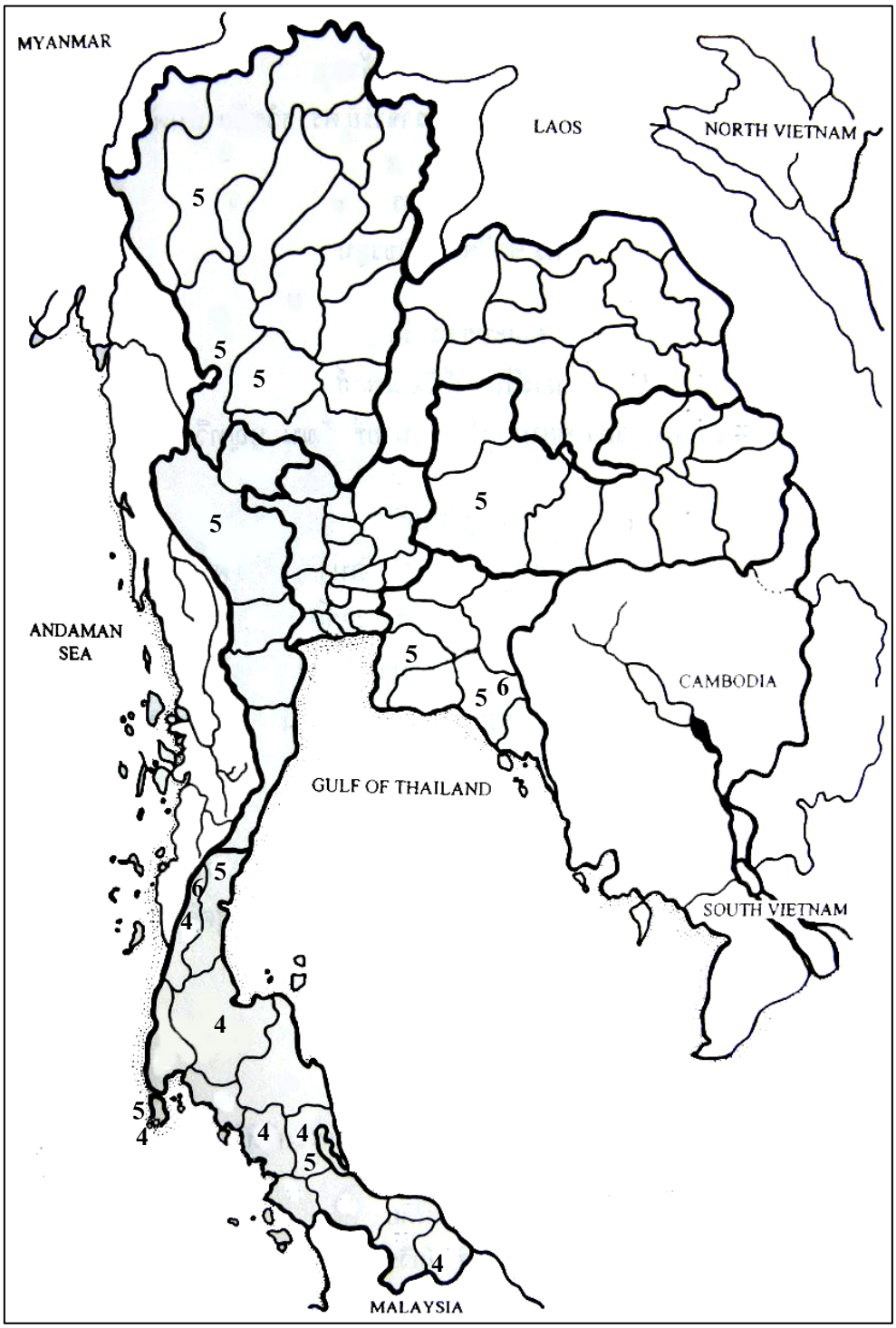
29. *Amomum* sp.16
30. *Amomum* sp. 17
31. *Amomum* sp.18

APPENDIX B

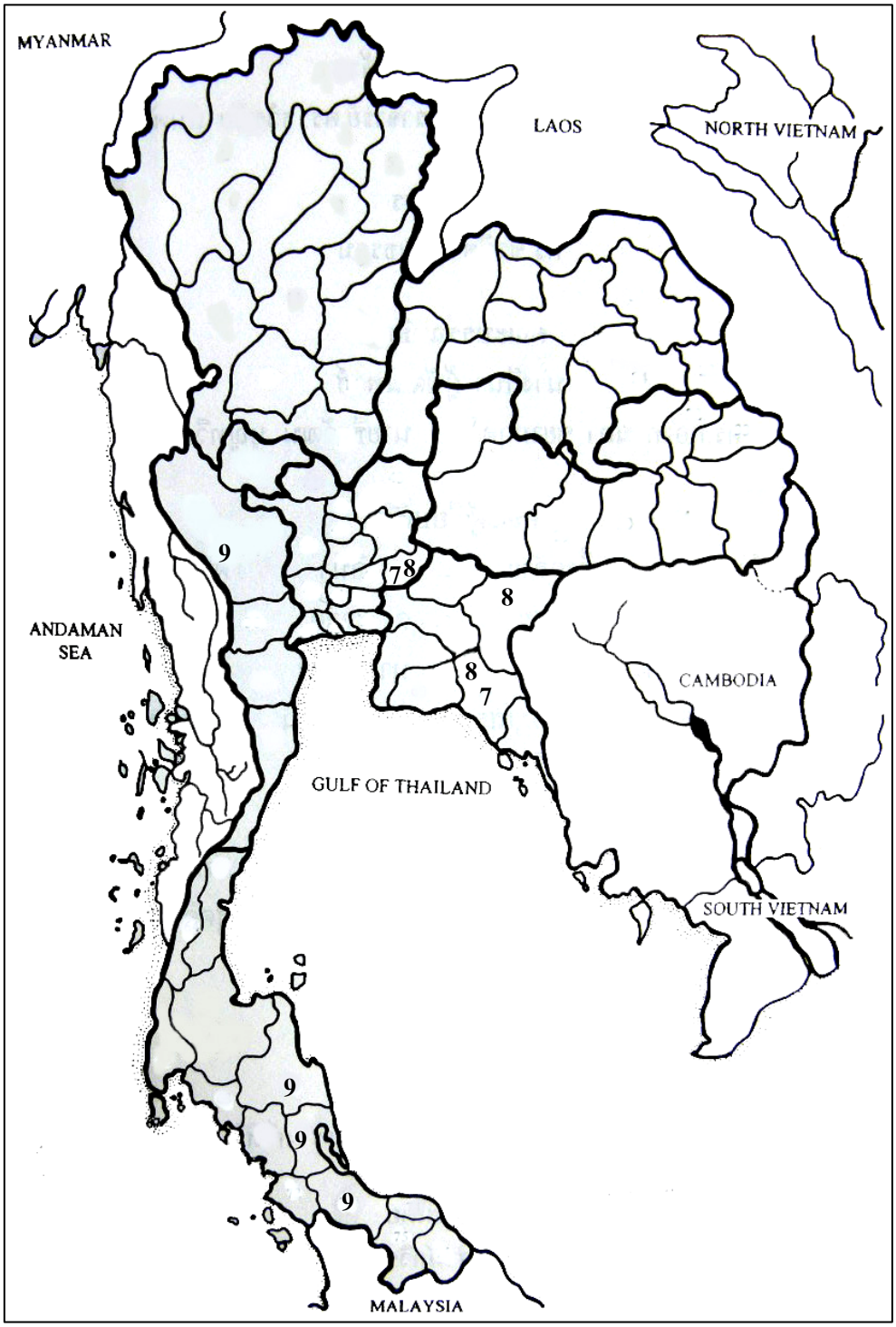
Distribution of *Amomum* species in Thailand



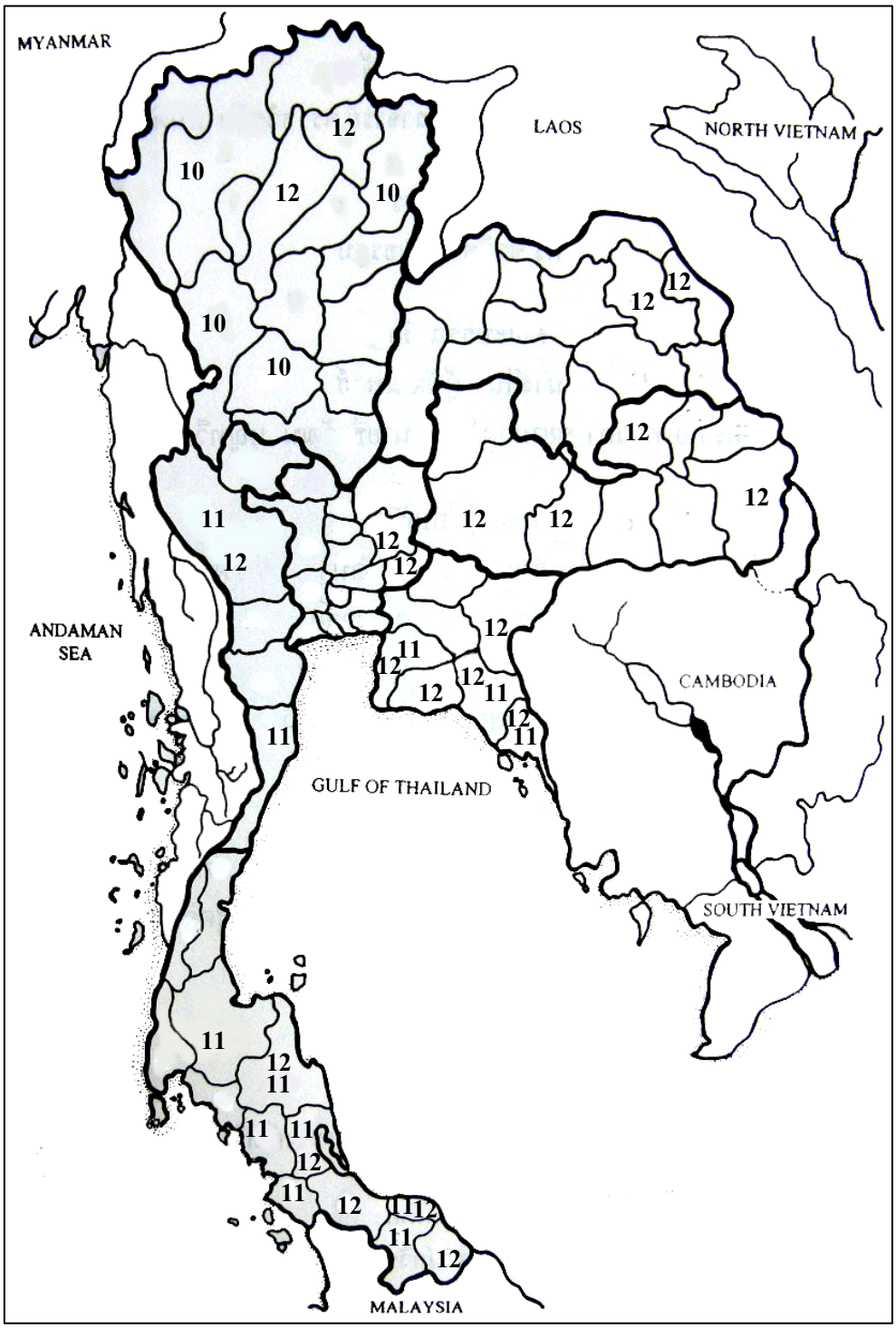
Appendix B(I) Distribution of *Amomum aculeatum* Roxb. (1), *A. biflorum* Jack (2) and *A. dealbatum* Roxb. (3)



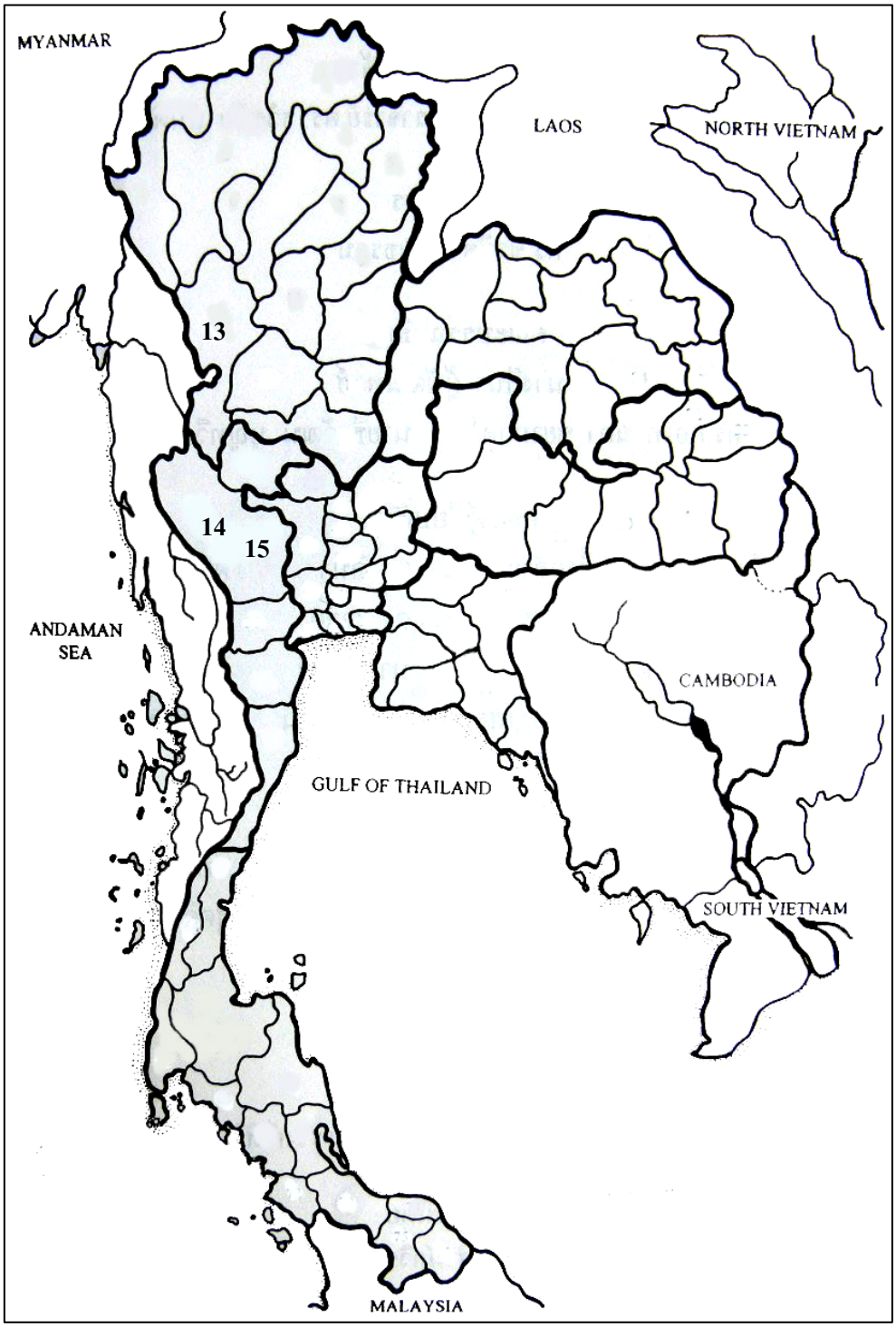
Appendix B(2) Distribution of *A. hastilabium*Ridl. (4), *A. koenigii* Gmelin (5) and *A. micranthum* Ridl. (6)



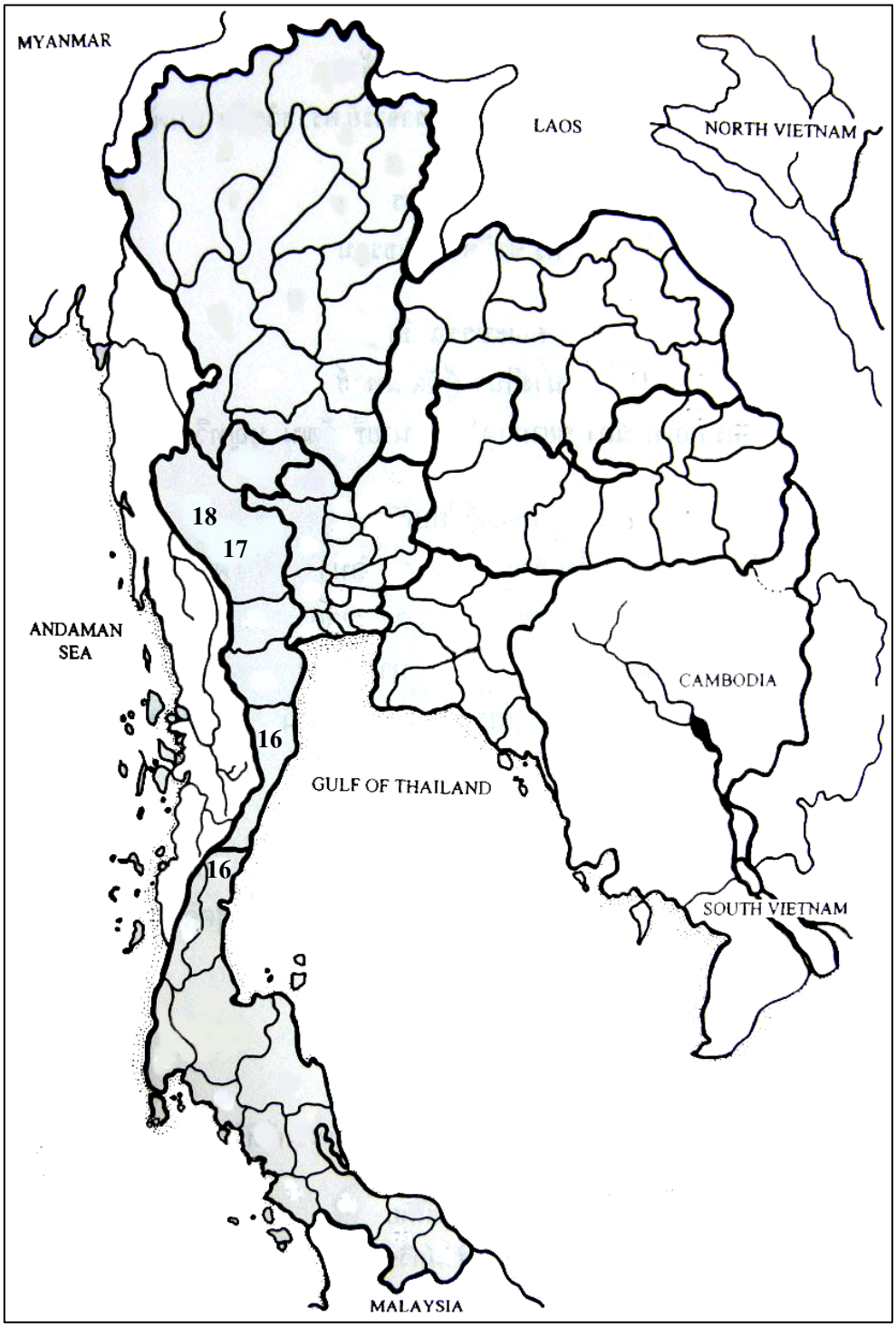
Appendix B(3) Distribution of *A. pierreanum* Gagnep. (7), *A. repoense* Pierre ex Gagnep. (8) and *A. rivale* Ridl. (9)



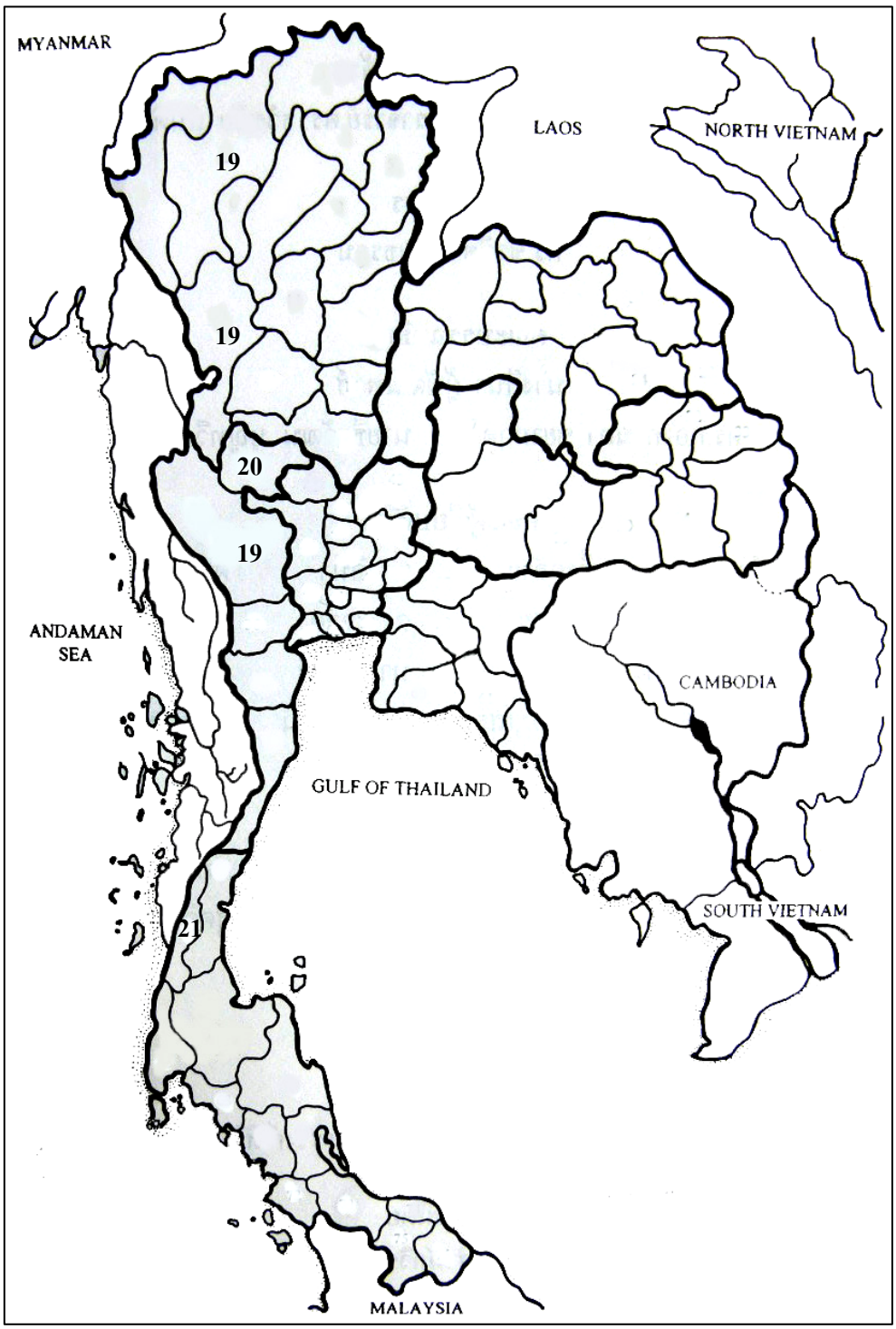
Appendix B(4) Distribution of *A. siamense* Craib. (10), *A. testaceum* Ridl. (11) and *A. uliginosum* König ex Retz. (12)



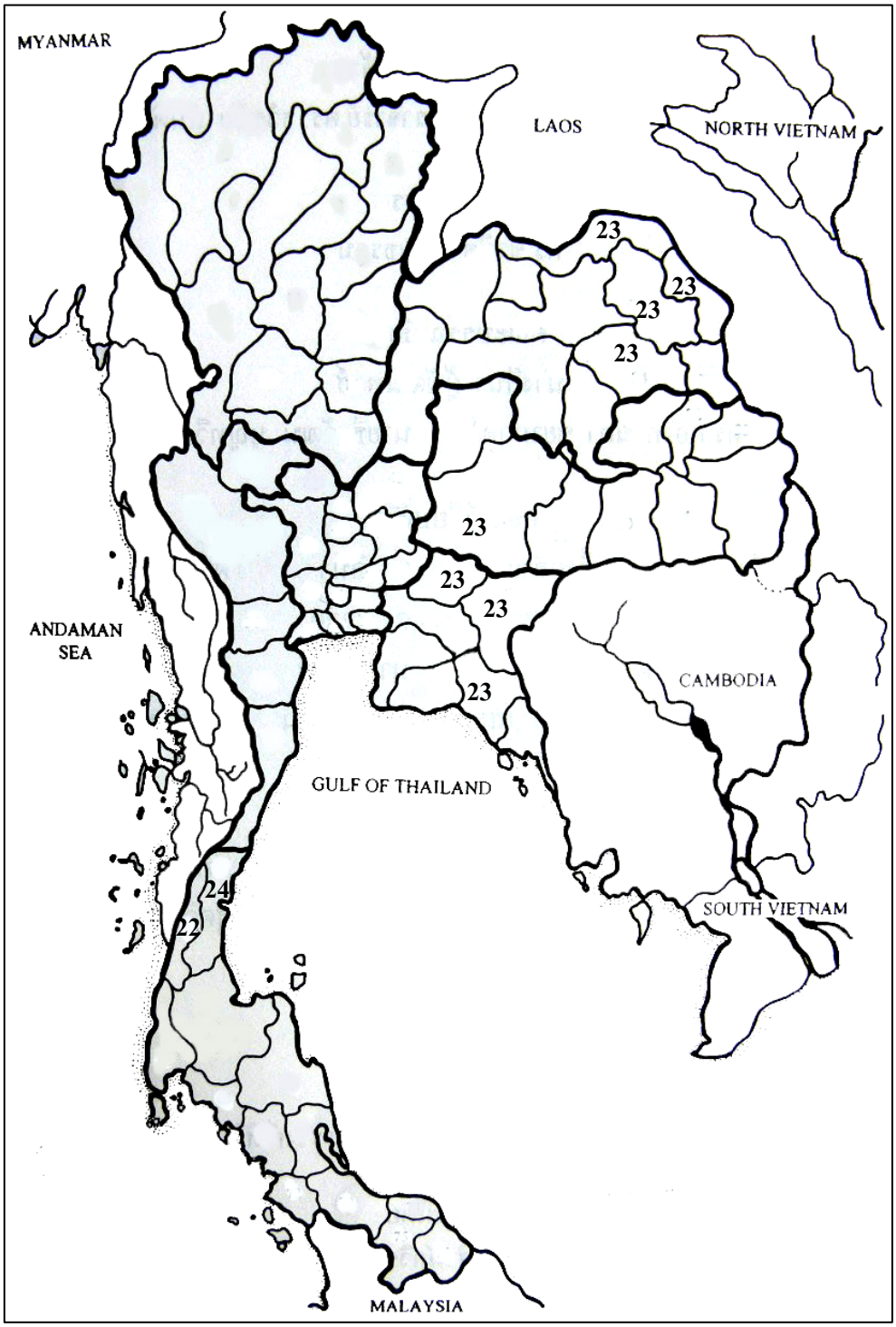
Appendix B(5) Distribution of *Amomum* cf.*villosum*. (13), *Amomum* sp.1 (14) and *Amomum* sp.2 (15)



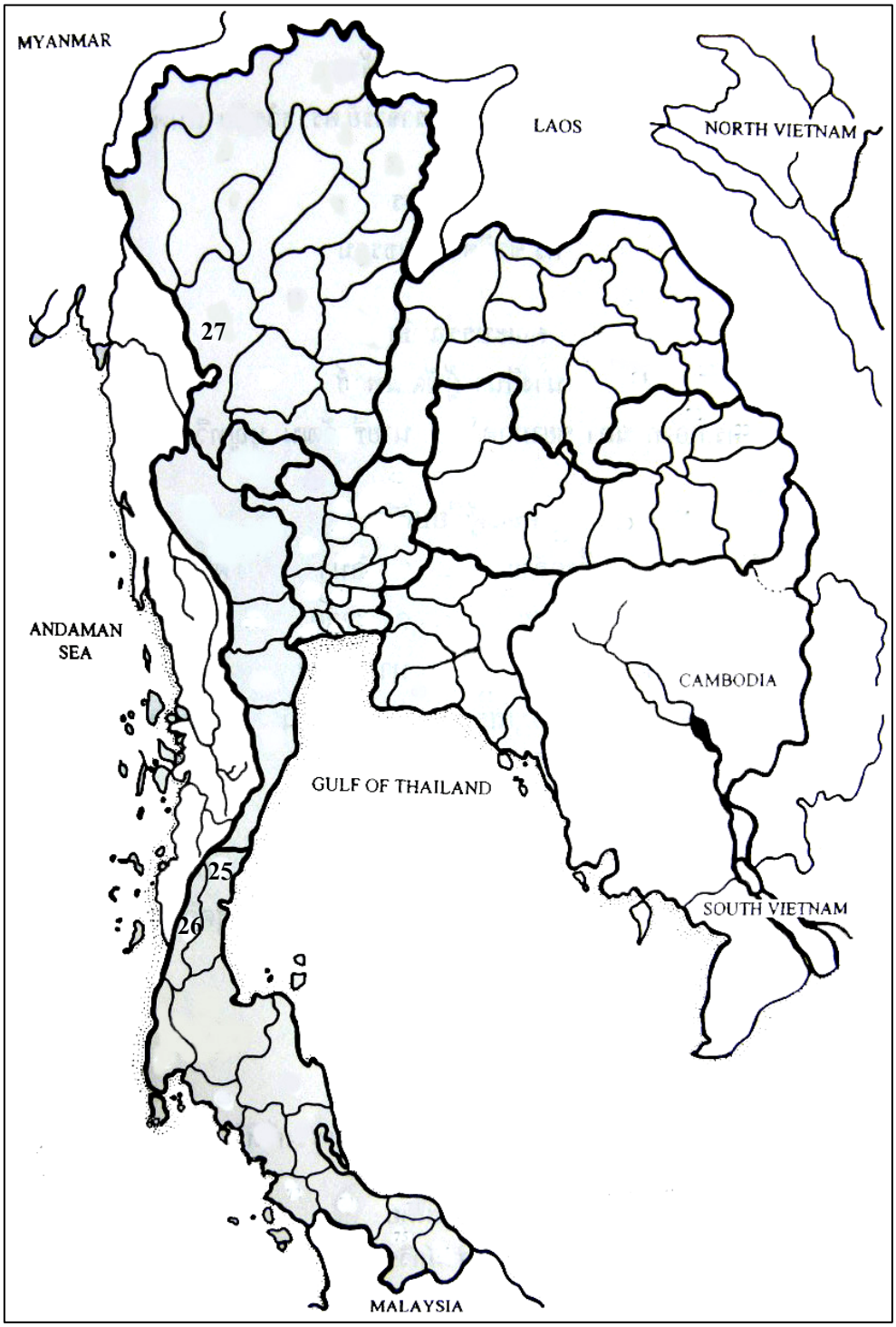
Appendix B(6) Distribution of *Amomum* sp.3 (16), *Amomum* sp.4 (17) and *Amomum* sp.5 (18)



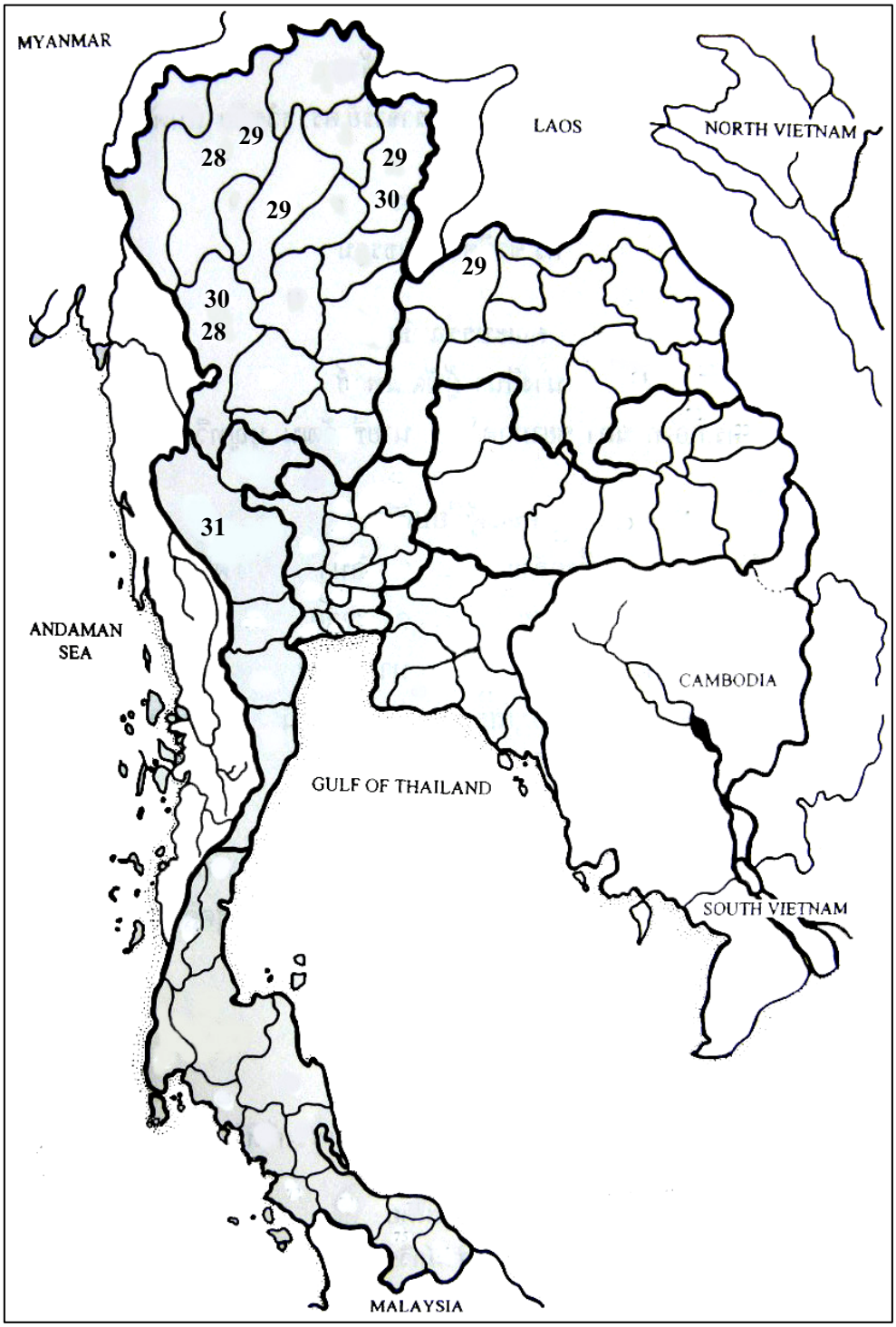
Appendix B(7) Distribution of *Amomum* sp.6 (19), *Amomum* sp. 7 (20) and *Amomum* sp.8 (21)



Appendix B(8) Distribution of *Amomum* sp.9 (22), *Amomum* sp. 10 (23) and *Amomum* sp.11 (24)



Appendix B(9) Distribution of *Amomum* sp.12 (25), *Amomum* sp. 13 (26) and *Amomum* sp.14 (27)



Appendix B(10) Distribution of *Amomum* sp.15 (28), *Amomum* sp. 16 (29), *Amomum* sp.17 (30) and *Amomum* sp.18 (31)

APPENDIX C

Tables

Appendix Table C1 Representative species of *Amomum* collected from all over Thailand during April 2003-June 2005.

No.	Botanical Name	Collector No.	Locality
1	*Amomum aculeatum* Roxb.	Kaewsri -2	Kanchanaburi
2	*Amomum biflorum* Jack	Kaewsri -58	Chanthaburi
3	*Amomum dealbatum* Roxb.	Kaewsri -110	Chiang Mai
4	*Amomum hastilabium* Ridl.	Kaewsri -37	Ranong
5	*Amomum koenigii* Gmelin.	Kaewsri -03	Kanchanaburi
6	*Amomum micranthum* Ridl.	Kaewsri -63	Chanthaburi
7	*Amomum pierreanum* Gagnep.	Kaewsri -122	Nakhon Nayok
8	*Amomum repoense* Pierre ex Gagnep.	Kaewsri -64	Chanthaburi
9	*Amomum rivale* Ridl.	Kaewsri -04	Kanchanaburi
10	*Amomum siamense* Craib	Kaewsri -14	Tak
11	*Amomum testaceum* var. *testaceum* Ridl.	Kaewsri -15	Tak (Cultivated)
12	*Amomum testaceum* var. *longipedunculatum*	Kaewsri -17	Tak (Cultivated)
13	*Amomum testaceum* var. *nanum*	Kaewsri -16	Tak (Cultivated)
14	*Amomum uliginosum* König ex Retz.	Kaewsri -30	Nakhon Nayok
15	*Amomum* cf. *villosum*	Kaewsri -13	Tak
16	*Amomum* sp.1	Kaewsri -01	Kanchanaburi
17	*Amomum* sp.2	Kaewsri -10	Kanchanaburi
18	*Amomum* sp.3	Kaewsri -19	Prachuap Khiri Khan
19	*Amomum* sp.4	Kaewsri -22	Kanchanaburi
20	*Amomum* sp.5	Kaewsri -24	Kanchanaburi
21	*Amomum* sp.6	Kaewsri -25	Kanchanaburi
22	*Amomum* sp.7	Kaewsri -27	Uthai Thani
23	*Amomum* sp.8	Kaewsri -35	Ranong
24	*Amomum* sp.9	Kaewsri -38	Ranong
25	*Amomum* sp.10	Kaewsri -50	Sakon Nakhon
26	*Amomum* sp.11	Kaewsri -68	Chanthaburi
27	*Amomum* sp.12	Kaewsri -70	Chumphon
28	*Amomum* sp.13	Kaewsri -81	Ranong
29	*Amomum* sp.14	Kaewsri -94	Tak
30	*Amomum* sp.15	Kaewsri -108	Chiang Mai
31	*Amomum* sp.16	Kaewsri -111	Chiang Mai
32	*Amomum* sp.17	Kaewsri -134	Nan (Doi Phu Kha NP.)
33	*Amomum* sp.18	Kaewsri -151	Kanchanaburi

Appendix Table C2 List of *Amomum* species used in morphological analysis.

Botanical Name	Collector No.	Locality
1. *A.aculeatum*1	Kaewsri-02	Kanchanaburi (Sai Yok NP.)
2. *A.aculeatum*2	Kaewsri-20	Prachuap Khiri Khan (Kaeng Krachan NP.)
3. *A.aculeatum*3	Kaewsri-65	Chanthaburi (Khlong Khuar Wai NP.)
4. *A.aculeatum*4	Kaewsri-71	Chumphon
5. *A.biflorum*1	Kaewsri-58	Chanthaburi (Khao Soi Dao WS.)
6. *A.biflorum*2	Kaewsri-66	Chumphon
7. *A.dealbatum*	Kaewsri-110	Chiang Mai (Doi Inthanon NP.)
8. *A. hastilabium*	Kaewsri-37	Ranong (Khlong Naka WS.)
9. *A.koenigii*1	Kaewsri-03	Kanchanaburi (Sai Yok NP.)
10. *A.koenigii*2	Kaewsri-29	Nakhon Nayok (Muang Dist.)
11. *A.koenigii*3	Kaewsri-136	Nan (Doi Phu Kha NP.)
12. *A.micranthum*1	Kaewsri-63	Chanthaburi (Khlong Khuar Wai NP.)
13. *A.micranthum*2	Kaewsri-84	Ranong
14. *A.pierreanum*	Kaewsri-122	Nakhon Nayok (Khao Yai NP.)
15. *A.repoense*1	Kaewsri-64	Chanthaburi (Khlong Khuar Wai NP.)
16. *A.repoense*2	Kaewsri-103	Sa Kaeo (Pang Sida NP.)
17. *A.repoense*3	Kaewsri-121	Nakhon Nayok (Khao Yai NP.)
18. *A.rivale*1	Kaewsri-04	Kanchanaburi (Sai Yok NP.)
19. *A.rivale*2	Kaewsri-23	Kanchanaburi (Thong Pha Phum NP.)
20. *A.rivale*3	Kaewsri-142	Kanchanaburi (Sai Yok NP.)
21. *A.siamense*1	Kaewsri-14	Tak (Doi Musur)
22. *A.siamense*2	Kaewsri-116	Tak (Doi Musur)
23. *A.siamense*3	Kaewsri-123	Nan (Si Nan NP.)
24. *A. testaceum*1	Kaewsri-15	Tak (Doi Musur)
25. *A.testaceum*2	Kaewsri-16	Tak (Doi Musur)
26. *A.testaceum*4	Kaewsri-96	Tak (Doi Musur)
27. *A.uliginosum*1	Kaewsri-120	Nakhon Nayok (Khao Yai NP.)
28. *A.uliginosum*2	Kaewsri-87	Tak (Um Phang WS.)
29. *A.uliginosum*3	Kaewsri-101	Sakon Nakhon (Phu Phan NP.)
30. *A.uliginosum*4	Kaewsri-30	Nakhon Nayok (Muang Dist.)
31. *A.uliginosum*5	Kaewsri-125	Nan (Si Nan NP.)
*32. A.*cf. *villosum*	Kaewsri-13	Tak (Doi Musur)

Appendix Table C2 (Continued)

Scientific Name	Collector No.	Locality
33. *Amomum* sp.1a	Kaewsri- 01	Kanchanaburi (Sai Yok NP.)
34. *Amomum* sp.1b	Kaewsri-93	Tak (Um Phang WS.)
35. *Amomum* sp.2	Kaewsri-10	Kanchanaburi (Sai Yok NP.)
36. *Amomum* sp.3	Kaewsri-19	Prachuap Khiri Khan (Kaeng Krachan NP.)
37. *Amomum* sp.4	Kaewsri-22	Kanchanaburi (Thong Pha Phum NP.)
38. *Amomum* sp.5	Kaewsri-24	Kanchanaburi (Thong Pha Phum NP.)
39. *Amomum* sp.6a	Kaewsri-25	Kanchanaburi (Thong Pha Phum NP.)
40. *Amomum* sp.6b	Kaewsri-89	Tak (Um Phang WS.)
41. *Amomum* sp.7	Kaewsri-27	Uthai Thani (Huai Kha Khaeng WS.)
42. *Amomum* sp.10a	Kaewsri-50	Sakon Nakhon (Phu Phan NP.)
43. *Amomum* sp.10b	Kaewsri-104	Buri Ram (Dong Yai WS.)
44. *Amomum* sp.10c	Kaewsri-107	Ubon Ratchathani (Yot Dom WS.)
45. *Amomum* sp.11	Kaewsri-68	Chumphon
46. *Amomum* sp.12	Kaewsri-70	Chumphon
47. *Amomum* sp.13	Kaewsri-81	Ranong
48. *Amomum* sp.14	Kaewsri-94	Tak (Um Phang WS.)
49. *Amomum* sp.15	Kaewsri-108	Chiang Mai (Doi Inthanon NP.)
50. *Amomum* sp.16a	Kaewsri-111	Chiang Mai (Doi Inthanon NP.)
51. *Amomum* sp.16b	Kaewsri-114	Chiang Mai (Huai Nam Dang NP.)
52. *Amomum* sp.16c	Kaewsri-137	Nan (Doi Phu Kha NP.)
53. *Amomum* sp.17	Kaewsri-134	Nan (Doi Phu Kha NP.)
54. *Alpinia nigra*	-	Refer from Jenjittikul (2003)
55.*Etlingera littoralis*	-	Refer from Jenjittikul (2003)
56.*Siamanthus siliquosus*	-	Refer from Jenjittikul (2003)

Appendix Table C3 Pollen grain samples of Thai *Amomum* species used in palynological study.

No.	Species	Collected No.	Collected Places
1.	*A. aculeatum* Roxb.	Kaewsri-71	Chumphon
2.	*A. biflorum* Ridl.	Kaewsri-66	Chanthaburi
3.	*A. dealbatum* Roxb.	Kaewsri-110	Chiang Mai
4.	*A. rivale* Ridl.	Kaewsri-04	Kanchanaburi
5.	*A. siamense* Craib	Kaewsri-14	Tak
6.	*A. testaceum* Ridl.	Kaewsri-16	Tak
7.	*A. uliginosum* König ex Retz.	Kaewsri-30	Nakhon Nayok
8.	*Amomum* sp.3	Kaewsri-19	Prachuap Khiri Khan
9.	*Amomum* sp.4	Kaewsri-22	Kanchanaburi
10.	*Amomum* sp.6	Kaewsri-89	Chiang Mai
11.	*Amomum* sp.11	Kaewsri-68	Chumphon
12.	*Amomum* sp.12	Kaewsri-70	Chumphon
13.	*Amomum* sp.15	Kaewsri-108	Chiang Mai
14.	*Amomum* sp.16	Kaewsri-114	Chiang Mai

APPENDIX D

Protocols

Appendix Table D1 Digestion cocktail (per reaction).

Item	Final Conc.	Volume (µl)	Source
DNA Template	20-50 ng/ µl	10	
Buffer A	10X	2.5	Bozinger
*Eco*RI	10 U / µl	1	
*MSe*I	10 U / µl	1	
dH_2O		10.5	
		25	

Appendix Table D2 Ligestion cocktail (per reaction).

Item	Final Conc.	Volume (µl)	Source
Buffer A	10X	1	Bozinger
*Eco*RI-Adapter	50 *p*mol / µl	1.5	
*MSe*I-Adapter	50 *p*mol / µl	1.5	
T4-ligase	3 U/µl	0.4	
ATP	10 mM	1.2	
dH_2O		4.4	
		10	

Appedix Table D3 Pre-amplification cocktail (per reaction).

Item	Final Conc.	Volume (µl)	Source
Template		3	
PCR Buffer A	10X	1	Bozinger
*Eco*RI	5 µM	0.5	
*MSe*I	5 µM	0.5	
Taq	1 U/µl	0.3	
dNTPs	1 mM	2	
dH_2O		2.7	
		10	

Appendix Table D4 PCR-I program.

Temperature (º C)	Time (min.)	Number of Cycle
50	5	1
94	3	1
94	0.5	24
56	1	24
72	1	24
72	5	1

Appendix Table D5 Selective amplification cocktail (per reaction).

Item	Final Conc.	Volume (µl)	Source
Template	-	2	
PCR Buffer A	10X	1	Bozinger
*Eco*RI	5 µM	0.5	
*MSe*I	5 µM	0.5	
Taq	1 U/µl	0.3	
dNTPs	1 mM	2	
dH_2O	-	3.7	
		10	

Appendix Table D6 PCR-II program.

Temperature (º C)	Time (sec.)	Number of Cycle	Remark
94	30	9	decrease annealing temperature by 1 º C each cycle until 57 º C
65	30		
72	60		
94	30	30	
56	30		
72	60		
	4		Hold

APPENDIX E

Procedures

1. Agarose Gel Electrophoresis Procedure

1.1 Agarose Gel Preparation

1.1.1 Plastic tray and comb were cleaned with wipers (Kimberly-Clark, USA)

1.1.2 Mixing agarose powder with TAE buffer and boiling. The agarose solution was poured onto the tray with 1 mm thick comb.

1.1.3 The agarose solution was let solidify for about 30 min at room temperature and the comb was carefully removed from the gel.

1.1.4 The well set agarose gel with the tray was put in TAE buffer in a submarine eletrophoresis tank.

1.2 Electrophoresis

1.2.1 DNA sample or PCR product was mixed with gel loading buffer before the sample was loaded into the wells of the gel.

1.2.2 The mixture was loaded into the gel and the unit was run at 200 V for 20 min.

2. Polyacrylamide Gel Electrophoresis Procedure

The procedure of polyacrylamide gel electrophoresis as follow: 5 µl of PCR product was mixed with 10 µl of loading buffer (containing 98% formamide, 10 mM EDTA, 0.025% bromophenol blue and 0.025% xylene cyanol). The samples were denatured for 10 min at 95 ºC and quickly cooled on ice. Suddenly, 2.5 µl of each sample was loaded into 6% non-denaturing acrylamide gel (acrylamide: bis-acrylamide=99:1), containing 1x buffer as quickly as possible. The electrophoresis was operated at constant voltage and temperature in 1x buffer. The duration of each electrophoresis depended on the size of PCR product fragment and DNA bands were visualized with silver staining.

Silver staining: The gel apparatus was carefully separated and gently agitated on a shaker during staining process. The glass plate with the bound gel was placed onto a plastic tray. The gel was fixed in 10% acetic acid for 20 min and wash three times with de-ionized water for 3 times (2 min at a time). Color impregnation lasted for 30 min with 0.1% silver nitrate and 0.075% formaldehyde and then the gel was rinsed for 10 sec with de-ionized water. After silver staining, the gel was put in cold developing solution [30 g per liter sodium carbonate (Na_2CO_3), 1.5 ml formaldehyde per liter, 200 µl (10mg/ml) sodium thiosulfate ($Na_2S_2O_3$)] and gently shaken until bands appeared with the desired intensity. The color reaction was stopped with 10% acetic acid and rinsed three times with de-ionized water for 2 min at a time and dried.