

CHAPTER II

LITERATURE REVIEW

Introduction

The Zingiberaceae, or Ginger family, belongs to the order Zingiberales (previously known as Scitamineae) of the class Monocotyledonae. This family was previously divided into 4 tribes: *Globbeae*, *Zingibereae*, *Hedychieae* and *Alpinieae* (Smith, 1981). Recently based on molecular studies by Kress & et al. (2002), 4 subfamilies were proposed: Zingiberoideae (2 tribes, Zingibereae and Globbeae), Alpinoideae (2 tribes, Alpinieae and Riedelieae), Tamijioideae (only one species, *Tamijia flagellaris*) and Siphnochiloideae (1 genus, *Siphonochilus*). About 50 genera and *ca.* 1400 species of Zingiberaceae are worldwide represented, and so far *ca.* 300 species (of 26 genera) have been found in Thailand.

The genus *Hedychium* is one of the ethnobotanically and economically important genera of the family Zingiberaceae. Some crude drugs employed in Thai traditional medicine or ethnomedical prescriptions, e.g. Wan Khing Haeng, Wan Pad Roi Sanom, Wan Chai Dam are the rhizomes of the genus *Hedychium* J. König (Zingiberaceae). Several taxa, especially those with showy and fragrant flowers, have or may have horticultural potential. Up to now, over 50 species, distributed mainly from Eastern Himalayas to South India, South China and Southeast Asia, are recognized.

Taxonomic history of the genus *Hedychium* J. König

König established the genus in 1783 based on the type species, *Hedychium coronarium* J. König.

Wallich (1853) enumerated 23 species and proposed 3 subgenera divisions, *Coronariae* (for taxa with imbricate bracts), *Spicatae* (for taxa with elongated inflorescence and not imbricate bracts) and *Siphonium* (with only 1 species, *H. scaposa*).

Baker (1890) recorded 24 species of *Hedychium* for the Flora of British India. All of these taxa were divided into two sections, *Gandasulium* and *Macrostemlum* based on the length of the stamen.

Ridley (1899) reported 5 species of *Hedychium* for the Malay Peninsula with the known *H. longicornutum* and 4 new species: *H. microchilum*, *H. macrorrhizum*, *H. denticulatum* and *H. collinum*. In 1924, he further recognized another 4 species with full descriptions and proposed an artificial key for the Malay Peninsular taxa.

Schumann (1904) published his monograph of the Zingiberaceae in “Das Pflanzenreich” and listed 38 species of *Hedychium*. He divided the genus into two subgenera: *Gandasulium* (taxa with dense flowers, imbricate bracts and invisible rachis, and *Euosmianthus* (included taxa with lax flowers, not imbricate bracts and visible rachis. His classification is presently often followed and recognized.

Gagnepain (1908) listed 5 species: *H. coronarium*, *H. coccineum*, *H. bousigonianum*, *H. yunnanense* and *H. villosum* from Indochina with full description, an artificial key, together with an illustration of some species.

Turrill (1914) recognized 8 species of *H. coronarium*, *H. maximum*, *H. urophyllum*, *H. elwesii*, *H. flavescens*, *H. chrysoleucum*, *H. flavum* and *H. subditum*.

Holtum (1950) enumerated 7 species, with descriptions and an artificial key of *Hedychium* in Malaya: *H. chrysoleucum*, *H. collinum*, *H. hirsutissimum*, *H. longicornutum*, *H. macrorrhizum*, *H. malayanum* and *H. paludosum*.

Larsen (1965) added 3 new taxa and described of *Hedychium* for Indochina, *H. boloveniorum*, *H. poilanii* and *H. forrestii* var. *latebracteatum*.

Baker and Bakhuizen (1968) recorded 3 species of *Hedychium* in the Flora of Java, i.e. *H. coronarium*, *H. hasseltii* and *H. roxburghii*.

Burt and Smith (1972) listed *H. coronarium* as key species of the genus *Hedychium*. An illustration of *H. cylindricum* were also provided in their list. Later, in 1983, they listed 3 species, *H. coccineum*, *H. coronarium* and *H. flavescens* for Ceylon.

Smith (1994) recognized 7 species in Flora of Bhutan: *H. aurantiacum*, *H. coccineum*, *H. coronarium*, *H. densiflorum*, *H. elatum*, *H. ellipticum*, *H. gardnerianum*, *H. glaucum*, *H. greenii*, *H. griersonianum*, *H. spicatum*, *H. stenopetalum* and *H. thyrsoforme*.

Wu & Larsen (2000) listed 28 species (8 endemic species) of *Hedychium* in the Flora of China, with description and key to species.

Kress et al. (2003) recorded 15 taxa in his checklist of the Plants of Myanmar, *H. coccineum*, *H. coronarium*, *H. elatum*, *H. ellipticum*, *H. flavum*, *H. forrestii*, *H. gomezianum*, *H. gracile*, *H. gracile* var. *glaucum*, *H. marginatum*, *H. spicatum*, *H. stenopetalum*, *H. thyrsoforme*, *H. venustum* and *H. villosum*.

Williams, Kress & Htun (2003) described a new species from Myanmar, *H. bordelonianum*.

Sabu and Pradeep (2005) recognized 14 species for Northeast India: *H. coccineum*, *H. coronarium*, *H. ellipticum*, *H. elwesii*, *H. flavescens*, *H. forrestii*, *H. gracile*, *H. gardnerianum*, *H. greenii*, *H. rubrum*, *H. spicatum*, *H. stenopetalum*, *H. thyrsoforme* and *H. wardii*.

Newman et al. (2007) listed 7 taxa in their "Checklist of the Vascular Plants of Lao PDR" which included *H. boloveniorum*, *H. bousigonianum*, *H. coccineum*, *H. coronarium*, *H. coronarium* var. *flavescens*, *H. ellipticum* and *H. stenopetalum*.

Chaturvedi and Moakum (2008) reported 14 species from Nagaland: *H. acuminatum*, *H. aruntiacum*, *H. chrysoleucum*, *H. coccineum*, *H. coronarium*, *H. elatum*, *H. flavescens*, *H. gardnerianum*, *H. griffithianum*, *H. greenii*, *H. luteum*, *H. marginatum*, *H. stenopetalum* and *H. villosum*.

Wongsuwan (2008) described a new species from Southern Laos, *H. chayanianum*.

Picheansoonthon and Wongsuwan (2009) recently added *H. champasakense* from Southern Laos.

Taxonomic history of the genus *Hedychium* in Thailand

Larsen (1996) recognized 20 species in his preliminary checklist of the Zingiberaceae of Thailand: *H. aureum*, *H. biflorum*, *H. coccineum*, *H. collinum*, *H. coronarium*, *H. ellipticum*, *H. flavum*, *H. forrestii*, *H. gardnerianum*, *H. gomezianum*, *H. gracile*, *H. griffithianum*, *H. hirsutissimum*, *H. longicornutum*, *H. samuiense*, *H. speciosum*, *H. spicatum*, *H. stenopetalum*, *H. tomentosum*, and *H. villosum*.

Smitinand (1980) listed 8 taxa in his “Plant Checklist of Thailand”, including *H. bousigonianum*, *H. coccineum* var. *angustifolium*, *H. coronarium*, *H. ellipticum*, *H. flavum*, *H. longicornutum*, *H. stenopetalum* and *H. villosum*.

Sirirugsa & Larsen (1995) reported 17 species (with one unknown taxon) for Thailand: *H. aureum*, *H. biflorum*, *H. coccineum*, *H. collinum*, *H. coronarium*, *H. ellipticum*, *H. flavescens*, *H. forrestii*, *H. gardnerianum*, *H. gomezianum*, *H. griffithianum*, *H. longicornutum*, *H. samuiense*, *H. speciosum*, *H. stenopetalum*, *H. tomentosum*, and *H. villosum*.

The Forest Herbarium (2001) listed 10 species, i.e. *H. bousigonianum*, *H. coccineum*, *H. coronarium*, *H. ellipticum*, *H. flavum*, *H. longicornutum*, *H. samuiense*, *H. stenopetalum*, *H. tomentosum* and *H. villosum*.

Picheansoonthon and Mookamul (2005) added 2 new species, *H. khaomaenense* from Southern and *H. thaianum* from northern Thailand.

Larsen & Larsen (2006) listed 22 species for Thailand, some with illustrations: *H. aureum*, *H. biflorum*, *H. coccineum*, *H. collinum*, *H. coronarium*, *H. densiflorum*, *H. ellipticum*, *H. flavescens*, *H. flavum*, *H. forrestii*, *H. gardnerianum*, *H. gomezianum*, *H. gracile*, *H. griffithianum*, *H. hirsutissimum*, *H. longicornutum*, *H. samuiense*, *H. speciosum*, *H. spicatum*, *H. stenopetalum*, *H. tomentosum* and *H. villosum*.

Kittipanangkul and Ngamriabsakul (2008) studied diversity of Zingiberaceae in Khao Nan and Khao Luang National Parks, southern Thailand. They found 1 species of *Hedychium*, *H. khaomaenense*.

Picheansoonthon and Wongsuwan (2008) preliminary listed 22 species and 2 varieties: *H. aureum*, *H. biflorum*, *H. coccineum*, *H. collinum*, *H. coronarium*, *H. coronarium* var. *chrysoleucum*, *H. ellipticum*, *H. flavescens*, *H. forrestii*, *H. gardnerianum*, *H. gomezianum*, *H. griffithianum*, *H. khaomaenense*, *H. longicornutum*, *H. malayanum*, *H. samuiense*, *H. speciosum*, *H. spicatum*, *H. spicatum* var. *acuminatum*, *H. stenopetalum*, *H. thaianum*, *H. tomentosum* and *H. villosum*. In their list, a Malayan taxon, *H. malayanum*, was newly recorded for Thailand. In 2009, they added 2 new species, *H. muanwongyathiae* from northern Thailand and *H. phuluangense* from northeastern Thailand.

Molecular history of the genus *Hedychium*

Wood, Whitten and Williams (2000) studied phylogenetic of *Hedychium* and related genera (Zingiberaceae) based on sequenced data of ITS1, ITS2 and 5.8S rDNA from 29 species, one interspecific hybrid of *Hedychium* and one species in each of 16 other genera within 4 tribe, Hedychieae, Globbeae, Zingibereae and Alpinieae. They proposed 4 major clades of *Hedychium*, distinguishable on the basis of the number of flowers per bract and their distribution. The first clade, based on 1 or 2 flowers per bract and occur only in southern Vietnam, the Malay Peninsula and Oceania, the second clade, only 1 flower per bract, the third clade, uncertain but within *H. acuminatum*, and fourth clade, 3-5 flowers per bract. Cladistic analysis concluded that the genus *Hedychium* is monophyletic, but the relationships to other genera were poorly supported in their research.

Kress, Prince and Williams (2002) proposed a new classification of Zingiberaceae, based on molecular studies, DNA sequences of the nuclear internal transcribed spacer (ITS) and plastid *matK* regions. Four subfamilies and 4 tribes, Zingiberoideae (Zingibereae and Globbeae), Alpinoideae (Alpinieae and Riedelieae), Tamijioideae (Tamijieae) and Siphnochiloideae (Siphonochileae) were recognized as shown in Table 2.1 and Table 2.2. Moreover, in this study the currently accepted classifications of the Zingiberaceae based on both vegetative and floral characteristics are shown in Table 2.3.

From previous molecular studied, only a few species of *Hedychium* from Thailand were represented. The phylogenetic relationship of the Thai taxa is, therefore poorly known.

Table 2.1 Placement of genera in the new classification of the family Zingiberaceae. (Asterisks indicate taxa not sampled in the molecular phylogenetic analyses; these genera are tentatively placed based on morphological features).

Subfamily Siphonochiloideae W. J. Kress	Subfamily Tamijioideae W. J. Kress	Subfamily Alpinioideae Link	Subfamily Zingiberoideae Haask.
Tribe Siphonochileae W. J. Kress <i>Siphonochilus</i>	Tribe Tamijieae W. J. Kress <i>Tamijia</i>	Tribe Alpinieae A. Rich. <i>Aframomum</i> <i>Alpinia</i> <i>Amomum</i> <i>*Aulotandra</i> <i>*Cyphostigma</i> <i>*Elettaria</i> <i>Elettariopsis</i> <i>Etlingera</i> <i>*Geocharis</i> <i>*Geostachys</i> <i>Hornstedtia</i> <i>*Leptosolena</i> <i>Paramomum</i> <i>Plagiostachys</i> <i>Renealmia</i> <i>Vanoverberghia</i> Tribe Riedelieae W. J. Kress <i>Burbidgea</i> <i>Pleuranthodium</i> <i>Riedelia</i> <i>Siamanthus</i> Incertae Sedis <i>Siliquamomum</i>	Tribe Zingibereae Meisn. <i>Boesenbergia</i> <i>Camptandra</i> <i>Cautleya</i> <i>Cornukaempferia</i> <i>Curcuma</i> <i>Curcumorpha</i> <i>Distichochlamys</i> <i>Haniffia</i> <i>*Haplochorema</i> <i>Hedychium</i> <i>Hitchenia</i> <i>Kaempferia</i> <i>*Laosanthus</i> <i>*Nanochilus</i> <i>*Paracautleya</i> <i>*Parakaempferia</i> <i>Pommereschea</i> <i>Pyrgophyllum</i> <i>Rhynchanthus</i> <i>Roscoea</i> <i>Scaphochlamys</i> <i>Smithatris</i> <i>*Stadiochilus</i> <i>Stahlianthus</i> <i>Zingiber</i> Tribe Globbeae Meisn. <i>Gagnepainia</i> <i>Globba</i> <i>Hemiorchis</i> <i>Mantisia</i> Incertae Sedis <i>Caulokaempferia</i>

Table 2.2 Characteristics of the subfamilies and tribes of the new classification of the Zingiberaceae (Burt, 1972; Burt and Smith, 1972; Larsen et al., 1998; Sakai and Nagamasu, 2000; W. J. Kress, personal observation). Some nondiagnostic features are included as a reference to the previous classification (see Table 2.3).

Character	Subfamilies and Tribes					
	Splachnaceae Sphumochitaceae	Tamniaceae Tanjaceae	Almaceae Redefaceae	Almaceae Almaceae	Zingiberoideae Zingiberoideae	Zingiberoideae Globaceae
1) Seasonality	dormancy period	evergreen	evergreen	evergreen	dormancy period	dormancy period
2) Rhizomes	fleshy	fibrous	fibrous	fibrous	fleshy	fleshy
3) Plane of distichy of leaves	perpendicular to rhizome	perpendicular to rhizome	perpendicular to rhizome	perpendicular to rhizome	parallel to rhizome	parallel to rhizome
4) Extrafloral nectaries	absent	absent	present on leaf blades	absent	absent	absent
5) Lateral stamnodes	petaloid, fused to labellum	petaloid, fused to labellum	small or absent, never petaloid	small or absent, never petaloid	petaloid, free from or fused to labellum	petaloid, free from labellum and sometimes connate to filament
6) Labellum	not connate to filament	not connate to filament	not connate to filament	not connate to filament	not connate to filament	connate to filament in slender tube
7) Filament	short	short	medium	medium, sometimes arching	short to long	short to long, sometimes arching
8) Anther crest	petaloid	petaloid	petaloid or absent	petaloid or absent	absent, petaloid, or well-developed and wrapped around style	spurred or absent
9) Ovary	3-locular (sometimes incompletely so)	1-locular	1- or 3-locular	3-locular	3-locular (sometimes incompletely so)	1-locular
10) Placentation	axial	parietal	axial or parietal	axial or free central	axial, basal, or free columnar	parietal
11) Capsule	fleshy	unknown	siliqua-like, opening by longitudinal slits	indehiscent or fleshy	fleshy and dehiscent	globbose and dehiscent

Table 2.3 Characteristics and genera of the previously recognized tribes of the Zingiberaceae (after Schumann, 1904; Holtum, 1950; Burt and Smith, 1972; Larsen et al., 1998. Authorities follow Reveal (2002).

Character	Alpinace A. Rich. (1841)	Hedycheie Horan. (1862)	Globoace Meisn. (1842)	Zingibereae Meisn. (1842)
1) Plane of distichy of leaves	perpendicular to rhizome	parallel to rhizome	parallel to rhizome	parallel to rhizome
2) Lateral staminodes	small or absent, never petaloid	petaloid, free from labellum	petaloid, free from labellum and sometimes connate to filament long with arching filament	petaloid, fused to labellum
3) Labellum	not connate to filament	not connate to filament	connate to filament in slender tube	not connate to filament
4) Stamen	medium length	short length	long with arching filament	anther crest elongated and wrapped around style
5) Ovary	3-locular (sometimes incompletely so)	3-locular (sometimes incompletely so)	1-locular	3-locular
6) Placentation	axial or free central	axial, basal, or free columnar	parietal	axial
7) Style	not exerted beyond anther sacs	not exerted beyond anther sacs	not exerted beyond anther sacs	exserted beyond anther sacs
8) Stigma	expanded	expanded	not expanded	not expanded
9) Placement of genera ^a	<i>Aframomum</i> (50) <i>Alpinia</i> (225) <i>Anomum</i> (150) <i>Aulotandra</i> (6) <i>Buribidga</i> (8) <i>Cyphostigma</i> (1) <i>Elektaria</i> (6) <i>Elektariopsis</i> (10) <i>Etilingera</i> (70) <i>Geocharis</i> (7) <i>Geostachys</i> (18) <i>Hornstedtia</i> (50) <i>Leptosolena</i> (1) <i>Nanochilus</i> (1) <i>Paramomum</i> (1) <i>Plagiosiachys</i> (20) <i>Pleuranthodium</i> (25) <i>Pommereschea</i> (2) <i>Renalmia</i> (75) <i>Rhynchanthus</i> (6) <i>Riedelia</i> (60) <i>Siamanthus</i> (1) <i>Stadiichilus</i> (1) <i>Tamijia</i> (1) <i>Vanoverberghia</i> (1)	<i>Boesenbergia</i> (60) <i>Camptandra</i> (4) <i>Caulokaempferia</i> (10) <i>Caulleya</i> (2) <i>Cornukaempferia</i> (2) <i>Curcuma</i> (50) <i>Curcumomorpha</i> (1) <i>Distichocheilamys</i> (3) <i>Haniffia</i> (2) <i>Haplochorema</i> (4) <i>Hedychium</i> (50) <i>Hitchenia</i> (3) <i>Kaempferia</i> (40) <i>Laosanthus</i> (1) <i>Paracaulleya</i> (1) <i>Parakaempferia</i> (1) <i>Pyrogophyllum</i> (1) <i>Roscoeia</i> (17) <i>Scaphochlamys</i> (30) <i>Siliquamomum</i> (1) <i>Siphonochilus</i> (15) <i>Smithatris</i> (2) <i>Stahlanthus</i> (7)	<i>Globba</i> (100) <i>Hemiorchis</i> (3) <i>Mantisia</i> (4) <i>Gagnepainia</i> (3)	<i>Zingiber</i> (100)

^a Placement according to references cited above. Number of species follows each genus.

