Natural Product Sciences
1(1) : 86 ~ 98 (1995)

A Chemotaxonomic Study on Euphorbiaceae in Korea

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Abstract—A chemosystematic study on euphorbiaceous plants in Korea has been performed by using phenolic constituents. The phenolic characteristics of subfamilies, genera and species were well distinguished from one another. Hydrolyzable tannins as constituents were considered to be a valuable taxonomic character in elucidating systematic relationships among the related taxa whereas flavonoids could be used in the classification of infraspecific taxa in this family. The phenolic fingerprints of each of the plants would be considered as a good tool to identify the species. In comparison with the morphological classification system, the chemical relationship supported the subfamilial system of Webster (1975) and the further division of *Euphorbia sensu lato* by Hurusawa (1954).

Keywords—Chemosystematic study · Euphorbiaceae · Hydrolyzable tannin · Flavonoid, Phenolic fingerprint

Introduction

The Euphorbiaceae, a large family of 300 genera and 7500 species, is abundant in the tropics and subtropics (Cronquist, 1981). The plants in this family are very diverse in their morphology and chemical constituents, and thus much disagreement still remains with respect to their ranks, delimitation and systematic relationships (Webster, 1967; William *et al.*, 1982). Many plants including *Mallotus japonicus, Euphorbia pekinensis* and *Securinega suffruticosa* in this family are frequently used as medicinal crude drugs in traditional Korean prescriptions.

Approximately 10 genera and about 30 species of euphorbiaceous plants are distributed in Korea. Some descriptive works of Korean species were conducted by several authors (Komarove, 1905; Nakai, 1952; Park, 1949, 1974). Two intensive studies about eastern asian species were made by Hurusawa (1940, 1954), and he described twelve new species endemic to Korea, but description of Korean Euphorbiaceae is very different according to the authors as shown in table below.

Descriptions of euphorbiaceous species in Korea by several authors

Author	Spesice number of Euphorbiaceae	Spesice number of genus *Euphorbia*
Hurusawa (1954)	34	22
Nakai (1952)	25	18
Park (1949)	39	22
Chung (1954)	21	11
Lee (1979)	21	10

It appears that the reason why the description is so different according to authors is due to the variability of this family, especially in the genus *Euphorbia*.

Chemotaxonomic studies are potent tools to

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elucidate the systematic relationships of the closely related taxa (Gershenzon *et al.*, 1983). Especially two-dimensional chromatographic analysis of plant phenolic extracts has proved to be an invaluable aid in the delineation of metabolic patterns of phenolics in plant kingdom (Haslam, 1982). Therefore, in this study, we compared phenolic fingerprints of euphorbiaceous plants by 2D-TLC.

Among the phenolic compounds, flavonoids have been widely studied and recognized as useful taxonomic characters at infraspecific and infrageneric levels due to their structural diversity, chemical stability and easy identification (Harbone *et al.*, 1971). Hydrolyzable tannins also appear to be a valuable class of compounds in establishing the systematic and evolutionary relationships because their structures are very differentiated and their distribution is restricted to some taxa of dicotyledon, except Magnoliideae (Bate Smith, 1973; Okuda *et al.*, 1993). Thus we have tried chemosystematic interpretation of this family based mainly on the hydrolyzable tannins among their constituents.

Experimental

Materials and instruments - Aerial parts of 23 euphorbiaceous plants distributed or cultivated in Korea were collected from 1990 to 1993 at the flowering times. Especially *Euphorbia ebracteolata* was collected from Korea, China and Japan (Table 1). Voucher specimens are deposited at this laboratory.

Two-dimensional thin layer chromatography was performed using precoated cellulose F254 plates with 2% AcOH and SBA (s-butanol-AcOH-water=14:1:4, v/v) as the developing solvent.

Methods - Plants collected were air-dried quickly. Dried leaves were extracted two times with 70% acetone at room temperature respectively, and the combined extracts were evaporated to give dark brown precipitates, which were removed by filtration. The filtrates were evaporated to dryness. The dried extracts were dissolved in acetone-MeOH-H_2O (8:1:1) with concentration of dry plant materials 1g/ml. Only the soluble parts of the extracts were taken because they mainly contained flavonoids, hydrolyzable tannins and other phenolic compounds.

Ten μl of the soluble part of each extract was applied on the cellulose plate (15cmx15cm) and developed with SBA and then 2% AcOH in two directions to get fingerprint of each plant. Each spot of the fingerprints was identified by comparison with authentic samples that were obtained beforehand by the columnchromatography of aqueous acetone extracts of E. pekinensis (Ahn 1995a), *E. ebracteolata* (Ahn *et al.*, 1992, 1995b, 1995c; Lee *et al.*, 1992), Securinega suffruticosa (Lee *et al.*, 1994, 1995) and Acalypha australis (Park *et al.*, 1993) and *E. helioscopia* (Lee *et al.*, 1990).

Results and discussion

Phenolic characteristics of subfamilies, genera, subsections and species were well distinguished from one another as shown in Table 2. By using this chemotaxonomic data, we discussed Hurusawa (1954) and Webster (1975) systems (Table 5 and Table 6) which were established on the basis of morphological features.

Chemical characteristics of each taxon

Daphniphyllum

Daphniphyllum has been classified as Euphorbiaceae by Baillon (1858) and Bentham & Hooker (1883). In the present study this taxon did not contain hydrolyzable tannins (Table 2 and Table 4). The genus was reported to contain iridoidal components which are not present in other euphorbiaceous plants (Gershenzon *et al.*, 1983). These favor Hurusawa's treatment, in which *Daphniphyllum* was separated as distinct family, Daphniphyllaceae in *Daphniphyllales*.

Table 1. Collection data of materials under study.

Scientific name (Abbrev.)	Locality and Date
Daphniphyllum macropodum (DM)	Cheju-do (1990.5.23)
D. glaucescens (DG)	Cheju-do (1990.5.23)
Euphorbia pekinensis (EPS)	Sobaeksan (1990.5.20)
	Chungbuk Univ. (1993.4.15)
(EPK)	Keoje-do (1993.5.30)
(EPJ)	Jeonju (1993.7.30)
E. fauriei (EF)	Cheju-do (1993.5.28)
E. ebracteolata (EEY)	Baekyangsan (1990.3.15)
(EEB)	(1991.5.15, 1993.4.28)
(EEP)	Poong-do(1990.4.9, 1992.4.25)
(EEO)	Okcheon (1990.4.19, 1992.5.24)
(EEO)	Chungbuk Univ. (1993.3.15, 1993.4.17, 1993.5.10)
(EEC)	Beijing, China (1992.6.25)*
(EEJ)	Mieken, Japan (1992.4.10, 20)*
E. jolkini (EJ)	Cheju-do (1993.5.28)
E. lathylis (EL)	Chungbuk Univ. (1990.7.12)
E. sieboldiana (EBK)	Kyeryongsan (1990.6.6)
(EBG)	Gochang (1993.7.13)
(EBC)	Chiaksan (1993.9.11)
E. esula (ES)	Cheju-do (1990.5.23)
E. helioscopia (EH)	Kobe,Japan (1990.4.30)*
E. humifusa (EUJ)	Kobe,Japan (1990.9.21)*
(EUS)	Sobaeksan (1993.8.3)
E. supina (EN)	Cheongju (1993.7.17)
E. maculata (EMS)	Sobaeksan (1991.8.3)
(EMJ)	Kobe,Japan (1990.9.13)*
Sapium japonicum (SJ)	Cheju-do (1990.5.22) (1993.6.10)
S. sebiferum (SE)	Kwangyang (1990.9.23)
Securinega suffruticosa (SS)	Cheongju (1990.6.20)
Phyllanthus ussuriensis (PSC)	Cheungju (1990.7.30)
(PSJ)	Kobe, Japan (1990.9.6)*
P. urinaria (PRJ)	Kobe, Japan (1990.9.25)*
Ricinus communis (RC)	Cheongju (1990.7.17)
Mallotus japonicus (MJ)	Cheju-do (1990.5.22)
Mercurialis leiocarpa (ML)	Cheju-do (1991.4.23)
Acalypha australis (AA)	Cheongju (1991.7.18)
Aleurites fordii (AF)	Kwangyang (1991.5.23)

*Taken from the specimens of Herbarium of College of Pharmacy, Chungbuk National University.

Euphorbia sensu lato

Both genus *Chamaesyce sensu* Hurusawa (EMJ, EMS, EUJ, EUS) and Galarhoeus sensu Hurusawa except ES, EB, EL (EEP, EEB, EEO, EEC, EEJ, EPS, EPK, EPJ, EF, EJ, EH) contain hydrolyzable tannins (Table 2). By the way, Chamaesyce contains *O*-glycosidic ellagitannins and *C*-glycosidic

Table 2. Distribution of phenolic constituents in Korean euphorbiaceous plants identified in the present study.

Spot no.*	Plants																														
	DM	DG	EL	EB	ES	EEP	EEB	EEO	EEC	EEJ	EPS	EPJ	EPK	EF	EJ	EH	SJ	SE	EMJ	EMS	EUJ	EUS	EN	AA	ML	MJ	AF	RC	PSJ	PSC	PRJ	SS
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																						+										
29						+	+	+	+	+	+	+	+	+	+	+	+	+	+	+		+	+	+		+	+	+	+	+	+	+

Table 2. Continued

Spot no.*	Plants																														
	DM	DG	EL	EB	ES	EEP	EEB	EEO	EEC	EEJ	EPS	EPJ	EPK	EF	EJ	EH	SJ	SE	EMJ	EMS	EUJ	EUS	EN	AA	ML	MJ	AF	RC	PSJ	PSC	PRJ	SS
30															+	+					+											
31														+		+																+
32																				+	+										
33					+	+	+	+	+	+	+	+	+	+	+	+			+	+	+	+	+									
34																			+				+									
35																			+	+												
36																			+				+									
37																			+	+		+	+									
38																		+	+	+			+	+				+				
A1																											+					
E1					+	+	+	+	+	+	+	+		+			+	+										+				
J1																	+															
J2																	+															
K1													+																			
S1																																
W1												+																				
W2												+																				

*The structure of each compound is described in Table 5.

A1, J1, J2, K1, S1, W1, W2: Flavonoids whose structures could not be identified.

E1: Hydrolyzable tannin whose structures could not be identified.

Abbreviations: See Table 1.

Table 3. Thirty eight compounds identified in this study.

Spot no.	Class	Compound
1	Phenol carboxylic acids	protocatechuic acid
2		caffeic acid
3		gallic acid
4		gallic acid 3-*O*-β-D-(6-*O*-galloyl)-glucoside
5		brevifolin carboxylic acid
6	Caffeoyl quinic acids	5-caffeoyl quinic acid
7		chlorogenic acid
8	Bergenin derivatives	norbergenin
9		bergenin
10		4-*O*-galloyl norbergenin
11		11-*O*-galloyl norbergenin
12	Flavonoids	isoquercitrin
13		quercitrin
14		kaempferol-3-*O*-rhamnoside
15		kaempferol-3-O-rutinoside
16		rutin
17		astragalin-2"-*O*-gallate
18		isoquercitrin-2"-*O*-gallate
19		rutin-2"-*O*-gallate
20	Gallotannins	glucogallin
21		3-*O*-galloyl quinic acid
22		3-*O*-galloyl shikimic acid
23		2,3-di-*O*-galloyl glucose
24		1,3,4,6-tetra-*O*-galloyl-β-D-glucose
25		1,2,3,4,6-penta-*O*-galloyl-β-D-glucose
26	*C*-Glycosidic ellagitannins	monomers casuariin
27	*O*-Glycosidic ellagitannins	monomers corilagin
28		carpinusin
29		geraniin
30		helioscopinin A
31		helioscopinin B
32		pedunculagin
33	*O*-Glycosidic ellagitannins dimers	euphorbin A
34		euphorbin B
35		euphorbin D
36		rugosin E
37		excoecarianin
38	Other tannins	furosin

ellagitannin, casuariin (spot no. 26), and pedunculagin (spot no. 32) which is the precursor of casuariin (Hanato *et al.*, 1986), whereas Galarhoeus only contains *O*-glycosidic ellagitannins (spot no. 27-31). Casuariin and pedunculagin was also reported from *E. thi...* *fo...a* by Lee *et al.* (1990a). Furthermore, 3-galloylquinic acid (spot no. 21), 3-galloylshikimic acid (spot no. 22) and caffeoylquinic acids (spot no. 5, 6) are lacking in *Chamaesyce* while *Galarhoeus* produces them all (Table 2 and Table 4). These results favor the division of *Euphorbia sensu* lato into *Chamaesyce* and *Galarhoeus* (Table 5 and Table 6).

Table 4. Symplified distibution table of phenolics in Korean euphorbiaceous plants detected in this study.

Species	3-Galloyl-quinic acid	3-Galloyl-shikimic acid	Galloyl-glucoses	Monomeric C-glycosidic-	ellagitannins O-glycosidic-	Dimeric ellagitannins	Bergenins	Flavan-3-ols	Caffeoyl quinic acids	Flavonoids	Flavonoid gallates
Daphniphyllum macropodum										+	
D. glaucescens										+	
Euphorbia lathylis									++	+	
E. sieboldiana									++	+	
E. esula									++	+	
E. pekinensis	+	+	+++		+++	+			+	++	+++
E. fauriei	+	++	+++		+++	+			+	++	+++
E. ebracteolata	+	++	+++		+++	+			+	+	++
E. jokini	+	+	+++		+++	+			+	+	++
E. helioscopia	+	+	+++		+++	+			+	+	++
E. humifusa			+++	+	+++	+				+	+
E. supina			+++		++	++				+	+
E. maculata			+++	+	+++	++				+	
Sapium japonicum			++		++				+	+	
S. sebiferum			+++		+++				+	+	++
Ricinus communis			++		++					+	
Mallotus japonicus			+		++		+++	+		+	
Acalypha australis			++		++					+	
Aleurites fordii			++		++					+	
Mercurialis leiocarpa											
Securinega suffruticosa			+		++		+++	+		+	
Phyllanthus ussuriensis			++		++		+		+	+	
Phyllanthus urinaria			++		++					+	

Table 5. Classification of Euphorbiaceae in Korea according to the Hurusawa system.

Species	Subsection	Section	Genus	Subfamily	Family
Daphniphyllum macropodum			*Daphniphyllum*	-	Daphniphyllaceae
D. glaucescens			"	-	"
*Euphorbia lathylis**		*Deccusatae*	*Galarhoeus*	Euphorbioideae	Euphorbiaceae
E. sieboldiana	*Esula*	*Tithymalus*	"	"	"
E. esula	"	"	"	"	"
E. pekinensis	*Galarhoei*	"	"	"	"
E. fauriei	"	"	"	"	"
E. ebracteolata	"	"	"	"	"
E. jolkini	"	"	"	"	"
E. fischeriana var. pilosa	*Verticillatae*	"	"	"	"
E. helioscopia		*Helioscopiae*	"	"	"
E. humifusa			*Chamaesyce*	"	"
*E. supina**			"	"	"
*E. maculata**			"	"	"
Sapium japonicum			*Triadica*	Sapioideae	"
*S. sebiferum**			*Shirakia*	"	"
*Ricinus communis**			*Ricinus*	Acalyphoideae	"
Mallotus japonicus			*Mallotus*	"	"
Mercurialis leiocarpa			*Mercurialis*	"	"
Acalypha australis			*Acalypha*	"	"
*Aleurites fordii**			*Aleurites*	"	"
Securinega suffruticosa			*Securinega*	Phyllanthoideae	Antidesmataceae
Phyllanthus ussuriensis			*Phyllanthus*	"	"
P. urinaria			"	"	"

* These plants are not Korean native but widely propagated or cultivated.

Table 6. Subfamilial classification of Euphorbiaceae in Korea according to the Webster system.

Family	Subfamily	Genus
Euphorbiaceae	Euphorbioideae	*Euphorbia*
		Sapium
		Chamaesyce
	Acalyphoideae	*Acalypha*
		Ricinus
		Mercurialis
		Mallotus
	Crotonoideae	*Aleurites*
	Phyllanthoideae	*Securinega*
		Phyllanthus

However, *E. esula* (ES), *E. sieboldiana* (EB) and *E. lathylis* (EL) which have cyathiums with crescent-shaped glands (projected on each side) are lacking hydrolyzable tannins, but *E. ebracteolata* (EEP, EEB, EEO, EEC, EEJ), *E. pekinensis* (EPS, EPK, EPJ), *E. fauriei* (EF), *E. jolkinii* (EJ), *E. helioscopia* (EH) which have cyathiums with half moon-shaped glands contain a lot of hydrolyzable tannins (Table 2 and Table 4). This is a very interesting and important observation that shows clear coincidence between chemical and morphological features, consequently the shape of glands seems very important character in taxonmy of genus *Euphorbia*. On the other hand, *E. pekinensis* (EP) and *E. ebracteolata* (EE) showed very intimate affinities in their tannin patterns revealing the close relationship between two taxa (Table 2).

Sect. *Helioscopiae sensu* Hurusawa, which is biennial without rhizomes, contains hydrolyzable tannins possessing galactoses as their sugar moieties (Lee *et al.*, 1989) whereas Sect. *Tithymalus sensu* Hurusawa, which is perennial with rhizomes, contains hydrolyzable tannins possessing only glucoses as their sugar moieties (Ahn *et al.*, 1992, 1995a, 1995b, 1995c, Lee *et al.*, 1991). Moreover, *E. helioscopia* (EH) contains helioscopins A and B, which have not been found in other Euphorbia species (Ahn *et al.*, 1992, 1995a, 1995b, 1995c, Lee *et al.*, 1990b). Therefore, chemical characteristics of this taxon was distinguished from other taxa of *Euphorbia* as well as in the case of morphological characters.

Sapium

Sapium sebiferum (SE) and *S. japonicum* (SJ) also contain large amounts of hydrolyzable tannins and flavonoid gallates (spot no. 17, 18, 19) which are not contained in other genus except Galarhoeus and Chamaesyce (Table 2 and Table 4). And their tannin patterns show intimate affinities with *E. ebracteolata* and *E. pekinensis* in Galarhoeus (Fig. 1). Moreover, they do not contain bergenins which are the main compenents of *Malotus* in Acalyphoideae and *Securinega* in Phyllanthoideae. *Sapium*, *Chamaesyce* and *Galarhoeus* were placed in different tribes or subfamilies by Bentham & Hooker (1883) and Hurusawa (1954), but in the same subfamily, Euphorbioideae, by Webster (1975). Chemotaxonomic patterns in this support the classification by Webster (1975) (Table 6).

Mallotus, *Mercurialis*, *Acalypha* and *Aleurites*

These genera were classified as Acalyphoideae by Hurusawa (1954). Each of the genera was well distinguished from one another in their chemical constituents although limited species were investigated (Table 2 and Table 4). *Mallotus japonicus* (MJ) has been reported to contain condensed tannins, bergenins and flavan-3-ols (Saijo *et al.*, 1989). However, the other genera did not contain bergenins and flavan-3-ols (Table 2 and Table 4). No hydrolyzable tannins andphenolics were detected from *Mercurialis leiocarpa* (ML) in this experimental condition (Table 2 and Table 4). And only *Aleurites fordii* (AF) has been reported to contain very rare hydrolyzable tannins possessing a cyanogenic glycoside core, aleurinins A and B, and related glycosidic ellagitannin, aleurinin C (Nonaka *et al.*, 1990), which are plausibly derived from valine or isoleucine precurser. Valine or isoleucine derived cyanogenic compounds are the characteristic of subfamily Crotonoideae (Seigler,

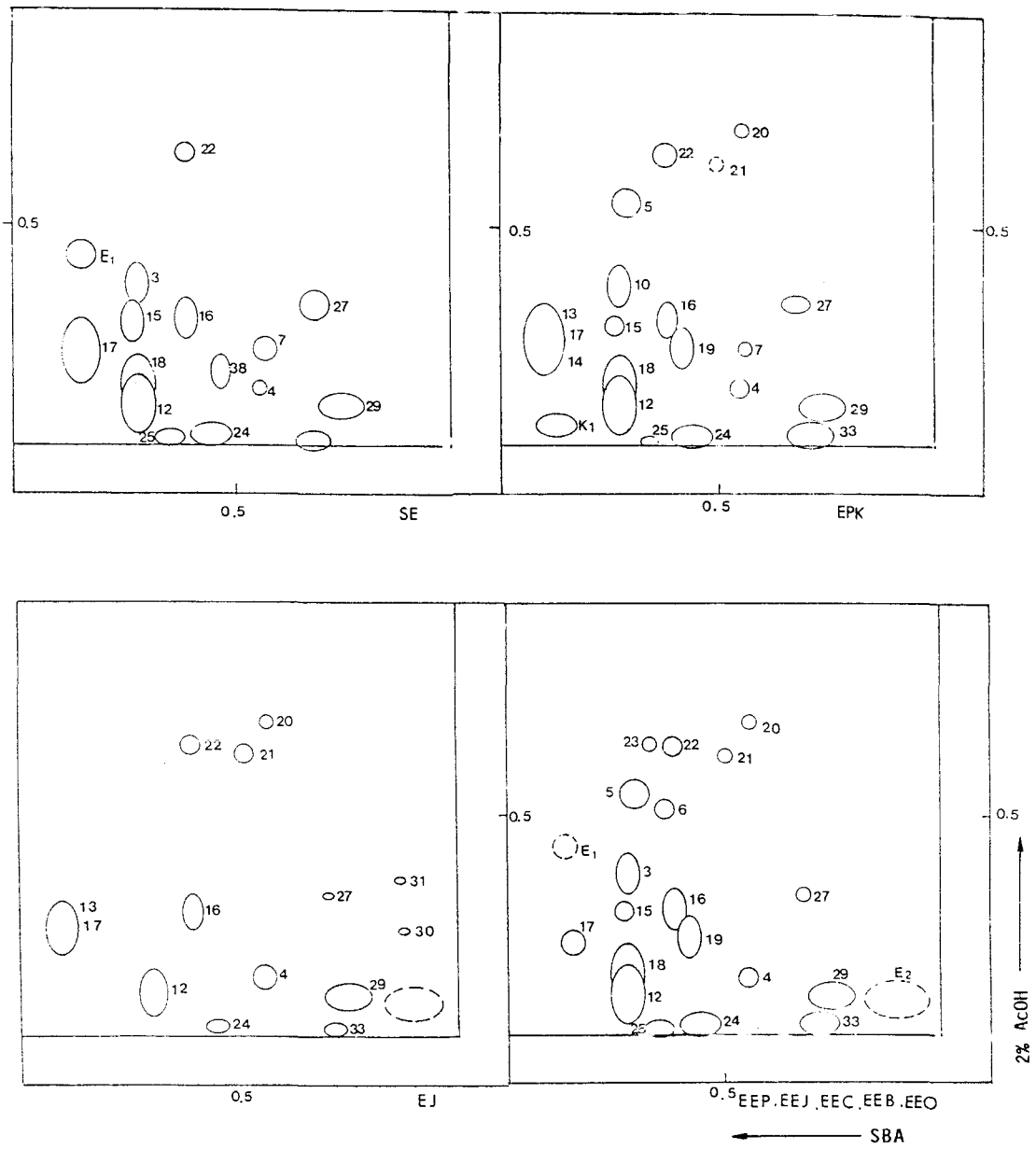

Fig. 1. Two-dimensional TLC of phenolic fractions of SE, EPK, EJ, EEP, EEJ, EEC, EEO and EEB.

1994). Consequently, *Aleurites* seems to be classified as Crotonoideae instead of Acalyphoideae. This observation supports Webster (1975) who placed *Aleurites* in Crotonoideae instead of Acalyphoideae (Table 6). On the other hand, isolation of caffeic acid, protocatechuic acid and gallic acid from *Acalypha australis* (Park *et al.*, 1993) (Table 2) confirmed the biogenetic pathway to gallic acid that had been proposed by Neish and Towers (1964) (Fig. 2). They had formulated a pathway from dehydroshikimic acid to caffeic acid followed by -oxidation to protocatechuic acid which is then further hydroxylated to give gal-

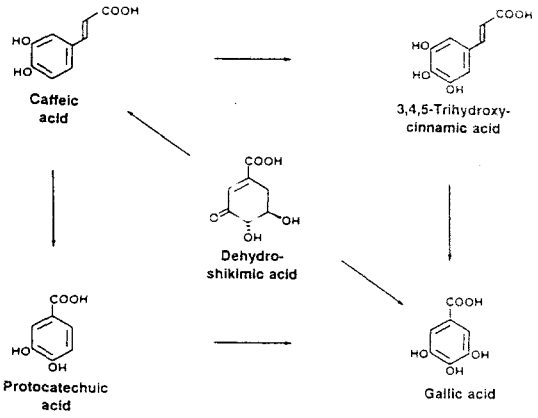

Fig. 2. Proposed biosynthetic pathways to gallic acid

lic acid.

Phyllanthus and *Securinega*

These taxa were classified as Phyllanthoideae in Antidesmataceae by Hurusawa (1954) on account of their having two ovules in each carpel, whereas other genera of Euphorbiaceae have one ovule in each carpel. Furthermore, these taxa are lacking latex tubes and most of them are woody as a rule, whereas most of the Euphorbioideae plants are herby and flesh and secrete latexes from their latex tubes when wounded.

Hydrolyzable tannins and other phenolics also have been detected in these taxa. Bergenin (spot no. 9) was detected in *Phyllanthus ussuriensis* (PSJ) (Table 2 and Table 4), and its isolation from *Phyllanthus flexuosus* was recently reported (Yoshida *et al.*, 1992). Flavan-3-ols such as (+)-catechin, (+)-gallocatechin and (-)-epicathechin have been isolated from the cultured root of *Phyllanthus niruri* (Ishimura *et al.*, 1992). Hydrolyzable tannins, flavan-3-ols and bergenins are also produced in *Securinega suffruticosa* (SS) (Lee *et al.*, 1994).

In summary, both *Phyllanthus* and *Securinega* produce hydrolyzable tannins, bergenins and flavan-3-ols. In addition, both genera also produce securinine alkaloids (Horii *et al.*, 1965; Shabana *et al.*, 1979), which are not contained in other subfamilies. So the current chemical analysis way suggests the allied relationship between two genera.

Geographic variations of *E. pekinensis*, *E. ebracteolata* and *E. sieboldiana* - Genus *Euphorbia*, especially *E. pekinensis*, is variable according to the regions. Therefore, new species or varieties were described by Hurusawa (1945, 1954) as already mentioned previously, and they have caused difficulty and confusion to the taxonomists engaged in the classification of the family. Thus we examined phenolic patterns of three populations of *E. pekinensis* (EPK, EPS, EPJ) that showed significant variation. Exomorphologically one of them was very similar to *E. jolkini* (EJ), but their fingerprints of hydrolyzable tannins were by no means similar (Fig. 1). The three localities of *E. pekinensis* were very similar in their fingerprints of hydrolyzable tannins and related compounds (spot no. 4, 5, 20, 21, 22, 24, 27, 29, 33, E1) but different from one another in those of flavonoids (spot no. 12, 16, 18, 19, K_1, W_1, W_2) (Table 2). On the other hand, *E. fauriei* (EF) which grows at Mt. Halla is very small (hight: 10-15cm) than *E. pekinensis* (hight: 50-100cm). However, it shows a very similar fingerprint as *E. pekinensis*, except that it has helioscopinin B (spot no. 31) (Table 2). Thus chemical characteristic favor the classification by Hurusawa (1954), *E. pekinensis* var. fauriei, rather than *E. fauriei* in treatment of EF. Therefore fingerprints of hydrolyzable tannins would be considered as a good tools for the identification of *Euphorbia* species, and those of the flavonoids as an important marker for classification of regional varieties of *E. pekinensis*.

On the other hand, the localities of *E. sieboldiana* (EBK, EBG, EBC) and *E. ebracteolata* (EEP, EEJ, EEC, EEB, EEO), did not show significant morphological variations, and phenolic patterns of *E. sieboldiana* (EB) and *E. ebracteolata* (EEP, EEJ, EEC, EEB, EEO) were almost the same, respectively (Table 2).

Considering our results described so far,

phenolic fingerprints and morphological features are compatible with each other, and thus phenolic fingerprints taken from 2D-TLC would be considered as a potent tools to identify the species. Among phenolics, hydrlyzable tannins seem to be applied for the classification of wide range levels of taxonomic hierarchy (e.g. subsection, section, genus, subfamily), and flavonoids appeaer to be a valuable character for the classification of *E. pekinensis* at infraspecific level.

We tried to discuss chemotaxonomy of Euphorbiaceae using restricted species in Korea with pitfalls and difficulty. And we hope chemotaxonomy will be increasingly useful for the establishment of a natural classification of this enigmatic family.

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(Accepted 5 December 1995)