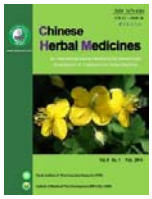


Available online at SciVarse ScienceDirect

Chinese Herbal Medicines (CHM)

ISSN 1674-6384

Journal homepage: www.tiprpress.com E-mail: chm@tiprpress.com

Review

Chemical Constituents of Plants from Tribe Chelidonieae and their Bioactivities

Qi-fang Lei, Xiao-ling Zhao, Li-jia Xu, Yong Peng, Pei-gen Xiao*

Institute of Medicinal Plant Development, Chinese Academy of Medical Science, Peking Union Medical College, Beijing 100193, China

ARTICLE INFO

Article history

Received: October 2, 2013

Revised: November 30, 2013

Accepted: December 16, 2013

Available online:

January 24, 2014

DOI:

10.1016/S1674-6384(14)60001-0

ABSTRACT

The tribe Chelidonieae comprises 23 species of eight genera with an extensive distribution and a long medicinal usage history both in China and Western countries. A large number of chemical constituents have been isolated and identified from the species in tribe Chelidonieae, such as alkaloids, organic acids, and their derivatives, aromatics, triterpenoids, sterols, essential oils, and proteins, most of which possess a variety of bioactivities, especially for the antibacterial, anti-inflammation, antitumor, analgesia, anti-oxidation, and antiparasitic activity. Meanwhile, potential toxicities have been discovered in some constituents. Therefore, the species in tribe Chelidonieae have become a rich source for new drug discovery, biologic study, and mechanism research. This paper presents comprehensive information of the chemical constituents, pharmacological and toxicological research on the plants in tribe Chelidoieae, which is a reference for the plants in this tribe for further development.

Key words

alkaloids; bioactivities; isoquinoline alkaloids; tribe Chelidonieae; triterpenoids

1. Introduction

The tribe Chelidonieae (family Papaveraceae), consisted of eight genera 23 species, is mainly distributed in the North Temperate Zone. In China, there are six genera 11 species, and almost all of them have been used as folk medicines for centuries. Some genera include only one species, such as genera *Eomecon* Hance, *Hylomecon* Maxim., and *Chelidonium* L. Though plants from different genera of this tribe have different medicinal merits, the whole plant [*Eomecon chinantha* Hance, *Stylophorum lasiocarpum* (Oliv.) Fedde, *Dicranostigma leptopodum* (Maxim.) Fedde, *Chelidonium majus* L., *Macleaya cordata* (Willd.) R. Br., and *Macleaya microcarpa* (Maxim.) Fedde] or the root and rhizome [*Hylomecon japonica* (Thunb.) Prantl] of these plants is effective in common for treating traumatic injuries and various types of carbuncle, stopping bleeding, relieving pain, and alleviating swelling (Feng et al, 1985). In addition, *C. majus* has been used as a traditional medicine for bile and liver disorders both in China and Europe for a long history and its fresh latex has also been used in the treatment of many skin complaints such as corns, eczema, tinea infections, and skin tumors (Gilca et al, 2010). Genera *Sanguinaria* L. and *Bocconia* L. could be found in North America or other warm areas except for China. The Native American used *Sanguinaria canadensis* L. to treat ulcers and sores, croup,

* **Corresponding author: Xiao PG** Tel/Fax: +86-10-6301 1294 E-mail: xiaopg@public.bta.net.cn Address: Institute of Medicinal Plant Development, No. 151 Malianwa Road, Haidian District, Beijing 100193, China

Fund: Key Program in the Major Research Plan of the National Natural Science Foundation of China (81072995); PUMC Youth Fund (3332013079)

burns, tapeworms, fevers diarrhea, and irregular periods (O'Keefe and Beecher, 1994). The broad medicinal applications of the plants in tribe Chelidonieae had elicited publications in the chemistry and pharmacology of this tribe in the past decades. In this review, we compile various studies on this tribe and critically evaluate the issues related to the phytochemistry, ethnopharmacology, and toxicity of the species in tribe Chelidonieae. The outlines of this paper and some plants of tribe Chelidonieae are shown in Figure 1.

2. Chemical constituents in tribe Chelidonieae

So far, 162 compounds have been isolated and identified from the plants of tribe Chelidonieae, including alkaloids, amides, organic acids and their derivatives, aromatics, triterpenoids, sterols, nutrients, essential oils, proteins, and so on. Their names and the corresponding plant sources are collected in Table 1, and their structures are shown in Figures 2–6.

2.1 Alkaloids

Phytochemical studies revealed that alkaloids are the major components of this tribe, and so far almost 80 alkaloids have been reported including benzophenanthridines, protopines, protoberberines, aporphinoids, and a few other alkaloids (Figure 2). Benzophenanthridines, protopines, protoberberines and aporphinoids belong to isoquinoline alkaloids.

2.1.1 Benzophenanthridines

Five benzophenanthridine alkaloids subtypes were found in this tribe. Dihydrophenanthridine alkaloids **1**–**25** were mainly centered in *Macleaya* R. Br., *Dicranostigma* Hook., *Chelidonium* L., and *Bocconia* L. Hexahydrophenanthridine alkaloids **26**–**30** were found and considered as the characteristic components in *C. majus*. Isochelidonine was the first benzophenanthridine alkaloid from Papaveraceae with C-10, 11 substituents. Chenidonine (**27**) was also obtained from the root of *Stylophorum diphyllum* (Michx.) Nutt. and rhizoma of *H. japonica*. Four alkaloids **31**–**34** with no *N*-methyl were identified from the fruit of *Bocconia pearcei* L. and genus *Macleaya* R. Br. Eight quaternary ammonium bases **35**–**42** were also identified from almost all genera of this tribe, and could be recognized as the distinctive compounds differing from other tribe of Papaveraceae (Huang and Du, 2002). Sanguianrine (**40**) was the first alkaloid of this tribe discovered from *Sanguinria canadensis* in 1827. Six bisbenzophenanthridines **43**–**48** were obtained from the fruit of *M. cordata* or whole plant of *M. microcarpa* and so on.

2.1.2 Proberberines

Eleven proberberine alkaloids were isolated from almost all the plants of this tribe except *E. chionantha* and *S. canadensis*. Compounds **49**–**54** are tetrahydroberberine-type alkaloids and compounds **55**–**59** are dihydroberberine-type alkaloids.

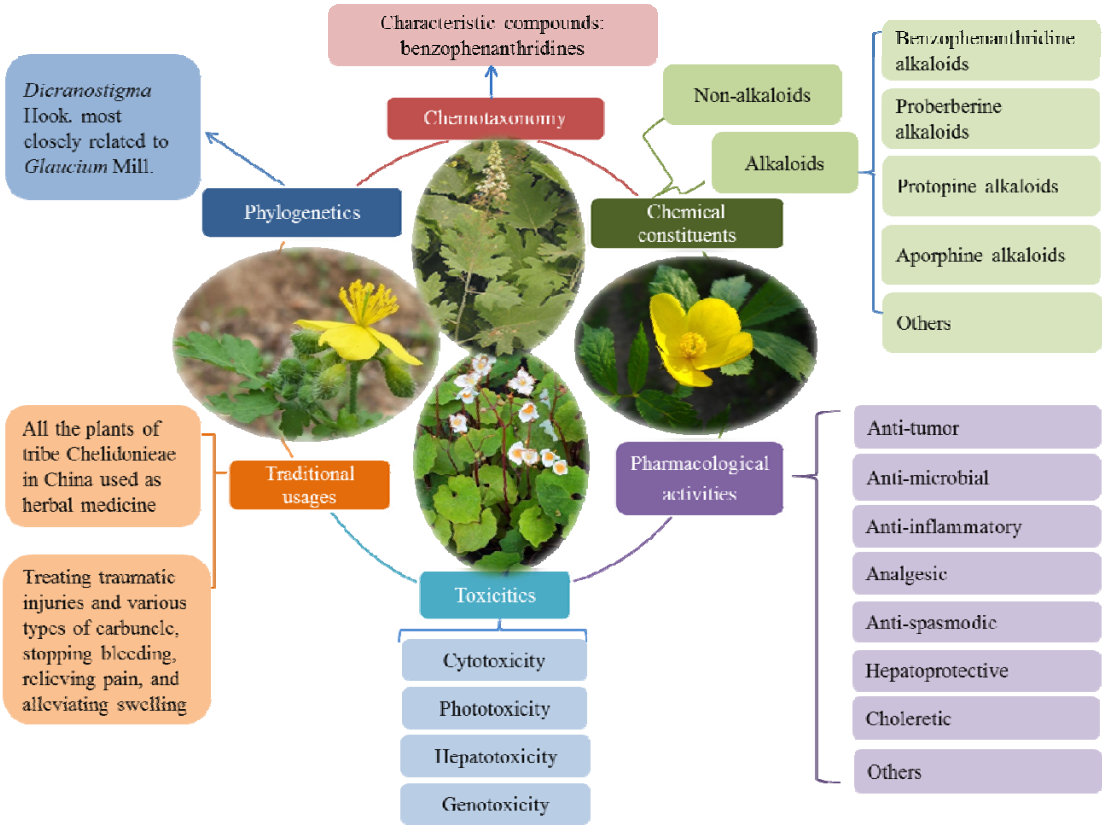


Figure 1 Outlines and representative plants of tribe Chelidonieae

(Left: *C. majus*; Right: *H. japonica*; Up: *M. cordata*; Down: *E. chinantha*)

Table 1 Chemical constituents of tribe Chelidonieae

No.	Compounds	Sources	Parts of plants	References
	Alkaloids			
	Benzophenanthridines			
1	(2′,6′-epoxy-1′2′α,3′β,4′α,5′α-pentahydroxy) hexane-(1′→6)-dihydrochelerythrin	*M. microcarpa*	root	(Deng, 2008)
2	(5′*R*)-3′-methyl-2′(5′H)furanone-(5′→6)-(6*S*)-dihydrochelerythrin	*M. microcarpa*	root	(Deng, 2008)
3	(5′*R*)-3′-methyl-2′(5′H)furanone-(5′→6)-(6*S*)-dihydrosanguinarine	*M. microcarpa*	root	(Deng, 2008)
4	(5′*R*)-3′-methyl-2′(5′H)furanone-(5′→6)-(6*R*)-dihydrosanguinarine	*M. microcarpa*	root	(Deng, 2008)
5	6-(1′-hydroxyethyl)dihydrochelerythrine	*M. microcarpa*	root	(Deng and Qin，2010)
6	(1′*E*)-5′-Methoxy-6′-hydroxy-cinnamenyl-(1′→6)-dihydrosanguinarine	*M. microcarpa*	root	(Deng and Qin, 2010)
7	11-acetonyldihydrochelerythrine	*B. arborea*	bark	(Perez et al, 2002)
8	6-acetonyl-dihydrosanguinarine	*D. leptopodum*	whole plant	(Liu et al, 2011)
		M. cordata	fruit and stem	(Ye et al, 2009; Pang, 2005)
		M. microcarpa	whole plant	(Yang et al, 2010)
9	6-acetonyl-dihyrochelerythrine	*M. cordata*	fruit	(Ye et al, 2009)
10	6-butoxy-dihydrochelerythrine	*D. lactucoides*	root	(Gregorová et al, 2010)
		M. microcarpa	root	(Deng and Qin, 2010)
11	6-butoxy-dihydrosanguinarine	*D. lactucoides*	root	(Gregorová et al, 2010)
12	6-ethoxydihydrosanguinarine	*M. microcarpa*	whole plant	(Yang et al, 2010)
13	6-methoxydihydrochelerythrine	*M. microcarpa*	root and stem	(Deng and Qin, 2010; Qin et al, 2004)
		M. cordata	stem	(Pang, 2005)
		C. majus	whole plant	(Zhou and Chen, 1989)
14	6-methoxydihydrosanguinarine	*M. microcarpa*	root and stem	(Deng and Qin, 2010)
		M. cordata	fruit	(Ye et al, 2009)
		C. majus	whole plant	(Zhou and Chen, 1989)
15	8-hydroxy-dihydrochelerythrine	*C. majus*	whole plant	(Meng et al, 2009)
16	8-hydroxy-dihydrosanguinarine	*C. majus*	whole plant	(Park et al, 2011)
17	angoline	*B. arborea*	bark	(Perez et al, 2002)
18	bocconoline	*M. cordata*	fruit	(Onda et al, 1970)
19	dihydrochelerythrine	*M. microcarpa*	whole plant, root, and stem	(Yang et al, 2010; Deng and Qin, 2010; Qin et al, 2004)
		M. cordata	fruit	(Ye et al, 2009)
		B. arborea	aerial part and bark	(Navarro and Delgado, 1999; Perez et al, 2002)
		B. pearcei	fruit	(Fuchino et al, 2010)
20	dihydrochelirubine	*B. pearcei*	fruit	(Fuchino et al, 2010)
21	dihydrosanguinarine	*B. arborea*	aerial part and bark	(Navarro and Delgado, 1999; Perez et al, 2002)
		B. pearcei	fruit	(Fuchino et al, 2010)
		D. leptopodum	whole plant	(Liu et al, 2011)
		M. microcarpa	whole plant, root and stem	(Yang et al, 2010; Deng and Qin, 2010; Qin et al, 2004)
		M. cordata	stem	(Pang, 2005)
		C. majus	whole plant	(Zhou and Chen, 1989)
22	methyl 2′-(7,8-dihydrosanguinarine-8-yl)acetate	*C. majus*	whole plant	(Park et al, 2011)
23	oxychelerythrine	*M. cordata*	fruit	(Kosina et al, 2010)
		B. pearcei	fruit	(Fuchino et al, 2010)
24	oxysanguinarine	*M. cordata*	fruit and stem	(Kosina et al, 2010; Pang, 2005)
		B. arborea	bark	(Perez et al, 2002)
		S. canadensis	rhizome	(Dostál et al, 1996)
		E. chionantha	rhizome	(Du et al, 1993)
25	spallidamine	*M. microcarpa*	root	(Deng and Qin, 2010)
26	(+)-chelamine	*C. majus*	root	(Nečas et al, 2005)

(To be continued)

(Continued Table 1)

No.	Compounds	Sources	Parts of plants	References
27	chelidonine	*C. majus*	whole plant	(Zhou and Chen, 1989)
		S. diphyllum	root	(Schlotterbeck and Watkins, 1902)
		H. japonica	rhizome	(Cheng et al, 2011)
28	(±)-homochelidonine	*C. majus*	root	(Nečas et al, 2005)
29	(±)-norchelidonine	*C. majus*	root and whole plant	(Nečas et al, 2005; Park et al, 2011)
30	isochelidonine	*C. majus*	whole plant	(De et al, 1992)
31	12-methoxynorchelerythrine	*B. pearcei*	fruit	(Fuchino et al, 2010)
32	norchelerythrine	*B. pearcei*	fruit	(Fuchino et al, 2010)
33	norsanguinarine	*M. cordata*	fruit and stem	(Kosina et al, 2010; Pang, 2005)
34	pancorine	*M. microcarpa*	root	(Deng and Qin, 2010)
35	6-ethoxychelerythrine	*E. chionantha*	rhizome	(Feng et al, 1985)
36	chelerythrine	*B. arborea*	bark	(Perez et al, 2002)
		M. cordata	fruit	(Hu et al, 1979)
		H. japonica	rhizome	(Cheng et al, 2011)
		D. lactucoides	root	(Gregorová et al, 2010)
		D. leptopodum	root	(Zhou, 1988)
		S. canadensis	rhizome	(Greathouse, 1939)
		E. chionantha	rhizome	(Zhou and Zhou, 1981)
37	chelilutine	*C. majus*	whole plant	(Slavik, 1977)
		H. japonica	rhizome	(Cheng et al, 2011)
38	chelirubine	*M. cordata*	fruit	(Hu et al, 1979)
		H. japonica	rhizome	(Cheng et al, 2011)
39	macarpine	*C. majus*	whole plant	(Slavik, 1977)
40	sanguinarine	*S. diphyllum*	root	(Schlotterbeck and Watkins, 1902)
		M. cordata	fruit and stem	(Hu et al, 1979; Pang, 2005)
		H. japonica	rhizome	(Cheng et al, 2011)
		D. lactucoides	root	(Gregorová et al, 2010)
		D. leptopodum	root and whole plant	(Zhou, 1988; Zhao et al, 2010)
		S. canadensis	rhizome	(Greathouse, 1939)
		E. chionantha	rhizome	(Zhou and Zhou, 1981)
41	sanguilutine	*M. cordata*	fruit	(Kosina et al, 2010)
42	sanguirubine	*M. microcarpa*	whole plant	(Pěnčíková et al, 2011)
43	bis[6-(5,6-dihydrochelerythrinyl)]ether	*M. microcarpa*	root	(Deng and Qin, 2010)
44	bocconarborine A	*M. cordata*	fruit	(Ye et al, 2009)
		M. microcarpa	whole plant	(Yang et al, 2010)
45	bocconarborine B	*M. cordata*	fruit	(Ye et al, 2009)
46	chelerythridimerine	*B. arborea*	bark	(Perez et al, 2002)
47	chelidimerine	*C. majus*	whole plant	(Tin-Wa et al, 1972)
		M. cordata	fruit	(Ye et al, 2009)
		E. chionantha	rhizome	(Du et al, 1993)
48	sanguidimerine	*M. cordata*	fruit	(Ye et al, 2009)
	Proberberine alkaloids			
49	1-canadine	*C. majus*	whole plant	(Zhou and Chen, 1989)
50	chelanthifoline	*M. cordata*	fruit	(Wu et al, 2009)
51	dehydrocicanthifoline	*M. cordata*	fruit	(Hu et al, 1979)
52	stylopine	*C. majus*	leave and whole plant	(Jang et al, 2004; Park et al, 2011)
		S. diphyllum	root	(Schlotterbeck and Watkins, 1902)
		H. japonica	rhizome	(Cheng et al, 2011)
53	tetrahydroberberine	*H. japonica*	rhizome	(Cheng et al, 2011)
54	tetrahydrocoptisine	*C. majus*	whole plant	(Zhou and Chen, 1989)
55	berberine	*C. majus*	whole plant	(Park et al, 2011)
		M. cordata	fruit	(Hu et al, 1979)
		H. japonica	rhizome	(Cheng et al, 2011)
		D. lactucoides	root	(Gregorová et al, 2010)
56	berberrabine	*M. microcarpa*	whole plant	(Yang et al, 2010)
57	dehydrocheilanthifoline	*M. cordata*	fruit	(Wu et al, 2009)
58	8-oxycoptisine	*C. majus*	whole plant	(Zhou and Chen, 1989)

(To be continued)

(Continued Table 1)

No.	Compounds	Sources	Parts of plants	References
59	coptisine	*C. majus*	whole plant	(Kuznetsova et al, 2005)
		M. cordata	fruit	(Hu et al, 1979)
		H. japonica	rhizome	(Cheng et al, 2011)
		D. lactucoides	root	(Gregorová et al, 2010)
	Protopine alkaloids			
60	α-allocryptopine	*M. cordata*	fruit	(Hu et al, 1979; Ye et al, 2009)
		M. microcarpa	whole plant	(Yang et al, 2010)
61	β-allocryptopine	*M. cordata*	fruit	(Hu et al, 1979)
		M. microcarpa	whole plant	(Yang et al, 2010)
62	cryptopine	*M. cordata*	fruit	(Ye et al, 2009)
		D. leptopodum	rhizome	(Zhou, 1988)
		H. japonica	rhizome	(Cheng et al, 2011)
63	protopine	*C. majus*	whole plant	(Zhou and Chen, 1989)
		M. cordata	fruit	(Pang, 2005)
		M. microcarpa	whole plant	(Yang et al, 2010)
		D. leptopodum	whole plant	(Zhou, 1988)
		D. lactucoides	root	(Gregorová et al, 2010)
		H. japonica	rhizome	(Cheng et al, 2011)
		S. canadensis	rhizome	(Dostál et al, 1996)
		E. chionantha	rhizome	(Du et al, 1993)
64	*cis*-protopinium	*D. leptopodum*	whole plant	(Liu et al, 2011)
65	*trans*-protopinium	*D. leptopodum*	whole plant	(Liu et al, 2011)
	Aporphines			
66	corydine	*C. majus*	root	(Shafiee and Jafarabadi, 1998)
		D. leptopodum	whole plant	(Chang et al, 1981)
67	dicranostigmine	*D. leptopodum*	whole plan	(Liu et al, 2011; Yan et al, 2009)
68	magnflorine	*D. leptopodum*	whole plant	(Chang et al, 1982)
69	glaucine	*D. leptopodum*	whole plant	(Zhao et al, 2010)
70	isocorydine	*D. leptopodum*	whole plant	(Chang et al, 1981; Liu et al, 2011)
71	*N*-norcorydine	*C. majus*	root	(Shafiee and Jafarabadi, 1998)
72	*N*-methylhernovine	*D. leptopodum*	whole plant	(Liu et al, 2011)
	Others			
73	(−)-turkiyenine	*C. majus*	whole plant	(Kadan et al, 1990)
74	corysamine	*M. cordata*	fruit	(Hu et al, 1979)
75	sinoacutine	*D. leptopodum*	whole plant	(Yan et al, 2009; Liu et al, 2011)
76	sparteine	*C. majus*	whole plant	(Preininger, 1986)
	Amides			
77	adenosine	*M. microcarpa*	root	(Deng, 2008)
78	arnottianamide	*M. microcarpa*	root	(Deng, 2008; Deng and Qin, 2010)
79	*n*-*p*-coumaroyltyramine	*M. microcarpa*	root	(Deng and Qin, 2010)
80	*n*-methyl-4,5-methylene-di-ol-succinimide	*M. cordata*	stem	(Pang, 2005)
	Aromatic acid and their derivatives			
81	*m*-hydroxybenzoic acid	*M. cordata*	aerial part and seed	(Kosina et al, 2010)
82	*p*-hydroxybenzoic acid	*M. cordata*	aerial part and seed	(Kosina et al, 2010)
83	gallic acid	*M. cordata*	aerial part and seed	(Kosina et al, 2010)
84	gentisic acid	*M. cordata*	aerial part and seed	(Kosina et al, 2010)
85	protocatechuic acid	*M. cordata*	aerial part and seed	(Kosina et al, 2010)
86	caffeic acid	*C. majus*	whole plant	(Hahn and Nahrstedt, 1993)
		M. cordata	aerial part and seed	(Kosina et al, 2010)
87	(+)-(*E*)-caffeoyl-*L*-malic acid	*C. majus*	aerial part	(Hahn and Nahrstedt, 1993)
88	(−)-4-(*E*)-caffeoyl-*L*-threonic acid	*C. majus*	aerial part	(Hahn and Nahrstedt, 1993)
89	(−)-2-(*E*)-caffeoyl-*L*-threonic acid lactone	*C. majus*	aerial part	(Hahn and Nahrstedt, 1993)
90	2-(−)-caffeoyl-*D*-glyceric acid	*C. majus*	aerial part	(Hahn and Nahrstedt, 1993)
91	ferulic acid	*C. majus*	aerial part	(Hahn and Nahrstedt, 1993)
		M. cordata	aerial part and seed	(Kosina et al, 2010)
92	4-*O*-β-*D*-glucoside of (*E*)-ferulic acid	*M. microcarpa*	root	(Deng, 2008)

(To be continued)

(Continued Table 1)

No.	Compounds	Sources	Parts of plants	References
93	coumaric acid	*C. majus*	aerial part	(Hahn and Nahrstedt, 1993)
		M. cordata	aerial part and seed	(Kosina et al, 2010)
94	sinapic acid	*M. cordata*	aerial part and seed	(Kosina et al, 2010)
95	3,4′,6′-trihydroxy-5-methoxy-2′-methyl-biphenyl-2-carboxylic acid	*M. cordata*	stem	(Pang, 2005)
96	3-*O*-feruloylquinic acid	*M. microcarpa*	root	(Deng, 2008)
97	methyl 3-*O*-feruloylquinate	*M. microcarpa*	root	(Deng, 2008)
98	chelidonic acid	*C. majus*	aerial part	(Ashok and Sharma, 1988)
		S. diphyllum	root	(Schlotterbeck and Watkins, 1902)
	Aliphatic acids and their derivatives			
99	15-nonacosanol	*E. chionantha*	aerial part	(Du et al, 2006)
100	citric acid	*C. majus*	whole plant	(Committee on herbal medicinal products, 2012)
101	malic acid	*C. majus*	whole plant	(Committee on herbal medicinal products, 2012)
102	succinic acid	*M. cordata*	aerial part and seed	(Kosina et al, 2010)
103	butyl stearate	*E. chionantha*	aerial part	(Du et al, 2006)
104	butyl palmitate	*E. chionantha*	aerial part	(Du et al, 2006)
105	monopalmilin	*M. microcarpa*	root	(Deng, 2008)
106	*n*-dotriacontanol	*E. chionantha*	aerial part	(Du et al, 2006)
107	*n*-nonanoic acid	*E. chionantha*	aerial part	(Du et al, 2006)
108	butyric acid	*M. cordata*	seed oil	(Kosina et al, 2010)
109	capronic acid	*M. cordata*	seed oil	(Kosina et al, 2010)
110	caprylic acid	*M. cordata*	seed oil	(Kosina et al, 2010)
111	capric acid	*M. cordata*	seed oil	(Kosina et al, 2010)
112	undecanoic acid	*M. cordata*	seed oil	(Kosina et al, 2010)
113	tridecanoic acid	*M. cordata*	seed oil	(Kosina et al, 2010)
114	myristic acid	*M. cordata*	seed oil	(Kosina et al, 2010)
115	*cis*-10-pentadecanoic acid	*M. cordata*	seed oil	(Kosina et al, 2010)
116	palmitoleic acid	*M. cordata*	seed oil	(Kosina et al, 2010)
117	*all-cis*-7,10,13-hexadecatrienoic acid	*M. cordata*	seed oil	(Kosina et al, 2010)
118	heptadecanoic acid	*M. cordata*	seed oil	(Kosina et al, 2010)
119	*cis*-10-heptadecanoic acid	*M. cordata*	seed oil	(Kosina et al, 2010)
120	stearic acid	*M. cordata*	seed oil	(Kosina et al, 2010)
121	elaidic acid	*M. cordata*	seed oil	(Kosina et al, 2010)
122	oleic acid	*M. cordata*	seed oil	(Kosina et al, 2010)
123	*cis*-11-octadecenoic acid	*M. cordata*	seed oil	(Kosina et al, 2010)
124	linolelaidic acid	*M. cordata*	seed oil	(Kosina et al, 2010)
125	linoleic acid	*M. cordata*	seed oil	(Kosina et al, 2010)
126	linolenic acid	*M. cordata*	seed oil	(Kosina et al, 2010)
127	arachidic acid	*M. cordata*	seed oil	(Kosina et al, 2010)
128	eicosenoic acid	*M. cordata*	seed oil	(Kosina et al, 2010)
129	palmitic acid	*E. chionantha*	aerial part	(Du et al, 2006)
		M. cordata	seed oil	(Kosina et al, 2010)
	Other aromatics			
130	4-hydroxy-3-methoxy-cinnamaldehyde	*M. cordata*	stem	(Pang, 2005)
131	4-hydroxy-3-methoxybenzaldehyde	*M. cordata*	stem	(Pang, 2005)
132	3,4,5-trimethoxy-phenol	*M. cordata*	stem	(Pang, 2005)
133	diphylline	*S. diphyllum*	root	(Schlotterbeck and Watkins, 1902)
	Alkanes and alkenes			
134	*n*-pentadecane	*E. chionantha*	aerial part	(Du et al, 2006)
135	*n*-hexadecane	*E. chionantha*	aerial part	(Du et al, 2006)
136	*n*-heptadecane	*E. chionantha*	aerial part	(Du et al, 2006)
137	*n*-octadecane	*E. chionantha*	aerial part	(Du et al, 2006)
138	*n*-nonadecane	*E. chionantha*	aerial part	(Du et al, 2006)
139	*n*-eicosane	*E. chionantha*	aerial part	(Du et al, 2006)
140	*n*-heneicosane	*E. chionantha*	aerial part	(Du et al, 2006)

(To be continued)

(Continued Table 1)

No.	Compounds	Sources	Parts of plants	References
141	*n*-docosane	*E. chionantha*	aerial part	(Du et al, 2006)
142	*n*-tricosane	*E. chionantha*	aerial part	(Du et al, 2006)
143	*n*-tetracosane	*E. chionantha*	aerial part	(Du et al, 2006)
144	*n*-pentacosane	*E. chionantha*	aerial part	(Du et al, 2006)
145	*n*-hexacosane	*E. chionantha*	aerial part	(Du et al, 2006)
146	*n*-heptacosane	*E. chionantha*	aerial part	(Du et al, 2006)
147	*n*-octacosane	*E. chionantha*	aerial part	(Du et al, 2006)
148	*n*-nonacosane	*E. chionantha*	aerial part	(Du et al, 2006)
149	*n*-triacontane	*E. chionantha*	aerial part	(Du et al, 2006)
150	*Z*-14-nonacosene	*E. chionantha*	aerial part	(Du et al, 2006)
	Triterpenoids			
151	3α,22α-dihydroxy-olean-12(13)-en-30-oic-acid	*E. chionantha*	aerial part	(Zhen et al, 2007)
152	3α-hydroxy-oleanan-12(13)-ene-30-oic acid	*M. cordata*	stem	(Pang, 2005)
153	3β-hydroxy-oleanan-12(13)-ene-30-oic acid	*M. microcarpa*	root	(Deng, 2008)
154	3-oxoolean-12(13)-en-30-oic acid	*M. microcarpa*	root	(Deng, 2008)
155	β-amyrin acetate	*E. chionantha*	aerial part	(Du et al, 2006)
156	oleanolic acid	*M. microcarpa*	stem	(Qin et al, 2004)
157	lupenyl acetate	*E. chionantha*	whole plant	(Du et al, 1993; Du et al, 2006)
158	1-oxohop-2,22(30)-dien-29-oic	*M. microcarpa*	root	(Deng, 2008)
159	dicranostigmone	*D. leptopodum*	whole plant	(Wang and Li, 2010)
	Sterols			
160	β-sitosterol	*M. cordata*	stem	(Pang, 2005)
		E. chionantha	aerial part	(Du et al, 2006)
161	β-daucosterol	*M. microcarpa*	root	(Deng, 2008)
		E. chionantha	aerial part	(Zhen et al, 2007)
162	stigmasterol	*M. microcarpa*	root	(Deng, 2008)

2.1.3 Protopines

Six protopine alkaloids **60**–**65** were identified in *D. leptopodum*, *H. japonica*, and genus *Macleaya* R. Br.

2.1.4 Aporphines

Seven aporphine alkaloids **66**–**72** were found from the root of *C. majus* and whole plant of *D. leptopodum*.

2.1.5 Others

There are other four alkaloids isolated from this tribe. (–)-Turkiyenine (**73**) is a turkitenine-type alkaloid, corysamine (**74**) is a benzoquinolizin-type alkaloid, sinoacutine (**75**) belongs to oxomorphine type, and sparteine (**76**) from *C. majus* is a nor-lupinane-type alkaloid.

2.2 Amides

Three amides **77**–**79** from the root of *M. microcarpa* were determined. As well, compound **80** from *M. cordata* was identified as an imine (Figure 3).

2.3 Organic acids and their derivatives

2.3.1 Aromatic acids and derivatives

Eighteen aromatic acids and their derivatives **81**–**98** were found in tribe Chelidonieae. Phenolic acids in *M. cordata* were determined in four fractions: free acids, constituents of soluble esters, glycosides, and insoluble esters. And the major acids were *p*-hydroxybenzoic, ferulic, and sinapic acids in all *M. cordata* samples (Kosina et al, 2010).

2.3.2 Aliphatic acids and derivatives

Thirty one aliphatic acids and their derivatives **99**–**129** were identified from *C. majus*, *M. cordata*, *M. microcarpa*, and *E. chionantha*.

2.3.3 Other aromatics

Another four aromatics **130**–**133** had been isolated from *M. cordata* and *S. diphyllum*. All the structures of organic acids and their derivatives from the tribe are shown in Figure 4.

2.4 Alkanes and alkenes

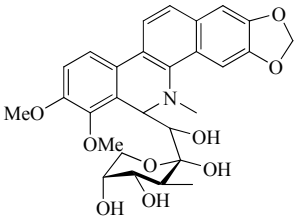
Du et al, (2006) identified sixteen alkanes **134**–**149** from *n*-pentadecane to *n*-triacontane, and one alkene **150** from the petroleum ether extract of *E. chionantha* by GC-MS.

2.5 Triterpenoids

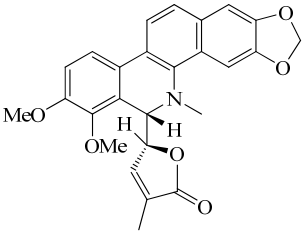
Six oleanane-type triterpenoids **151**–**156** were isolated from genera *Macleaya* R. Br. and *Eomecon* Hance. Lupenyl acetate (**157**), a lupane-triterpenoid, was found in *E. chionantha*. 1-oxohop-2,22(30)-dien-29-oic (**158**) and dicranostigmone (**159**) were hopane-triterpenoid, and **159** was yet only found in *D. leptopodum* (Figure 5).

2.6 Sterols

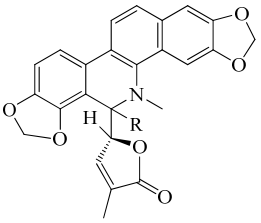
β-Sitosterol (**160**) and β-daucosterol (**161**) were found both in *M. cordata* and *E. chionantha*. Stigmasterol (**162**) was obtained from *M. microcarpa* (Figure 6).



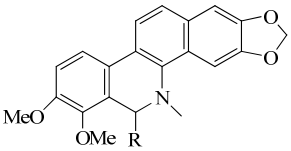
1



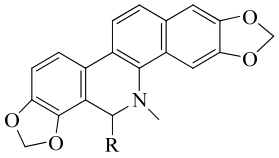
2



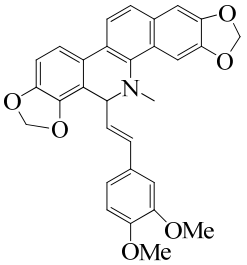
3 R = β-H **4** R = α-H



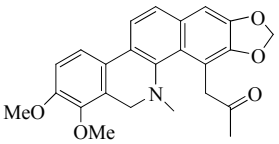
5 R = CH(OH)CH$_3$
9 R = CH$_2$COCH$_3$
10 R = OCH$_2$(CH$_2$)$_2$CH$_3$
13 R = OMe
15 R = OH
19 R = H
23 R= =O



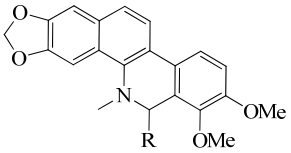
8 R = CH$_2$COCH$_3$
11 R = OCH$_2$(CH$_2$)$_2$CH$_3$
12 R = OEt
14 R = OMe
16 R = OH
21 R = H
22 R = CH$_2$COOCH$_3$
24 R = =O
25 R = CH$_2$COOH



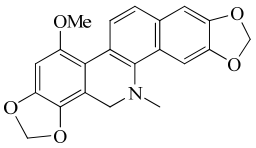
6



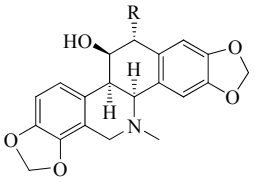
7



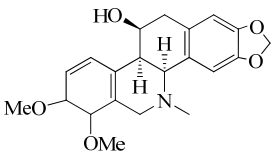
17 R = OMe **18** R = CH$_2$OH



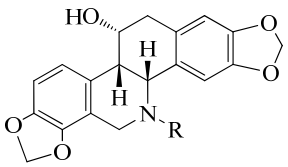
20



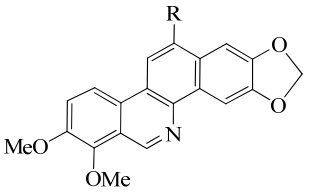
26 R = OH **27** R = H



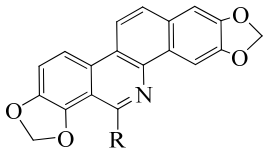
28



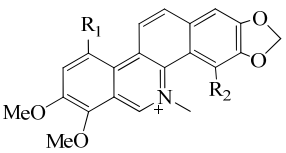
29 R = H **30** R = CH$_3$



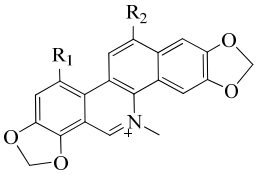
31 R = OMe **32** R = H



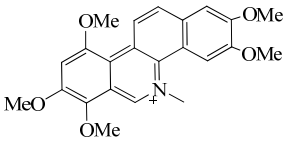
33 R = H
34 R = OMe



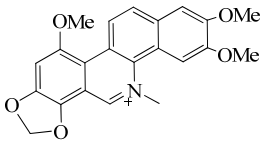
35 R$_1$ = H; R$_2$ = OEt
36 R$_1$ = H; R$_2$ = H
37 R$_1$ = OMe; R$_2$ = H



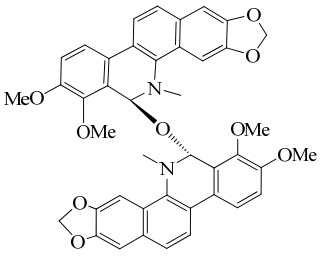
38 R$_1$ = OMe; R$_2$ = H
39 R$_1$ = OMe; R$_2$ = OMe
40 R$_1$ = H; R$_2$ = H



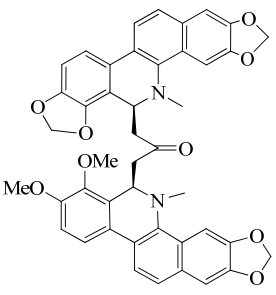
41



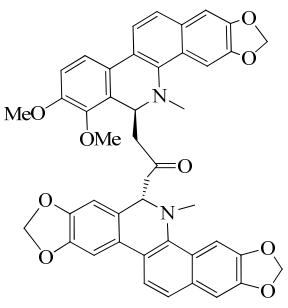
42



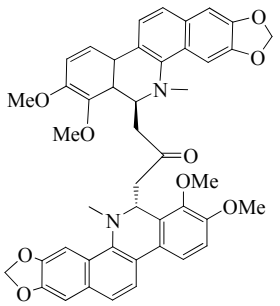
43



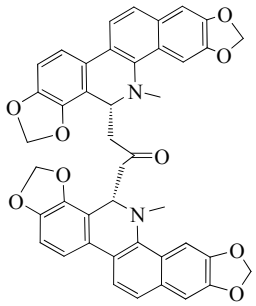
44



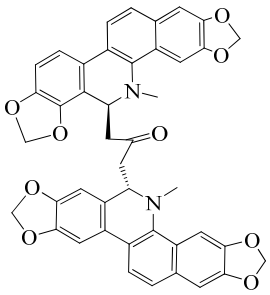
45



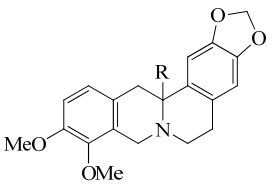
46



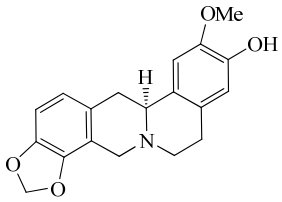
47



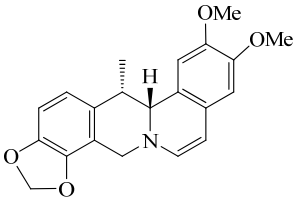
48



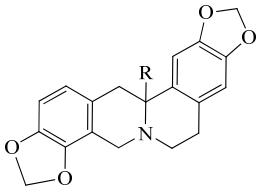
49 R = β-H **53** R = α-H



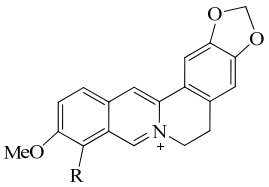
50



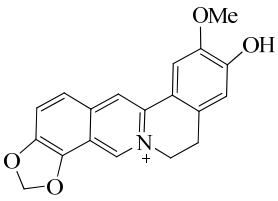
51



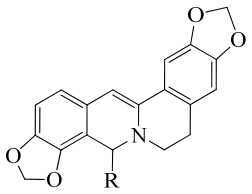
52 R = β-H **54** R = α-H



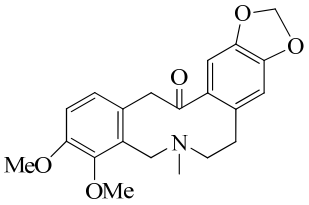
55 R = OMe **56** R = OH



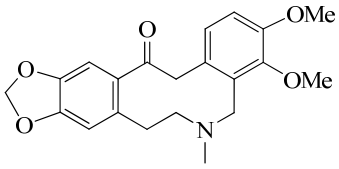
57



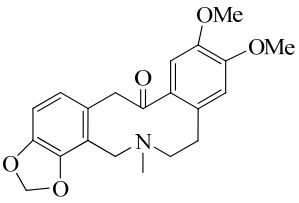
58 R = =O **59** R = H



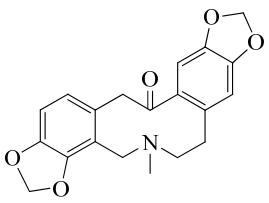
60



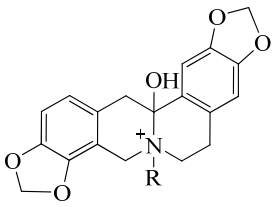
61



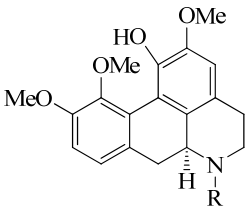
62



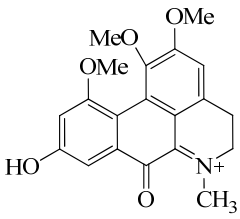
63



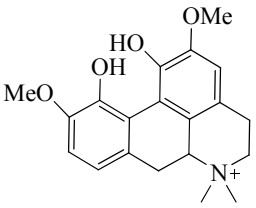
64 R = α-CH_3 **65** R =β-CH_3



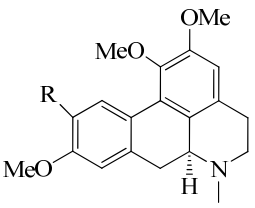
66 R = H **71** R = CH_3



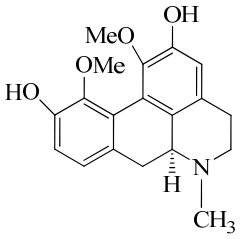
67



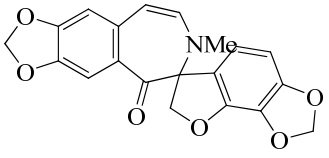
68



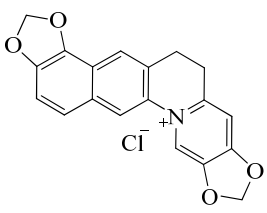
69 R = α-CH_3 **70** R =β-CH_3



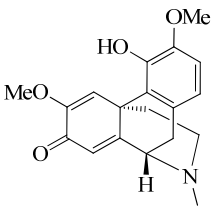
72



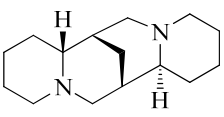
73



74

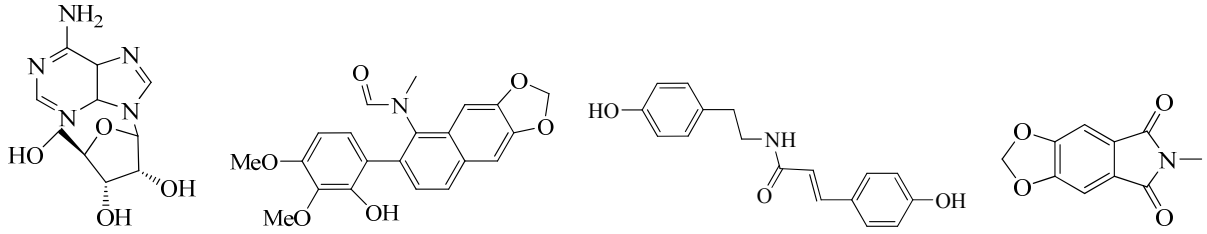


75



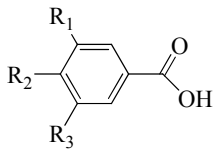
76

Figure 2 Chemical structures of alkaloids in tribe Chelidonieae

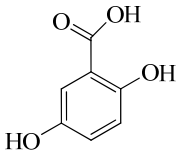


77 **78** **79** **80**

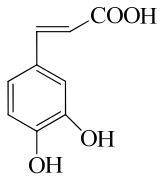
Figure 3 Chemical structures of amides in tribe Chelidonieae



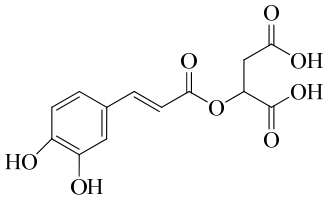
81 R_1 = H; R_2 = H; R_3 = OH
82 R_1 = H; R_2 = OH; R_3 = H
83 R_1= OH; R_2 = OH; R_3 = OH
85 R_1 = H; R_2 = OH; R_3 = OH



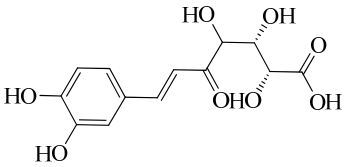
84



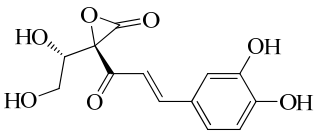
86



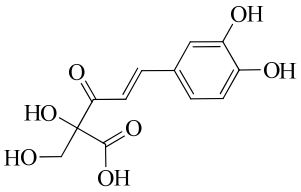
87



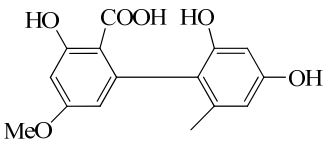
88



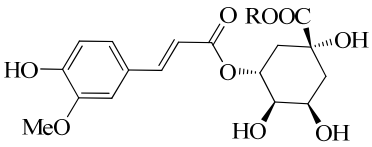
89



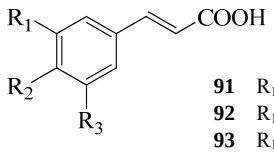
90



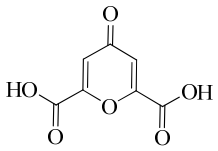
95



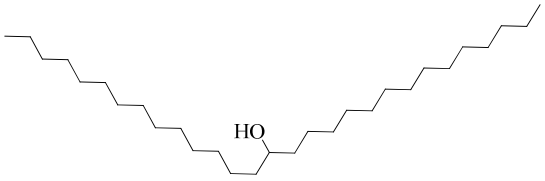
96 R = H **97 R = Me**



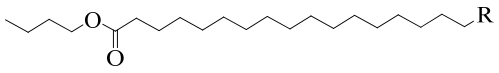
91 R_1 = H; R_2 = OH; R_3 = OMe
92 R_1 = H; R_2 = 4-*O*-β-*D*-Glc; R_3 = OMe
93 R_1 = H; R_2 = OH; R_3 = H
94 R_1 = OMe; R_2 = OH; R_3 = OMe



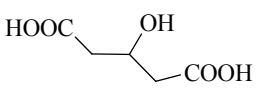
98



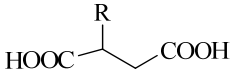
99



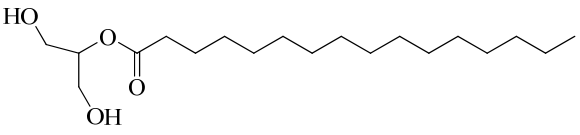
103 R = H **104** R = CH_2CH_3



100



101 R = OH **102** R = H



105

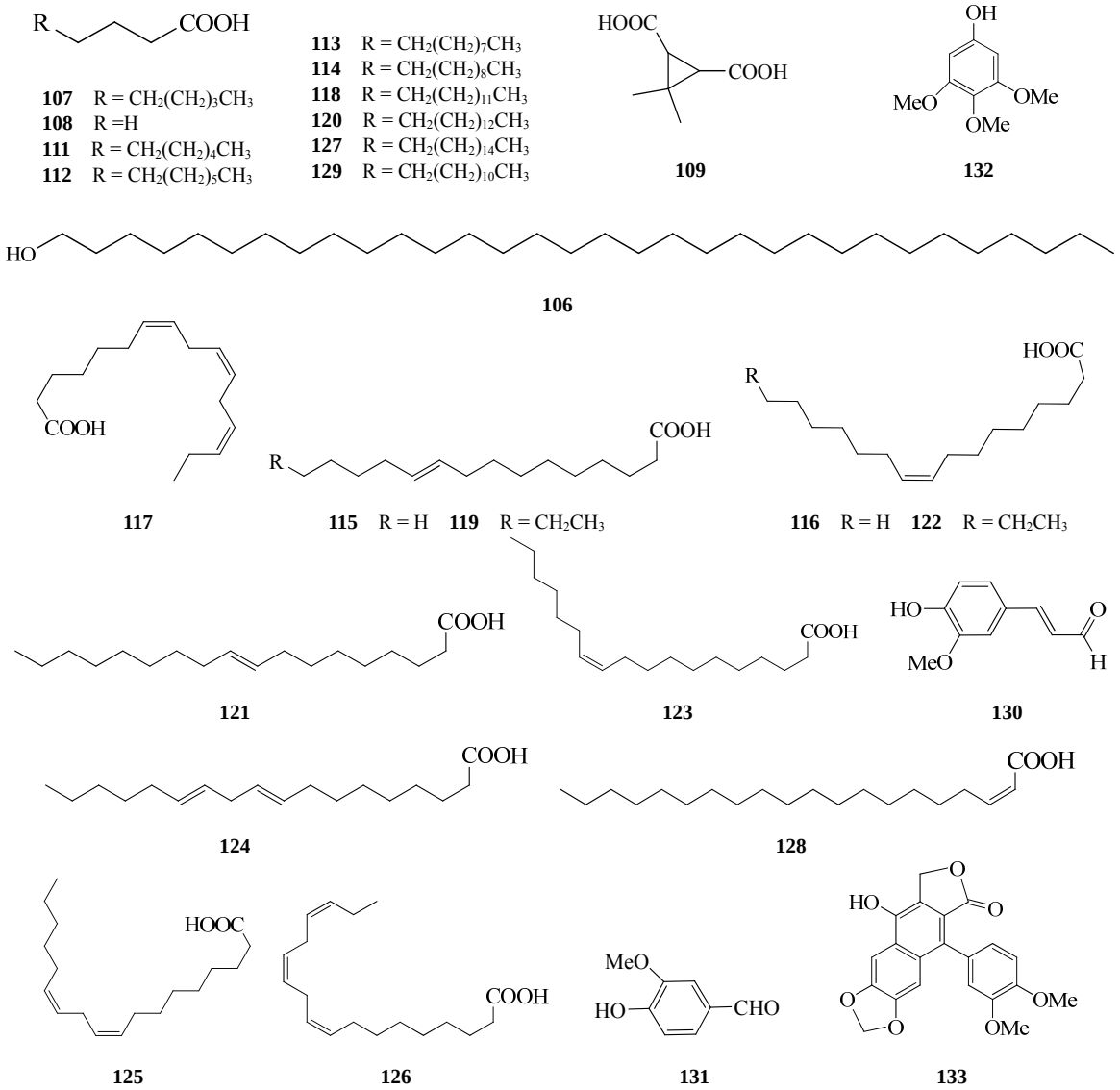


Figure 4 Chemical structures of organic acids and their derivatives in tribe Chelidonieae

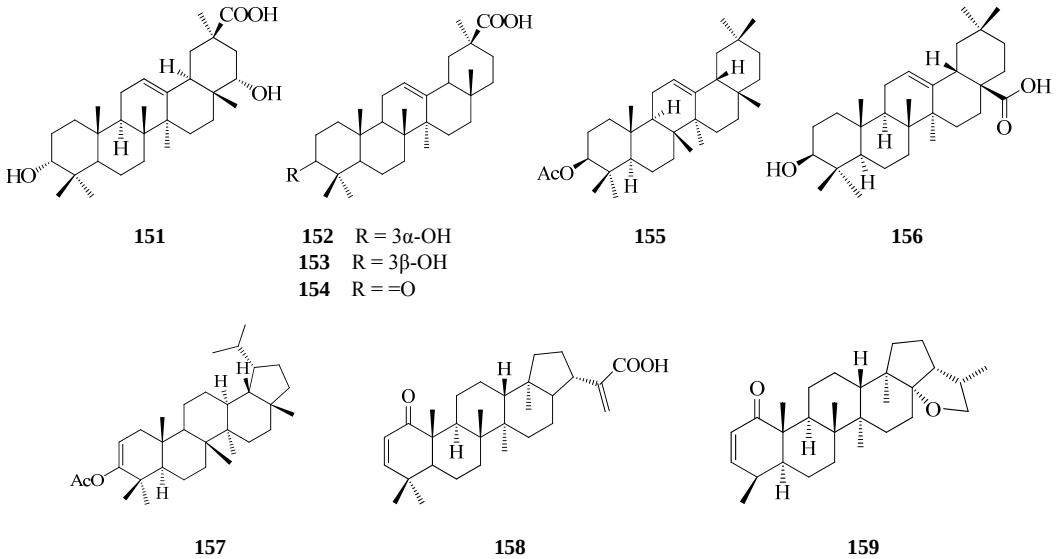
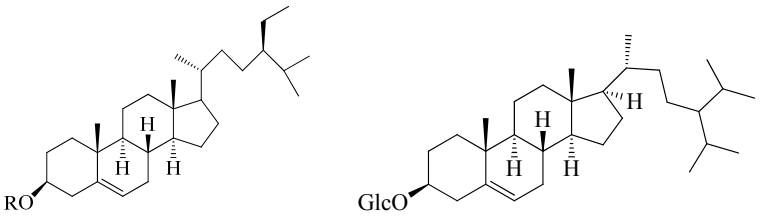


Figure 5 Chemical structures of triterpenoids in tribe Chelidonieae



160 R = H **161** R = 3-*O*-β-*D*-Glc **162**

Figure 6 Chemical structures of sterols in tribe Chelidonieae

2.7 Essential oils

An analysis of the essential oils extracted from *M. cordata* by GC-MS showed that 48 ingredients had been found and 39 of them had been identified, accounting for 92.464% of the total essential oils. The main compounds were 2-methoxy-4-vinylphenol (11.270%), benzoic acid, 4-nitroso-ethyl ester (11.178%), (*E*)-2-hexenal (10.415%), cedrol (7.371%), 2-undecanone, 6,10-dimethyl-phthalic acid (6.929%), isobutyl actyl ester (5.700%), and 2-phenylpropenal (4.509%), etc (Chen et al, 2009).

2.8 Minerals

To date, the concentration of 24 elements (Al, As, B, Ba, Ca, Cd, Co, Cr, Cu, Fe, Hg, K, Li, Mg, Mn, Mo, Na, Ni, P, Pb, S, Ti, V, and Zn) in crude drugs (herb and root), in their aqueous solutions (infusion and decoction) and alcoholic extracts were studied by ICP-OES. The difference among the concentration of the elements in extracts, except for Cu, Mg, and Na, was highly significant. It has been found that the root contains higher concentrations of mineral elements except for B, Cu, P, and S. The infusion contained most elements in the highest concentration and proved to be the best source for obtaining minerals. The same tendency was observed in the case of dissolutions. In aqueous extracts, the dissolution of mineral elements was between 10%–65% for most elements, especially for K (65%) and P (54%). The dissolution of mineral elements in the case of tinctures decreased with increasing alcohol concentration. It may be stated that the presence of macro- and microelements in extracts greatly contributed to their therapeutical value (Sárközi et al, 2005).

2.9 Proteins

A new extracellular peroxiedase of about 40 000 from *C. majus* milky sap was isolated and characterized. This preotein belonged to secretory class III plant peroxidases and its activity was also accompanied by DN-ase activities (Nawrot et al, 2007). Two nucleases, CMN1 of 20 000 and CMN2 of 36 000, were also isolated from *C. majus* milky sap (Nawrot et al, 2008). A cysteine proteinase inhibitor, named chelidocystain, was isolated from *C. majus* using papain sepharose affinity chromatography followed by gel filtration and ion-exchange chromatography (Rogelj et al, 1998). A polyphenoloxidase (PPO) of 65 000 was purified from *C. majus* by means of affinity chromatography into electrophoretic homogeneity. It exerted two activities, the monophenolase and diphenolase ones (Bilka et al, 2007).

S-Adenosyl-*L*-methionine: a tetrahydroberberine-*cis*-*N*-methyltransferase was isolated and characterized from suspendsion cultures of *S. canadensis* (O'Keefe and Beecher, 1994). Sanguinarine reductase, a key enzyme in sanguinarine/dihydrosanguinarine equilibrium, was found for the first time in the soluble proteins of leaves of *M. cordata* (Kosina et al, 2010).

3. Biological activities

Crude extracts and purified compounds derived from the plants of tribe Chelidonieae exhibited a broad spectrum of biological activities (anti-inflammatory, antimicrobial, antitumor, analgesic, hepatoprotective effects) that could support some of their traditional uses.

3.1 Anti-inflammatory effects

The crude extract, quaternary benzophenanthridine fraction, and individual alkaloid of *C. majus* were screened for their anti-inflammatory activities in assays involving collagen-induced arthritis in mice (Lee et al, 2007), carrageenan-induced rat paw oedema (Lenfeld et al, 1981), atopic dermatitis (AD) mouse model (Yang et al, 2011) and detecting the NO and PGE_2 production in macrophages (Park et al, 2011; Jang et al, 2004; Chung et al, 2004). Moreover, chelidonic acid (**98**) might serve as a potential component for use in treatment of mast cell-mediated inflammatory diseases, because it could inhibit the production of interleukin-6 (IL-6) and the expression of IL-6 mRNA through the regulation of nuclear factor-κB and suppress the activation and expression of caspase-1 (Shin et al, 2011). These results provided new insights into the pharmacological effects of *C. majus* in which many components may contribute to its anti-inflammatory activity.

3.2 Immunomodulatory effects

A clinical study showed that *C. majus* tincture improved cellular and humoral immunity, nonspecific resistance and promoted a reduction in the number of recurrences in children with chronic tonsillitis (Khmel'Nitskaia et al, 1998). *C. majus* extract (1.25 mL/kg in single dose) also suppressed immune responses locally by decreasing epidermal Langerhans cells

and contacting hypersensitivity by UVA irradiation in mice (Bark et al, 2010). And the total alkaloids of *C. majus* showed an obvious effect of eliminating phlegm, reliving cough, and antiasthma (Tong et al, 2004; Liu et al, 2006). Furthermore, a protein-bound polysaccharide extracted from *C. majus* showed the mitogenic activity on spleen cells, bone marrow cells, and increased the number of granulocyte macrophage-colony forming cells (GM-CFC) (Song et al, 2002).

The influences of *D. leptopodum* on the immune functions of peritoneal macrophage (PMΦ) were investigated both *in vitro* and *in vivo*. It was found that *D. leptopodum* could induce the activation of PMΦ and enhance their immune functions (Chen et al, 2001).

3.3 Antimicrobial activity

3.3.1 Antibacterial and antifungal activities

Crude extract and a *C. majus* lectin (CML), chelerythrine (**36**), sanguinarine (**40**), 8-hydroxydihydrosanguinarine (**16**), and 8-hydroxydihydrochelerythrine (**15**) showed the significant antibacterial activities on *Bacillus careus*, *Staphylococcus aureus* (Kokoska et al, 2002) and methicillin-resistant *S. aureus* (MRSA), *Streptococcus mutans* (Meng et al, 2009), *Actinobacillus*, multiresistant *Enterococci* (Bark et al, 2010), and antifungal activities on *Candida albicans* (Kokoska et al, 2002), *Fusarium* strains, *Botrytis cinerea*, some clinical drug- resistant yeast isolates (Meng et al, 2009; Dzink and Socransky, 1985), *Tricophyton* strains, *Epidermophyton floccosum*, *Microsporum canis*, *Aspergillus fumigates*, and some dermatophytes, especially the anthropophilic and zoophilic strains (Lenfeld et al, 1981).

Antimicrobial effects of the extracts from *M. cordata* aerial part, seeds, capsules and individual alkaloids were tested *in vitro* against standard reference bacterial strains *S. aureus* CCM 3953, *S. aureus* CCM 4223, *P. aeruginosa* CCM 3955, two strains of *E. coli* (CCM 4225 and CCM 3954), and *S. agalactiae*, representing selected human pathogens. And the most effective compounds were found to be **40** and **36** (Kosina et al, 2010; Zhao et al, 2005); The individual alkaloid hydrochlorides of *M. cordata* displayed the antifungal activities against *Saccharomyces cerevisiae*, *Aspergilla niger*, *Penicitlium*, *Rhizopus*, *Mucor*, *Trichoderma*, *Aspergillus oryzea*, and *Aspergillus flavus* (Yu et al, 2006).

Ethanol extract and 6-methoxydihydrosanguinarine (**14**), 6-acetonylhydrosanguinarine (**8**), and dihydrosanguinarine (**21**) of *H. hylomeconoides* were very active against MRSA and compound **13** appeared to be the most active with MICs in the range of 1.9–3.9 mg/mL (Choi et al, 2010).

Ethanol extract and total alkaloids of *E. chionantha* and *D. leptopodium* showed potent inhibitory activities on *E. coli*, *Staphylococcus aureus*, *Sarcina*, *Bacillus cereus*, *B. pumilus*, and *Candida albicans* (Sun et al, 2010; Wu et al, 1979).

Crude extracts from the barks and leaves of *B. frutescens* displayed anti-*Mycobacterium tuberculosis* ability (Cruz-Vega et al, 2008). The extracts of *B. integrifolia* could restrain Gram-positive, Gram-negative bacteria, and *C. albicans* (Gachet et al, 2010). MeOH extract, dihydrochelerythrine (**19**) and dihydrosanguinarine (**21**) of *B. arborea* showed the potent antibacterial and antifungal activities on Gram-positive and Gram-negative bacteria, *S. aureus*, *E. coli*, *P. aeruginosa*, and *C. albicans* (Navarro and Delgado, 1999; Navarro et al, 1996).

3.3.2 Antiviral activity

Alkaloid extracts of *C. majus* showed the antiviral activity against several virus such as herpesvirus, poxvirus, grippevirus, influenza virus, adenoviruses, DNA herpes virus, and the RNA polio virus (Lozjuk et al, 1996; Kéry et al, 1987). A new substance isolated from *C. majus* could inhibit human immunodeficiency virus 1 (HIV-1) (Gerencer et al, 2006).

Preparation of *D. leptopodium* displayed the antiviral activity on contagious pustular dermatitis virus (CPDv) (Wang and Dong, 1998; Dang et al, 2008). Additionally, protoberberine and benzophenanthridine alkaloids were tested for the inhibition of reverse transcriptase (RT) activity of RNA tumor viruses. It was observed that the higher T/C % value resulted in a stronger inhibition of reverse transcriptase activity and the alkaloids with the benzophenanthridine ring system were found to display potent inhibition (Kéry et al, 1987; Sethi, 1981).

3.4 Antitumor activity

The extracts and different compounds from *C. majus* had the following activities that might be responsible for its anti-tumor effect: (a) reduced telomerase activity by chelidonine (**27**) (Noureini and Wink, 2009); (b) inducing tumor cell apoptosis and blister cell death by different alkaloids (Noureini and Wink, 2009; Hichenkov et al, 2008) and nucleases (Nawrot et al, 2008); (c) arrest of mitosis by inhibition (Noureini and Wink, 2009); (d) enhancing NO and tumour necrosis factor-alpha (TNF-α) production via nuclear factor-κB (NF-κB) activation (Chung et al, 2004); (e) suppressing the carcinogenesis induced by kinds of carcinogens (Kim et al, 1997; Biswas et al, 2008); and (f) reversing the multidrug resistance (MDR) in carcinoma cells by chelerythrine (**36**) (Cao et al, 2011; Gilca et al, 2010). Both *Chelidonium* extract and isolated alkaloids had cytotoxic effects towards the tumor cells as follows: sarcoma 180, Erlich carcinoma, BGC823, MDR in breast carcinoma cells, OCM-1 and HeLa tumour cell lines, murine NK/Ly lymphoma cells, HT29, MCF-7, MCF-7/ADR, DaOY, SQ20B, SCC61, JSQ3, SCC35, and LnCaP cell lines lymphoblastic leukaemia MT-4 cells (Hichenkov et al, 2008; Sokoloff, 1968).

The crude alkaloid of *M. cordata* significantly inhibited the proliferation of human Hep3B cells and murine H_{22} cells in a dose-dependent manner *in vitro*. In the tumor-bearing mice, these alkaloids inhibited the development of H_{22} tumor cells and prolonged the survival time of S_{180} tumor-bearing mice (Pang et al, 2005). Sanguinarine (**40**) and chelerythrine (**36**) were tested to be the active antitumor components of *M. cordata* by determining the IC_{50} values against A-549, HCT-8 and Bel-7402 cell lines (Yang et al, 2011).

6-Methoxy-dihydro-sanguinarine (**14**) from the plants of *Hylomecon* Maxim. suppressed the growth of HepG2 cells

and HT29 colon carcinoma cells in a concentration and time dependent manner by causing apoptotic cell death (Yin et al, 2005; Lee et al, 2004)

The benzophenanthridines from *M. microcarpa*, in particular those methoxylated at C-6, showed the cytotoxic activities against five human cancer cell lines: HCT-8, Bel-7402, BGC-823, A2780, and A549 (Deng and Qin, 2010). And these crude alkaloids could induce the degeneration necrosis of sarcoma cells in rats as well (Fan et al, 2000).

Several studies suggested that Ukrain™ (an anticancer drug whose major components were thiophosphate derivative of total alkaloids from *C. majus*) (Habermehl et al, 2006) exerted multiple selective effects on cancer cells, such as cytotoxic effects on cancer cells without negative effects on normal cells (Hohenwarter et al, 1992) and radio-sensitising effects on cancer cells, but radio-protective effects on normal cells (Cordes et al, 2002).

3.5 Analgesic and antispasmodic effects

The aqueous extract from *C. majus* suppressed glycine, and gamma-aminobutyric acid (GABA) activated ion currents and elevated glutamate-activated ion currents in rat peri-aqueductal gray neurons which represented a key structure of the descending pain control system (Shin et al, 2003; Kim et al, 2001). *C. majus* alkaloids also had an analgesic effect, similar to that of morphine, which might last 4–48 h (Huang, 1999). In addition, the extracts of *C. majus*, as well as the isolated alkaloids, exhibited the antispasmodic and relaxant effects on the abdominal and gastrointestinal muscles of animals, being especially efficient in treating abdominal pain (Boegge et al, 1996; Hiller et al, 1998).

3.6 Hepatoprotective activity

The ethanol extract from *C. majus* exerted the marked hepatoprotective effect against CCl_4 toxicity of rats by a reduction of the necrotic cells a prevention of fibrotic changes, and decreased the activities of transaminases and bilirubin (Mitra et al, 1992; 1996). It was also efficient in combating *p*-dimethylaminoazobenzene-induced hepatocarcinogenesis in mice (Biswas et al, 2008).

The extracts from *M. cordata* could improve the liver functions of acute hepatic injuries in rats caused by CCl_4 or galactosamine according to its abilities of reducing the level of serum LDH and mortality, increasing the ratio of A/G, protecting cellular membrane and inhibiting fibrosis (Yang et al, 1999). It could also protect the alcohol-induced acute hepatic injuries by inhibiting hepatic lipid peroxidation and alleviating the inflammation (Xiao et al, 2011).

The extract from *D. leptopodum* had the protective effects on the experimental liver injuries induced by CCl_4 in mice. The mechanisms may contribute to its anti-oxidative activities and its effects of removing free radicals generated by CCl_4 metabolization, suppressing LPD of membrane, and decreasing the level of MDA (Mao et al, 2008; Zhang et al, 2004). It had a certain effect as well on the immune hepatic injuries induced by BCG plus LPS in mice (Mao et al, 2004).

The single alkaloid chelerythrine (**36**) could improve the hepatic injuries in rats with tetrachloride-induced hepatic fibrosis in a dose-dependent manner (Li et al, 2009), it could reduce the level of serum HA but not serum ALT, while it could not protect the liver cells of hepatic fibrosis in rats (Wang et al, 2010).

3.7 Choleretic activity

A hydroethanolic extract containing 1.5% total alkaloids of *C. majus* calculated as chelidonine (**27**) ig administered could increase the bile flow in subjects with liver diseases and healthy volunteers (Baumann 1975; Baumann et al, 1971). Stimulatory effects of the total alkaloids and phenolic fraction from *C. majus* had been reported on bile acid-independent flow in isolated perfused rat liver. After 40 min, the amount of bile was more than twice of the initial value and the bile acid concentration was reduced. However, this effect could not just be assigned to one of the two isolated fractions (Vahlensieck et al, 1995).

3.8 Anti-oxidantive activity

Although the alcoholic extract from *C. majus* showed the strong anti-oxidative activity measured by different assays, such as 1, 1-diphenyl-2-picrylhydrazyl radical scavenging assay or FRAP assay, this did not depend on the alkaloid content of the drug or transition metal element content (Then et al, 2003; Nadova et al, 2008). There was also an animal study that reported a slight but significant reduction of glutathione level and SOD activity in the liver after ig administration of a massive dose of *C. majus* [1.5–3 g/(kg·d)] (Mazzanti et al, 2009). These results suggest that, in spite of its intrinsic antioxidant properties, *C. majus* might compromise the hepatic anti-oxidant protection in case of overdose (Gilca et al, 2010).

In murine macrophage RAW264.7 cells, *M. cordata* extract increased both mRNA and protein levels of 20 HO-1. And only sanguinarine (**40**) appeared to be responsible for these effects by increasing the capacity of the enzymatic anti-oxidant defence system via activation of the p38 MAPK/Nrf2 pathway (Vrba et al, 2012).

Major alkaloids from *C. majus*, *M. cordata*, and *M. microcarpa*, namely, berberine (**55**), sanguinarine (**40**), chelidonine (**27**), and drugs Ukrain and Sanguirythrine [a mixture of alkaloids sanguinarine (**40**) and chelerythrine (**36**), 3:7, isolated from *Macleaya*] were tested for their anti-oxidative activities. They were all irreversible inhibitors of oxidative deamination reaction of serotonin and tyramine as substrates, catalyzed by rat liver mitochondrial monoamine oxidase (MAO) (Iagodina et al, 2003; Kuznetsova et al, 2001).

Chelerythrine (**36**) chloride illustrated the neuroprotective activity by protecting SHSY5Y neuronal cells against oxygen-glucose deprivation through activating the superoxide dismutase, then reducing the intracellular concentration of superoxide anion and calcium, thereafter inhibiting protein

kinase C (Zou et al, 2009).

Anticholinesterase effect was related tightly to anti-oxidative activity. Ethanol extract from the aerial parts of *C. majus* inhibited acetylcholinesterase (AChE) activity without a significant inhibition of butyrylcholinesterase (BuChE). Using mass spectrometry and NMR studies, three active constituents were isolated and identified as 8-hydroxy-dihydrochelerythrine (**15**), 8-hydroxy-dihydrosanguinarine (**16**), and berberine (**55**). They showed potent inhibitory activity against AChE, with IC_{50} values of 0.61–1.85 mmol/L. Compound **15** exhibited the competitive and selective inhibition for AChE (Cho et al, 2006). Then five isoquinoline alkaloids, along with two artifacts from the roots and aerial parts of *C. majus* were tested for the inhibitory activity against human blood acetylcholinesterase (HuAChE) and human plasma butyrylcholinesterase (HuBuChE). The most active one of the naturally-occurring alkaloids was chelidonine (**27**) which inhibited both HuAChE and HuBuChE in a dose-dependent manner with IC_{50} values of (26.8 ± 1.2) and (31.9 ± 1.4) mmol/L, respectively (Cahlikova et al, 2010). Meanwhile, it showed that some benzophenanthridine and diisoquinoline alkaloids from *C. majus*, *M. cordata*, *M. microcarpa* (**55**, **40**, and **36**) and two drugs (Ukrain and Sanguirythrine) inhibited the enzyme activity of AChE from human erythrocyte. All agents under the study had been shown to be reversible inhibitors of the enzymatic hydrolysis of acetylthiocholine. It had been determined that compound **31** belonged to the reversible inhibitors of a competitive type and all other examined agents had been demonstrated to be the inhibitors of a mixed competitive-noncompetitive type (Kuznetsova et al, 2005).

3.9 Antiparasitic and antimolluscicidal effects

In vivo anthelmintic efficacy tests exhibited that chelidonine (**27**) and chelerythrine (**36**) from *C. majus* were 100% effective against *Dactylogyrus intermedius* at the concentration of 0.9 and 1.60 mg/L, with EC_{50} values of 0.48 mg/L for compound **27** and 0.68 mg/L for compound **36** after 48 h exposure (Yao et al, 2011; Li et al, 2011).

In vitro antiparasitic efficacy tests indicated that sanguinarine (**40**) from *M. cordata* was 100% effective against *Ichthyophthirius multifiliis* in grass carp (*Ctenopharyngodon idella*) at a concentration of 0.7 mg/L, with LC_{50} and LC_{90} values of 0.437 and 0.853 mg/L after 4 h exposure, and the number of *I. multifiliis* on the gills in the treatment group (in 0.9 mg/L, **40**) was reduced by 96.8%, comparised to the untreated group at 25 °C for 48 h. Mortality of fish did not occur in the treatment group during the trail, although 40% the untreated fish died (Yao et al, 2010). The chloroform extract from *M. microcarpa* also showed a promising antiparasitic activity against *I. multifiliis*. The *in vivo* tests revealed that dihydrosanguinarine (**21**) and dihydrochelerythrine (**19**) were effective against *I. multifiliis* with EC_{50} values of 5.18 and 9.43 mg/L, respectively. The LC_{50} values of compounds **21** and **19** for richadsin were 13.3 and 18.2 mg/L, respectively (Yao et al, 2011), and these two active alkaloids at the same time were clarified to have insecticidal activities against *Mythimna separata* larvae (Feng et al, 2008). Other five bioactive alkaloids, sanguinarine (**40**), cryptopine (**67**), β-allocryptopine (**61**), protopine (**63**), and 6-methoxyl-dihydrochelerythrine (**13**) from *M. microcarpa* were found to be 100% effective at the concentration of 0.7, 8.0, 8.0, 16.0, and 7.0 mg/L with the EC_{50} values of 0.37, 3.31, 4.64, 8.13, and 3.63 mg/L, respectively, in *in vivo* anthelmintic assays (Wang et al, 2010). Additionally, the alkaloids from *E. chionantha* were testified to be against *Schistosoma japonicum* cercaria (Huang et al, 2003).

Crude methanolic extract from *B. frutescens* showed the moderate activity (IC_{50} 30.9 μg/mL) against *Trichomonas vaginalis*, which was the etiological agent of trichomoniasis (Calzada et al, 2007). And *B. integrifolia* showed the *in vitro* activity against axenic amastigotes of *Leishmania donovani*, *Plasmodium falciparum*, *Trypanosoma brucei rhodesiense*, and *Trypanosoma cruzi* (Gachet et al, 2010). As well, the methanolic extract from *B. pearcei* fruit exhibited the most potent leishmanicidal activity *in vitro* with the minimum lethal concentration (MLC) of 3.1 mg/mL (Fuchino et al, 2010).

The molluscicidal effects of the alkaloids and derivatives from *Macleaya cordata* and *Eomecon chionantha* against *Oncomelania hupensis* snails, the intermediate host of schistosemiasis was revealed to be both time and concentration dependent (Huang et al, 2003; Zhong et al, 2011; Liu et al, 2001). The toxicity of these alkaloids to fish was lower than that to oncomelania, the total alkaloids thus represented a promising plant-derived molluscicide (Yang et al, 2003).

3.10 Anti-ulcerogenic activity

The extract from *C. majus* had demonstrated the anti-ulcerogenic activity against indomethacin-induced gastric ulcers in rats as well as antisecretory and cytoprotective activities. The anti-ulcerogenic activity was associated with an increase in prostaglandin E_2 release and a decrease in leukotrienes (Khayyal et al, 2001). The aqueous extract of *B. frutescens* showed the highest antisecretory activity on cholera toxin-induced intestinal secretion in rat jejunal loops model with inhibition values of 86.0% (Velázquez et al, 2006).

3.11 Other activities

3.11.1 Irradiation-protective activity

An extract from *C. majus* was found to increase the number of bone marrow cells, spleen cells, GM-CFC, platelets and to favour the survival at lethal doses in irradiated mice (Song et al, 2003). Also, Ukrain minimized the consequences of irradiation in the endocrine system of the trial animals (Luksa-Lichtenthaeler et al, 2000).

3.11.2 Anti-osteoporotic activity

Ukrain™, when ip administered to ovariectomized mature female rats, prevented the decrease of bone mineral density of the femur measured by energy X-ray absorptiometry densitometry (Jabloński et al, 2000), and

increased the electron paramagnetic resonance (EPR) signal intensity of the femur (Jabloński et al, 2000). These effects are most probably related to an increased production of estrogens (Gilca et al, 2010; Jabloński, 2000).

3.11.3 Antihematolysis activity

The effect of *D. leptopodum* extract on oxidative hemolysis of mouse erythrocytes was tested *in vitro*. It had been found that *D. leptopodum* extract was effective in suppressing the hemolysis induced by H_2O_2 or acetyl phenyl hydrazine (APH), which might be due to the enhancement of activity of glucose-6-phosphate dehydrogenase (G-6-PD) (Zhao et al, 2006).

3.11.4 Antimicrotubule activity

Chelidonine (**27**), sanguinarine (**40**), and chelerythrine (**36**) were tested to inhibit taxol-mediated polymerization of rat brain tubulin in the micromolar range. Compound **27** was a weak and competitive inhibitor of colchicine binding to tubulin and did not inhibit podophyllotoxin binding. On the other hand, compound **40** inhibited both colchicine and podophyllotoxin binding to tubulin with ISO values of 32 and 46 pmol/L, respectively, and compound **36** inhibited with ISO values of 55 and 60 pmol/L, respectively. The inhibition by these two agents was of the mixed type. A number of previously described pharmacologic effects of these agents might be due to their inhibition of microtubule function (Wolff and Knipling, 1993).

3.11.5 Vasoactive activity

The extract from *B. frutescens* induced concentration-dependent contraction of rat aortic rings, suggesting that this plant had potential health benefits for the treatment of ailments such as venous insufficiency (Ibarra-Alvarado et al, 2010).

3.11.6 Receptors inhibiting effects

The 80% ethanol extract from the roots of *B. frutescens*, showed a dose-dependent inhibitory effect towards both [3H]-angiotensin II and [3H]-BQ-123 binding to the human angiotensin II At1 and endothelin 1 ETA receptors. Sanguinarine (**40**) and chelerythrine (**36**) were significant inhibitors of [3H]-angiotensin II binding (hAT1 receptor), with IC_{50} values within the micromolar range (Caballero-George et al, 2002). Chelidocystatin of *C. majus* was a strong inhibitor of cathepsin L ($K_i = 5.6 \times 10^{11}$ mol/L), papain ($K_i = 1.1 \times 10^{10}$ mol/L) and cathepsin H ($K_i = 7.5 \times 10^{9}$ mol/L) (Rogelj et al, 1998).

3.12 Toxicities

3.12.1 Cytotoxicity

Pang (2005) had tested the cytotoxic activity of 14 components from *M. cordata* on MCF-7, NCI-H460, Hela, and HepG2 cancer cell lines as well as human normal 293 cells by MTT method. Results showed that sanguinarine (**40**) and 6-methoxydihydrochelerythrine (**13**) strongly inhibited the growth of four kinds of tumor cells together with 293 cells *in vitro*, and protopine (**63**) showed the selective cytotoxicity on Hela and HepG2 cell lines while displayed relatively weak cytotoxicity on human normal 293 cells. The *M. cordata* decoction could induce and improve the apoptosis of myocardium cells in low dose，and these effects might be induced by stimulating the activity of Ca^{2+}•Mg^{2+}-ATPase and SDH in myocardium cells (Wu et al, 2008).

The individual alkaloids had been proved their cytotoxic activities too. Chelerythrine (**36**) rapidly induced cardiac myocyte apoptosis and the production of ROS, possibly H_2O_2, and subsequent cytochrome c released from mitochondria played an important role in mediating chelerythrine-induced apoptosis (Yamamoto et al, 2001). Sanguinarine (**40**) exhibited the greatest toxicity toward NK/Ly cells, and the toxicity of the other three alkaloids decreased in descending order: chelerythrine (**36**), coptisine (**59**), and chelidonine (**27**) (O Kaminskyy et al, 2006).

3.12.2 Hepatotoxicity

Several isolated cases of hepatotoxicity (e.g. acute cholestatic hepatitis) of *C. majus* had been reported (Van, 2002; Hardeman et al, 2008; Moro et al, 2009). But there was also an animal study that found no hepatotoxicity at doses about 50–100 times higher than those generally used in humans (Mazzanti et al, 2009). Therefore, it needs further assessment on the hepatotoxicity of *C. majus*.

3.12.3 Phototoxicity

A test had been taken to determine the phototoxicity of 17 plants. The extract from *C. majus* had been revealed the ability to induce sunburn oedema and formation of sunburn cells in mice (Bark et al, 2010).

3.12.4 Genotoxicity

Chelerythrine (**36**) and sanguinarine (**40**) were indicated to cause DNA damage, which was illustrated by the formation of comets of the third class. Coptisine (**59**) was less toxic than compounds **36** and **40**, and affected the formation of comets in the same class at higher concentration, and the quantity of comets induced by chelidonine (**27**) was negligible (O Kaminskyy et al, 2006). But it could not find the genotoxic effects of 120 mg/kg *M. cordata* extract (a mixture of compounds **40** and **36**) on pigs or rats in 90-d studies by ig administration (Stiborova et al, 2008).

4. Conclusion

Almost all species of tribe Chelidonieae have a long history to be used as folk medicine for the treatment of many diseases in northern hemisphere. *Chelidonium majus*, the most widely used as an important raw material, has been recorded in *Chinese Pharmacopoeia* (Pharmacopoeia Committee of P. R. China, 2010) as well as *European Pharmacopoeia* (Henning and Tsoka, 2003). Phytochemical researches of tribe Chelidonieae have shown that isoquinoline alkaloids are the main components, and the widespread benzophenanthridine alkaloids, especially chelerythrine and

sanguinarine, could be regarded as the characteristic compounds of this tribe. The mixtures of some benzophenanthridine alkaloids (sanguinarine, chelerythrine, chelidonine, etc) and their derivatives have now been developed as antitumor drugs (Ukrain and Sanguirythrine). In addition, other components from the plants of this tribe, such as chelidonic acid and some proteins have been manifested to have different bioactivities.

Modern pharmacological investigations of crude extracts and purified compounds from these plants elucidated a broad spectrum of biological activities, including anti-inflammatory, immunomodulatory, antimicrobial, antitumor effects and so on, which support a number of their traditional uses. Veterinary activities of some species of this tribe had also been verified. In additional, the studies on the toxicities of these plants were concentrated on cytotoxicity, hepatotoxicity, phototoxicity, and genotoxicity. However, the some results on the hepatotoxicity and genotoxicity were inconsistent to call out further investigations.

Therefore, further comparative research on the relatives of each species in tribe Chelidonieae is needed to explore the medicinal recourses. Based on four data sets of *atp*B and *rbc*L sequences, *trn*K restriction sites, and morphological characters, Hoot et al (1997) had obtained the phylogenetic topologies of Papaveraceae. It suggested that genus *Dicranostigma* Hook. was the most closely related to genus *Glaucium* Mill. in tribe Papavereae. This result is consistent with the fact that aporphine alkaloids, the characteristic components from the species of Papavereae, are rich in *D. leptopodum*. Consequently, according to the huge potential medicinal value of the plants in tribe Chelidonieae, in-depth scientific comparative analyses of the phytochemical constituents and genetic information are required, not only to investigate the evolutionary and pharmaphylogenic relationship, but also to guide the medicinal exploitation and utilization of the medicinal plants in this tribe.

References

Ashok D, Sharma PN, 1988. Chemical examination of flowers of *Cassia spetabilis* DC. *Indian J Chem B* 27: 862-862.

Bark KM, Heo EP, Han KD, Kim MB, Lee ST, 2010. Evaluation of the phototoxic potential of plants used in oriental medicine. *J Ethnopharmacol* 127(1): 11-18.

Baumann JC, 1975. Effect of *Chelidonium*, *Curcuma*, *Absinth* and *Carduus marianus* on the bile and pancreatic secretion in liver diseases. *Med Monatsschr* 29(4): 173-180.

Baumann JC, Heintze K, Muth HW, 1971. Clinico-experimental studies on the secretion of bile, pancreatic and gastric juice under the influence of phytocholagogous agents of a suspension of *Carduus marianus*, *Chelidonium* and *Curcuma*. *Arzneimittel-Forsch* 21(1): 98-101.

Bilka F, Vanko M, Balazová A, Bilková A, Holková I, 2007. Characterization of polyphenoloxidase from the latex of greater celandine (*Chelidonium majus* L.). *Ceska Slov Farm* 56(2): 90-94.

Biswas SJ, Bhattacharjee N, Khuda-Bukhsh AR, 2008. Efficacy of a plant extract (*Chelidonium majus* L.) in combating induced hepatocarcinogenesis in mice. *Food Chem Toxicol* 46(5): 1474-1487.

Boegge SC, Kesper S, Verspohl EJ, Nahrstedt A, 1996. Reduction of ACh-induced contraction of rat isolated ileum by coptisine, (+)-caffeoylmalic acid, *Chelidonium majus* and *Corydalis lutea* extracts. *Planta Med* 62(2): 173-174.

Caballero-George C, Vanderheyden PM, Apers S, Van den Heuvel H, Solis PN, Gupta MP, Claeys M, Pieters L, Vauquelin G, Vlietinck AJ, 2002. Inhibitory activity on binding of specific ligands to the human angiotensin II AT(1) and endothelin 1 ET(A) receptors: Bioactive benzo[c]phenanthridine alkaloids from the root of *Bocconia frutescens*. *Planta Med* 68(9): 770-775.

Cahlikova L, Opletal L, Kurfurst M, Macakova K, Kulhankova A, Hostalkova A, 2010. Acetylcholinesterase and butyryl-cholinesterase inhibitory compounds from *Chelidonium majus* (Papaveraceae). *Nat Prod Commun* 5(11): 1751-1754.

Calzada F, Yepez-Mulia L, Tapia-Contreras A, 2007. Effect of Mexican medicinal plant used to treat trichomoniasis on *Trichomonas vaginalis* trophozoites. *J Ethnopharmacol* 113(2): 248-251.

Cao J, Wang LJ, Wu MH, Qiao Y, Sun YJ, Guo J, 2011. Mechanism governing reversal of multidrug resistance in human breast carcinoma cells by chelerythrine. *Acta Acad Med Sin* 33(1): 45-50.

Chang XR, Wang HX, Ma GE, 1981. Study on the chemical constituents of *Dicranostigma leptopodum*. *Chin Pharm Bull* 2(16): 52-54.

Chang XR, Wang HX, Zhou GZ, Ma GE, 1982. Studys on the chemical constituents and morphology of *Dicranostigma leptopodum*. *Chin J Pharm Anal* (5): 273-278.

Chen LJ, Zhou SY, Shi HZ, Yin J, 2009. Determination of chemical composition of the essential oil from *Macleaya cordata* by GC-MS. *Chin Agri Sci Bull* 25(7): 94-96.

Chen ZS, Wang Q, Wang TP, Zhang Q, Gong YN, Zhao Q, 2001. Influences of *Dicranostigma leptopodum* (Maxim) Fedde (DLF) on the immune functions of murine peritoneal macrophages (PMφ). *Shanghai J Immun* 21: 216-218.

Cheng HY, Cheng JX, Wei H, Bai JQ, 2011. The research progress of a "TaiBai Seven Herbal Medicine" *Hylomecon japonica*. *J Shaanxi Coll Trad Chin Med* 34(4): 94-95.

Cho KM, Yoo ID, Kim WG, 2006. 8-hydroxydihydrochelerythrine and 8-hydroxydihydrosanguinarine with a potent acetylcholine-sterase inhibitory activity from *Chelidonium majus* L. *Biol Pharm Bull* 29(11): 2317-2320.

Choi JG, Kang OH, Chae HS, Obiang-Obounou B, Lee YS, Oh YC, Kim MS, Shin DW, Kim JA, Kim YH, Kwon DY, 2010. Antibacterial activity of *Hylomecon* hylomeconoides against methicillin-resistant *Staphylococcus aureus*. *Appl Biochem Biotechol* 160: 2474-2567.

Chung HS, An HJ, Jeong HJ, Won JH, Hong SH, Kim HM, 2004. Water extract isolated from *Chelidonium majus* enhances nitric oxide and tumour necrosis factor-alpha production via nuclear factor-kappaB activation in mouse peritoneal macrophages. *J Pharm Pharmacol* 56(1): 129-134.

Committee on Herbal Medicinal Productsn, 2012. Assessment report on *Chelidonium majus* L. herba in European Medicines Agency.

Cordes N, Plasswilm L, Bamberg M, Rodemann HP, 2002. Ukrain, an alkaloid thiophosphoric acid derivative of *Chelidonium majus* L. protects human fibroblasts but not human tumour cells *in vitro* against ionizing radiation. *Int J Radiat Biol* 78(1): 17-27.

Cruz-Vega DE, Verda-Star MJ, Salinas-González N, Rosales-Hernández B, Estrada-García I, Mendez-Aragón P, Carranza-Rosales P, González-Garza MT, Castro-Garza J, 2008. Anti-mycobacterial activity of *Juglans regia*, *Juglans mollis*, *Carya illinoensis* and *Bocconia frutescens*. *Phytother Res* 22: 557-559.

Dang Y, Sun CX, Xun XZ, Ma ZH, 2008. Vaccines and formulation of *Dicranostigma leptopodum* to the control effect of sheep contagious pustular dermatitis. *Contemp Anim Husb* (10): 17-18.

De Rose S, Di Vincenzo G, 1992. Isochelidonine, a benzo-phenanthridinealkaloid from *chelidonium majus*. *Phytochemistry* 31(3): 1085-1086.

Deng AJ, Qin HL, 2010. Cytotoxic dihydrobenzophenanthridine alkaloids from the roots of *Macleaya microcarpa*. *Phytochemistry* 71(7): 816-822.

Deng AJ, 2008. Studies on the chemical constituents of *Macleaya microcarpa* and *Bridelia tomentosa*. Chinese Academy of Medical Science & Peking Union Medical College.

Dostál J, Bochořáková H, Táborská E, Slavík J, 1996. Structure of anguinarine bases. *J Nat Prod* 59: 599-602.

Du FL, Chen SH, Yang CM, 1993. Study on the chemical constituents of *Eomecon chionantha* Hance. *Chin Tradit Herb Drugs* 24(4): 177-179.

Du FL, Zhang Y, Zheng GD, Ou YW, 2006. Studies on the lipophilic compound from the aerial parts of *Eomecon chionantha* Hance. *J Chin Med Meter* 29(7): 581.

Dzink JL, Socransky SS, 1985. Comparative *in vitro* activity of sanguinarine against oral microbial isolates. *Antimicrob Agents Chemother* 27(4): 663-665.

Fan SL, Jiao F, Zhang Y, An CX, Fu JM, 2000. Study on effect of total alkaloids of *Macleaya cordata* to animal's transplanted tumor. *Shanxi Oncol Med* 8(3): 174-175.

Feng G, Zhang J, Feng JT, Zhang X, 2008. Isolation and identification of insecticidal composition of *Macleaya microcarpa*. *Acta Bot Boreal-Occident Sin* 28(1): 179-182.

Feng RZ, Lian WY, Fu GX, Xiao PG, 1985. Chemical classification and resource utilization of tribe Chelidonieae (Pavaveraceae). *Acta Phytotaxon Sin* 23(1): 36-42.

Fuchino H, Kawano M, Mori-Yasumoto K, Sekita S, Satake M, Ishikawa T, Kiuchi F, Kawahara N, 2010. *In vitro* leishmanicidal activity of benzophenanthridine alkaloids from *Bocconia pearcei* and related compounds. *Chem Pharm Bull* 58(8): 1047-1050.

Gachet MS, Lecaro JS, Kaiser M, Brun R, Navarrete H, Muñoz RA, Bauer R, Schühly W, 2010. Assessment of anti-protozoal activity of plants traditionally used in Ecuador in the treatment of *leishmaniasis*. *J Ethnopharmacol* 128: 184-197.

Gerencer M, Turecek PL, Kistner O, Mitterer A, Savidis-Dacho H, Barrett NP, 2006. *In vitro* and *in vivo* anti-retroviral activity of the substance purified from the aqueous extract of *Chelidonium majus* L. *Antiviral Res* 72(2): 153-156.

Gilca M, Gaman L, Panait E, Stoian I, Atanasiu V, 2010. *Chelidonium majus*–an integrative review: Traditional knowledge versus modern findings. *Forschende Komplementarmedizin* 17: 241-248.

Greathouse GA, 1939. Alkaloids from *Sanguinaria canadensis* and their inflence in growth of *Phymatotrichun omnivorum*. *Plant Physiol* 14(2): 377-380.

Gregorová J, Babica J, Marek R, Paulová H, Táborská E, Dostál J, 2010. Extractions of isoquinoline alkaloids with butanol and octanol. *Fitoterapia* 81: 565-568.

Habermehl D, Kammerer B, Handrick R, Eldh T, Gruber C, Cordes N, Daniel PT, Plasswilm L, Bamberg M, Belka C, Jendrossek V, 2006. Proapoptotic activity of Ukrain is based on *Chelidonium majus* L. alkaloids and mediated via a mitochondrial death pathway. *BMC Cancer* 6: 14.

Hahn R, Nahrstedt A, 1993. Hydroxycinnamic acid derivatives, caffeoylmalic and new caffeoylaldonic acid esters, from *Chelidonium majus*. *Planta Med* 59(1): 71-75.

Hardeman E, Van Over beke L, Ilegems S, Ferrante M, 2008. Acute hepatitis induced by greater celandine (*Chelidonium majus*). *Acta Gastro-Ent Belg* 71(2): 281-282.

Henning HG, Tsoka A, 2003. Greater celandine, In: *European Pharmacopoeia, Fourth Edition* (Ed. D.H. Calan), European Pharmacopoeia, Strasbourg.

Hichenkov A, Kaminsky V, Zavelevich M, Stoika R, 2008. Apoptogenic activity of two benzophenanthridine alkaloids from *Chelidonium majus* does not correlate with their DNA damaging effects. *Toxicol In Vitro* 22(2): 287-295.

Hiller KO, Ghorbani M, Schilcher H, 1998. Antispasmodic and relaxant activity of chelidonine, protopine, coptisine, and *Chelidonium majus* extracts on isolated guinea-pig ileum. *Planta Med* 64(8): 758-760.

Hohenwarter O, Strutzenberger K, Katinger H, Liepins A, Nowicky JW, 1992. Selective inhibition of *in vitro* cell growth by the anti-tumour drug Ukrain. *Drugs Exp Clin Res* 18: S1-S4.

Hoot SB, Kadereit JW, Blattner FR, Jork KB, Schwarzbach AE, Crane PR. 1997. Data congruence and phylogeny of the Papaveraceae s.l. based on four data sets: *atpB* and *rbcL* sequences, *trnK* restriction sites, and morphological characters. *Syst Bot* 22: 575-590.

Hu ZB, Xu Y, Feng SC, Fan GJ, 1979. Study on the effective compounds in the seeds of *Macleaya cordata*. *Acta Pharm Sin* 14(9): 535-540.

Huang CK, 1999. *The Pharmacology of Chinese Herbs*. 2 ed. CRC Press: Boca Raton.

Huang QY, Peng F, Liu NM, Yang HZ, Hu Q, Feng F, Sun H, 2003. An experimental study on alkaloids of *Eomecon chionantha* Hance against *Oncomelania hupensis* and *Schistosoma japonicum* cercaria. *Pract Prev Med* 10(3): 289.

Huang S, Du FL, 2002. Research progress on Papaveraceae Chelidonieae's chemical component and phytochemistry classification basis. *Hunan Guiding J TCMP* 8(10): 582-584.

Iagodina OV, Nikol'Skaia EB, Faddeeva MD, 2003. Inhibition of liver mitochondrial monoamine oxidase activity by alkaloids isolated from *Chelidonium* and *Macleaya* and by their derivative drugs. *Tsitologiia* 45(10): 1032-1037.

Ibarra-Alvarado C, Rojas A, Mendoza S, Bah M, Gutierrez DM, Hernandez-Sandoval L, Martinez M, 2010. Vasoactive and antioxidant activities of plants used in Mexican traditional medicine for the treatment of cardiovascular diseases. *Pharm Biol* 48(7): 732-739.

Jabloński M, 2000. Ukrain (NSC-631570) influences on bone status: A review. *Drug Exp Clin Res* 26(5/6): 317-320.

Jabloński M, Gorzelak M, Patyra M, Jagiełło-Wójtowicz E, 2000. Intermittent three-month treatment with Ukrain in intact and ovariectomized rats. Part II: Effect on bone mineral density of the femur. *Drug Exp Clin Res* 26(5/6): 327-331.

Jabloński M, Korczak W, Gorzelak M, Jagiełło-Wójtowicz E, 2000. Intermittent three-month treatment with Ukrain in intact and ovariectomized rats. Part III: Effect on the native electron paramagnetic resonance signal intensity of the femur. *Drug Exp Clin Res* 26(5/6): 333-336.

Jang SI, Kim BH, Lee WY, An SJ, Choi HG, Jeon BH, Chung HT, Rho JR, Kim YJ, Chai KY, 2004. Stylopine from *Chelidonium majus* inhibits LPS-induced inflammatory mediators in RAW 264.7 cells. *Arch Pharm Res* 27(9): 923-929.

Kadan G, Gözler T, Shamma M, 1990. (–)-Turnyenine, a new alkaloid from *Chelidonium majus*. *J Nat Prod* 53(2): 531-532.

Kéry A, Horváth J, Nász I, Verzár-Petri G, Kulcsar G, Dán P, 1987. Antiviral alkaloid in *Chelidonium majus* L. *Acta Pharm Hung* 57(1/2): 19-25.

Khayyal MT, El-Ghazaly MA, Kenawy SA, Seif-el-Nasr M, Mahran

LG, Kafafi YA, Okpanyi SN, 2001. Antiulcerogenic effect of some gastrointestinally acting plant extracts and their combination. *Arzneimittel-Forsch* 51(7): 545-553.

Khmel'Nitskaia NM, Vorob'Ev KV, Kliachko LL, Ankhimova ES, Kosenko VA, Tryrnva EV, Mal'Tseva GS, Medveded EA, 1998. A comparative study of conservative treatment schemes in chronic tonsillitis in children. *Vestn Otorinolaringol* (4): 39-42.

Kim DJ, Ahn B, Han BS, Tsuda H, 1997. Potential preventive effects of *Chelidonium majus* L. (Papaveraceae) herb extract on glandular stomach tumor development in rats treated with *N*-methyl-*N*′-nitro-*N*-nitrosoguanidine (MNNG) and hypertonic sodium chloride. *Cancer Lett* 112(2): 203-208.

Kim Y, Shin M, Chung J, Kim E, Koo G, Lee C, Kim C, 2001. Modulation of Chelidonii herba on GABA activated chloride current in rat PAG neurons. *Am J Chinese Med* 29(2): 265-279.

Kokoska L, Polesny Z, Rada V, Nepovim A, Vanek T, 2002. Screening of some Siberian medicinal plants for antimicrobial activity. *J Ethnopharmacol* 82(1): 51-53.

Kosina P, Gregorova J, Gruz J, Vacek J, Kolar M, Vogel M, Roos W, Naumann K, Simanek V, Ulrichova J, 2010. Phytochemical and antimicrobial characterization of *Macleaya cordata* herb. *Fitoterapia* 81: 1006-1012.

Kuznetsova LP, Nikol'Skaia EB, Sochilina EE, Faddeeva MD, 2001. The inhibition enzymatic hydrolysis of acetylthiocholine by acetylcholinesterase using principal alkaloids isolated from celandine and macleya and their derivatives. *Tsitologiia* 43(11): 1046-1050.

Kuznetsova LP, Sochilina EE, Faddeeva MD, Lagodina OV, 2005. Effect of some isoquinoline alkaloids on enzymatic activity of acetylcholinesterase and monoamine oxidase. *Ukr Biokhim Zh* 77(2): 147-153.

Lee YC, Kim SH, Roh SS, Choi HY, Seo YB, 2007. Suppressive effects of *Chelidonium majus* methanol extract in knee joint, regional lymph nodes, and spleen on collagen-induced arthritis in mice. *J Ethnopharmacol* 112(1): 40-48.

Lee YJ, Yin HQ, Kim YH, Li GY, Lee BH, 2004. Apoptosis inducing effects of 6-methoxydihydrosanguinarine in HT29 colon carcinoma cells. *Arch Pharm Res* 27(12): 1253-1257.

Lenfeld J, Kroutil M, Marsálek E, Slavik J, Preininger V, Simánek V, 1981. Antiinflammatory activity of quaternary benzophenanthridine alkaloids from *Chelidonium majus*. *Planta Med* 43(2): 161-165.

Li XL, Yao JY, Zhou ZM, Shen JY, Ru HS, Liu XL, 2011. Activity of the chelerythrine, a quaternary benzo[c]phenanthridine alkaloid from *Chelidonium majus* L. on *Dactylogyrus intermedius*. *Parasitol Res* 109(1): 247-252.

Li YJ, Wang YH, Liu YM, Liu YX, 2009. Effects of chelerythine on hepatic pathology and hydroxyproline level in rats with CCl_4-induced hepatic fibrosis. *J Clin Hepatol* 12(3): 167-171.

Liu CZ, Tong JM, Zhang LM, 2006. Atiasthmatic action of total alkaloid from *Chelidouium majus*. *Chin Hosp Pharm J* 26(1): 27-29.

Liu DH, Zhang TC, Liu JX, Di DL, Dang Y, 2011. Chemical constituents of alkaloids from *Dicranostigma leptopodum*. *Chin Trad Herb Drugs* 42(8): 1505-1509.

Liu NM, Peng F, Huang QY, Yang HZ, Hu Q, Feng F, Zhou XX, Zhou TD, 2001. Primary discussion on the effect of total alkaloids of *Eomecon chionantha* Hance to *Oncomelania*. *Chin J Schistosomiasis Contr* 13(5): 303.

Lozjuk RM, Lisnyak OI, Lozjuk LV, 1996. Theoretical grounds and experimental confirmation of the antiviral effect of the preparation Ukrain. *Drugs Exp Clin Res* 22(3/5): 213-217.

Luksa-Lichtenthaeler GL, Ladutko EI, Nowicky JW, 2000. Radiomodification effects of Ukrain, a cytostatic and immunomodulating drug, on intracellular glucocorticoid reception during short-term gamma-irradiation. *Drug Exp Clin Res* 26(5/6): 311-315.

Mao AH, Tang DP, Xia XH, Wei J, Wang Q, 2008. Protective effects of *Dicranostigma leptopodum* (Maxim.) Fedde extractives on acute liver injury induced by CCl4 in mice. *J Lanzhou Univ Med Sci* 34(2): 17-20.

Mao AH, Zhang Y, Zhao Q, Wang Q, Wang TP, 2004. Protective effect of *Dicranostiga leptodu* (Maxim.) Fedde on immunological live injury in mice. *Chin Pharmacol Bull* 20(8): 940-943.

Mazzanti G, Di Sotto A, Franchitto A, Mammola CL, Mariani P, Mastrangelo S, Menniti-lppolito F, Vitalone A, 2009. *Chelidonium majus* is not hepatotoxic in Wistar rats, in a 4 weeks feeding experiment. *J Ethnopharmacol* 126(3): 518-524.

Meng FY, Zuo GY, Hao XY, Wang GC, Xiao HT, Zhang JQ, Xu GL, 2009. Antifungal activity of the benzo[c]phenanthridine alkaloids from *Chelidonium majus* Linn against resistant clinical yeast isolates. *J Ethnopharmacol* 125: 494-496.

Mitra S, Gole M, Samadjar K, Sur RK, Chakraborty BN, 1992. Antihepatotocix activity of *Chelidonium majus*. *Int J Pharmacognosy* 30: 125-128.

Mitra S, Sur RK, Roy A, Mukherjee AS, 1996. Effect of *Chelidonium majus* L. on experimental hepatic tissue injury. *Phytother Res* 10: 354-356.

Moro PA, Cassetti F, Giugliano G, Falce MT, Mazzanti G, Menniti-lppolito F, Raschetti R, Santuccio C, 2009. Hepatitis from Greater celandine (*Chelidonium majus* L.): Review of literature and report of a new case. *J Ethnopharmacol* 124(2): 328-332.

Nadova S, Miadokova E, Alfoldiova L, Kopaskova M, Hasplova K, Hudecova A, Vaculcikova D, Gregan F, Cipak L, 2008. Potential antioxidant activity, cytotoxic and apoptosis-inducing effects of *Chelidonium majus* L. extract on leukemia cells. *Neuro Endocrinol Lett* 29(5): 649-652.

Navarro V, 1999. Two antimicrobial alkaloids from *Bocconia arborea*. *J Ethnopharmacol* 66: 223-226.

Navarro V, Villarreal ML, Rojas G, Lozoya X, 1996. Antimicrobial evaluation of some plants used in Mexican traditional medicine for the treatment of infectious diseases. *J Ethnopharmacol* 53: 143-147.

Nawrot R, Lesniewicz K, Pienkowska J, Gozdzicka-Jozefiak A, 2007. A novel extracellular peroxidase and nucleases from a milky sap of *Chelidonium majus*. *Fitoterapia* 78: 496-501.

Nawrot R, Woluń-Cholewa M, Goździcka-Józefiak A, 2008. Nucleases isolated from *Chelidonium majus* L. milky sap can induce apoptosis in human cervical carcinoma HeLa cells but not in Chinese Hamster Ovary CHO cells. *Folia Histochem Cyto* 46(1): 79-83.

Nečas M, Dostál J, Kejnovská I, Vorlíčková M, Slavík J, 2005. Molecular and crystal structures of (+)-homochelidonine, (+)-chelamine and (-)-norchelidonine. *J Mol Struct* 734: 1-6.

Noureini SK, Wink M, 2009. Transcriptional down regulation of hTERT and senescense induction in HepG2 cells by chelidonine. *World J Gastroenterol* 15(29): 2603-3610.

O Kaminskyy V, D Lootsik M, S Stoika R, 2006. Correlation of the cytotoxic activity of four different alkaloids, from *Chelidonium majus* (greater celandine), with their DNA intercalating properties and ability to induce breaks in the DNA of NK/Ly murine lymphoma cells. *Centr Euro J Biol* 1(1): 2-15.

O'Keefe BR, Beecher CWW, 1994. Isolation and characterization of *S*-adenosyl-*L*-methionine: Tetrahydroberberine-*cis*-*N*-methyltransferase from suspension cultures of *Sanguinaria canadensis*.

Plant Physiol 105: 395-403.

Onda M, Abe K, Yonezawa K, Esumo N, Suzuki T, 1970. Studies on the constituents of *Bocconia cordata* II. Bocconine. *Chem Pharm Bull* 18: 1435.

Pang FG, 2005. Study on the Anticancer constituents of *Macleaya cordata* (Willd) R. Br., in Shenyang Pharmaceutical University.

Pang JX, Ma RQ, Liu LM, Jiang YP, Sun LS, 2005. Total alkaloid of *Macleaya cordata*: *In vitro* cytotoxic effect on Hep3B cells and *in vivo* antitumor effect in mice. *J First Mil Med Univ* 25(3): 325-328.

Park JE, Cuong TD, Hung TM, Lee I, Na M, Kim JC, Ryoo S, Lee JH, Choi JS, Woo MH, Min BS, 2011. Alkaloids from *Chelidonium majus* and their inhibitory effects on LPS-induced NO production in RAW264.7 cells. *Bioorg Med Chem Lett* 21: 6960-6963.

Pěnčíková K, Urbanová J, Musil P, Táborská E, Gregorová J, 2011. Seasonal variation of bioactive alkaloid contents in *Macleaya microcarpa* (Maxim.) Fedde. *Molecules* 16(4): 3391-3401.

Perez GR, Vargas SR, Diaz GG, Martinez-Martinez F, 2002. Identification of benzophenanthridine alkaloids from *Bocconia arborea* by gas chromatography-mass spectrometry. *Phytochem Analysis* 13(3): 177-180.

Pharmacopoeia Committee of P. R. China, 2010. *Pharmacopoeia of People's Republic of China*. China Medical Science and Technology Press: Beijing.

Preininger V, 1986. Chemotaxonomy of Papaveraceae and Fumariaceae. *The Alkaloids: Chemistry and Physiology*.

Qin HL, Wang P, Li ZH, Liu X, He WY, 2004. The Establishment of the control substance and ^{1}H nuclear magnetic resonance fingerprint of *Macleaya microcarpa* (Maxim.) Fedde. *Chin J Anal Chem* 32(9): 1165-1170.

Rogelj B, Popovič T, Ritonja A, Strukelj B, Brzin J, 1998. Chelidocystatin, a novel phytocystatin from *Chelidonium majus*. *Phytochemistry* 49(6): 1645-1649.

Sárközi Á, Then M, Szentmihályi K, 2005. Mineral element content of Great Celandine (*Chelidonium majus* L.). *Acta Alimentaria* 34(2): 113-120.

Schlotterbeck JO, Watkins HC, 1902. Contribution to the chemistry of *Stylophorum diphyllum*. *J Am Chem Soc* 24: 1-20.

Sethi ML, 1981. Screening of benzophenanthridine alkaloids for their inhibition of reverse transcriptase activity and preliminary report on the structure-activity relationships. *Can J Pharm Sci* 16: 29-34.

Shafiee A, Jafarabadi AH, 1998. Corydine and norcorydine from the roots of *Chelidonium majus*. *Planta Med* 64(5): 489.

Shin HJ, Kim HL, Kim SJ, Chung WS, Kim SS, Um JY, 2011. Inhibitory effects of chelidonic acid on IL-6 production by blocking NF-κB and caspase-1 in HMC-1 cells. *Immunopharm Immunot* 33(4): 614-619.

Shin MC, Jang MH, Chang HK, Lim S, Han SM, Park HJ, Shim I, Lee JS, Kim KA, Kim CJ, 2003. Modulation of *Chelidonii Herba* on glycine-activated and glutamate-activated ion currents in rat periaqueductal gray neurons. *Clin Chim Acta* 337: 93-101.

Slavik JS, 1977. Minor alkaloids from *Chelidonum majus*. *Collect Czech Chem Commun* 42: 2686-2693.

Sokoloff B, 1968. The oncostatic and oncolytic factors present in certain plants. *Oncology* 22(1): 49-60.

Song JY, Yang HO, Pyo SN, Jung IS, Yi SY, Yun YS, 2002. Immunomodulatory activity of protein-bound polysaccharide extracted from *Chelidonium majus*. *Arch Pharm Res* 25(2): 158-164.

Song JY, Yang HO, Shim JY, Ahn JY, Han YS, Jung IS, Yun YS, 2003. Radiation protective effect of an extract from *Chelidonium majus*. *Int J Hematol* 78(3): 226-232.

Stiborova M, Wostalova J, Zdarilova A, Ulrichova J, Hudecek J, Tschirner K, Simanek V, 2008. *Macleaya cordata* extract and Sangrovit® genotoxicity assessment *in vivo*. *Biomed Pap Med Fac Univ Palacky Olomouc Czech Repub* 152(1): 35-39.

Sun WX, Yuan SS, Huang QY, Yang J, Liu NM, Zhong ZH, 2010. Study on bacteriostasis of *Eomecon Chionantha* alkaloids and sanguinarine. *Prac Prev Med* 17(9): 1864-1867.

Then M, Szentmihályi K, Sarkozi A, Vargas IS, 2003. Examination on antioxidant activity in the greater celandine (*Chelidonium majus* L.) extracts by FRAP method. *Acta Biol Szeged* 47(1/4): 115-117.

Tin-Wa M, Kim HK, Fong HH, Farnsworth NR, 1972. The structure of chelidimerine, a new alkaloid from *Chelidonium majus*. *Lloydia* 35(1): 87-89.

Tong JM, Guo XM, Shi YH, Meng YB, 2004. Study on relieving cough and eliminating phlegm of total alkloid from *Chelidonium majus*. *Chin Hosp Pharm J* 24(1): 18-19.

Vahlensieck U, Hahn R, Winterhoff H, Gumbringer HG, Nahrstedt A, Kemper FH, 1995. The effect of *Chelidonium majus* herb extract on choleresis in the isolated perfused rat liver. *Planta Med* 61(3): 267-271.

Van NJ, 2002. "Dosis solum facit venenum" also for herbal products. *Ned Tijdschr Geneeskd* 146(3): 100-102.

Velázquez C, Calzada F, Torres J, González F, Cebeallos G, 2006. Antisecretory activity of plants used to treat gastrointestinal disorders in Mexico. *J Ethnopharmacol* 103(1): 66-70.

Vrba J, Orolinova E, Ulrichova J, 2012. Induction of heme oxygenase-1 by *Macleaya cordata* extract and its constituent sanguinarine in RAW264.7 cells. *Fitoterapia* 83(2): 329-335.

Wang F, Li YM, 2010. New hopane triterpene from *Dicranostigma leptopodum* (Maxim) Fedde. *J Asian Nat Prod Res* 12(1): 94-97.

Wang GX, Zhou Z, Jiang DX, Han J, Wang JF, Zhao LW, Li J, 2010. *In vivo* anthelmintic activity of five alkaloids from *Macleaya microcarpa* (Maxim) Fedde against *Dactylogyrus intermedius* in *Carassius auratus*. *Vet Parasitol* 171(3/4): 305-313.

Wang TP, Dong ZH, 1998. Determination of *Dicranostigma leptopodium* (Maxim) on the contagious pustular dermatitis virus. *J Tradit Chin Veter Med* (1): 9-10.

Wang YH, Li YJ, Liu YM, 2010. Effects of chelerythrine on the serum ALT and HA level of hepatic fibrosis in rats. *J Univ South China Med Edit* 38(3): 325-327.

Wolff J, Knipling L, 1993. Antimicrotubule properties of benzophenanthridine alkaloids. *Biochemistry* 32(48): 13334-13339.

Wu ML, Zhang DZ, Xu QJ, Xie RR, Li QQ, 2009. Advance in studies on *Macleaya Cordata*. *Asia-Pacific Trad Med* 5(7): 144-145.

Wu MW, Zhu JH, Zhang DY, Zhu SH, Liu L, Huang GZ, 2008. Activity of Ca^{2+}·Mg^{2+}-ATPase and SDH in myocardium of rat induced by *Macleaya cordata* and ultrastructures. *Chin J Forensic Med* 23(3): 154-157.

Wu XC, Pan SQ, Zhang ZD, 1979. Pharmacological study on *Eomecon chionantha* Hance. *Hunan J Med* 6(4): 50.

Xiao L, Yi J, Zhao J, Xu L, Liu BY, Liu DM, Zeng JG, 2011. Protective effect of *Macleaya Cordata* extract on alcohol-induced acute hepatic injury in rats. *Centr South Pharm* 9(7): 485-489.

Yamamoto S, Seta K, Morisco C, Vatner SF, Sadoshima J, 2001. Chelerythrine rapidly induces apoptosis through generation of reactive oxygen species in cardiac myocytes. *J Mol Cell Cardiol* 33: 1829-1848.

Yan D, Hong FG, Jun XL, Si JY, 2009. Alkaloid from *Dicranostigma leptopodum* (Maxim) Fedde. *Chin Chem Lett* 20: 1218-1220.

Yang G, Lee K, Lee MH, Kim SH, Ham IH, Choi HY, 2011. Inhibitory effects of *Chelidonium majus* extract on atopic

dermatitis-like skin lesions in NC/Nga mice. *J Ethnopharmacol* 138(2): 398-403.

Yang HZ, Huang QY, Peng F, Liu NM, Feng F, Sun H, 2003. Observations on acute toxicity of *Eomecon chionantha* Hance alkaloids to fish. *Chin J Schistosomiasis Contr* 15(4): 276.

Yang J, Wang J, Liu XS, Fang XM, 1999. Experimental studies on pharmacodynamic effect of *Macleaya cordata*. *J Chin Med Mater* 22(2): 82-85.

Yang S, Liu Y, Yang QF, Xiang JF, Tang YL, Xu GZ, 2011. Antitumor effect of *Macleaya cordata* and its molecular mechanism on inducement of human telomeric DNA to form G-quadruplex. *Chin Tradit Herb Drugs* 42(4): 738-742.

Yang XJ, Miao F, Zheng F, Zhou L, Wang X, Geng HL, Sun W, 2010. Isolation and identification of alkaloids from *Macleaya microcarpa* (Maxim.) Fedde. *Acta Bot Boreal-Occident Sin* 30(2): 405-411.

Yao JY, Shen JY, Li XL, Xu Y, Hao GJ, Pan XY, Wang GX, Yin WL, 2010. Effect of sanguinarine from the leaves of *Macleaya cordata* against *Ichthyophthirius multifiliis* in grass carp (*Ctenopharyngodon idella*). *Parasitol Res* 107(5): 1035-1042.

Yao JY, Zhou ZM, Li XL, Yin WL, Ru HS, Pan XY, Hao GJ, Xu Y, Shen JY, 2011. Antiparasitic efficacy of dihydrosanguinarine and dihydrochelerythrine from *Macleaya microcarpa* against *Ichthyophthirius multifiliis* in richadsin (*Squaliobarbus curriculus*). *Vet Parasitol* 183(1/2): 8-13.

Yao JY, Zhou ZM, Pan XY, Hao GJ, Li XL, Xu Y, Shen JY, Ru HS, Yin WL, 2011. *In vivo* anthelmintic activity of chelidonine from *Chelidonium majus* L. against *Dactylogyrus intermedius* in *Carassius auratus*. *Parasitol Res* 109(5): 1465-1469.

Ye FZ, Feng F, Liu WY, 2009. Alkaloids from *Macleaya cordata*. *China J Chin Mater Med* 34(13): 1683.

Yin HQ, Kim YH, Moon CK, Lee BH, 2005. Reactive oxygen species-mediated induction of apoptosis by a plant alkaloid 6-methoxydihydrosanguinarine in $HepG_2$ cells. *Biochem Pharm* 70: 242-248.

Yu JP, Zhao DL, Meng XB, Zhou XQ, 2006. The antibacterial effect of the alkaloids from *Macleaya cordata* on eight kinds of fungi. *J Mount Agri Biol* 25(1): 89-91.

Zhang Y, Zhang W, Tian YZ, Wang JQ, Ma QS, 2004. The protective effects and the mechanism of DLF estraction on acute liver injury caused by CCl_4. *J Qinghai Med Coll* 25(1): 7-11.

Zhao DL, Yu JP, Zhou XQ, Meng XB, Wu JZ, 2005. Antibacterial effect of the sanguinarine hydrochloride and bocconoline from *Macleaya cordata*. *Food Sci* 26(1): 45-47.

Zhao Q, Han Y, Du YP, Wang TP, Wang Q, 2006. The effect of *Dicranostigma leptopodum* (Maxim) fedde (DLF) extraction on suppressing oxidative hemolysis of erythrocytes and its mechanism. *J Lanzhou Univ Med Sci* 32(3): 40-45.

Zhao Q, Wang TP, Sun GL, Yang M, 2010. The research progress of the component analysis and pharmacological effects about *Dicranostigma Leptopodum* (Maxim) Fedde's alkaloid. *J Longdong Univ* 21(2): 53-59.

Zhen GD, Du FL, Long LN, Ou YW, Yan M, 2007. Studies on The lipophilic compound from the aerial Parts of *Eomecon chionantha* Hance (II). *J Chin Med Mater* 30(12): 1530-1532.

Zhong M, Li GY, Zeng JG, Zhang L, Huang KL, She JM, Li X, Wei WY, 2011. Evaluation of molluscicidal activities of benzo[c]phenanthridine alkaloids from *Macleaya cordata* (Willd) R. Br. on snail hosts of *Schistosoma japonicum*. *J Med Plants Res* 54(4): 521-526.

Zhou JY, Chen BZ, 1989. Study on the chemical constituents of *Chelidonium majus*. *Chin Tradit Herb Drugs* 20(4): 2-4.

Zhou RH: Medicinal plant chemical taxonomy, in Shanghai, Shanghai Science and Technology Press, 1988, 252-253.

Zhou TD, Zhou XX, 1981. An anti-bateria compound of *Eomecon chionantha*. *Chin Tradit Herb Drugs* 12(1): 1-3.

Zou LY, Zhu XF, Rao YG, Li G, Fu XJ, Lu Y, 2009. Role of chelerythrine chloride, the protein kinase C inhibitor, on the cell damage of SHSY5Y neuronal cells from oxygen-glucose deprivation. *Chin J Stroke* 4(4): 280-283.