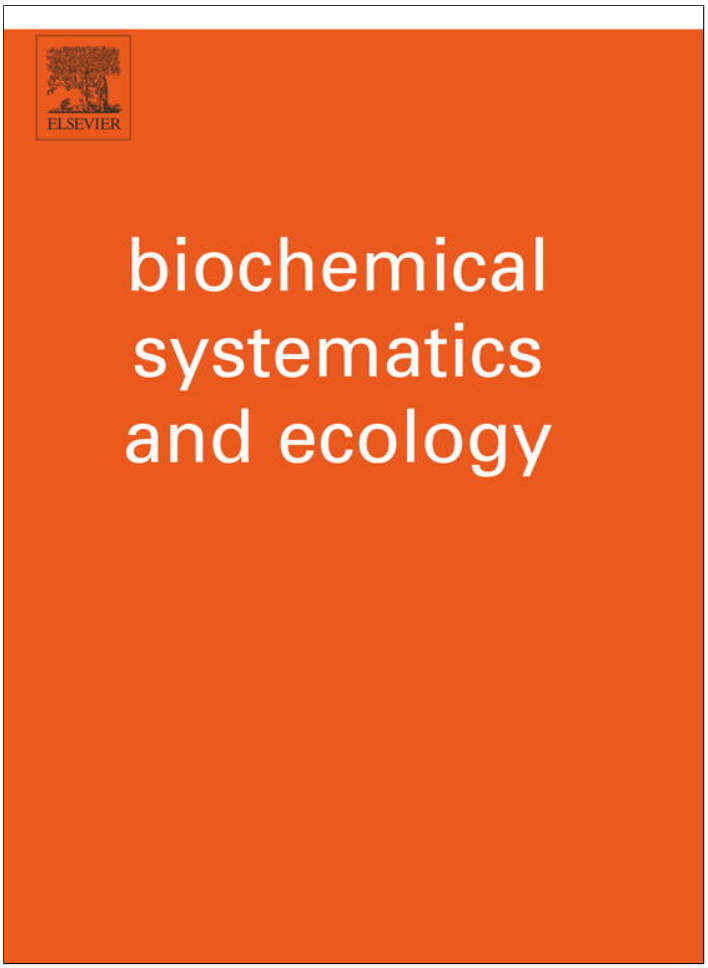

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Chemical constituents from *Striga asiatica* and its chemotaxonomic study

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ABSTRACT

Six flavonoids, diosmetin (**1**), apigenin (**2**), luteolin (**3**), chrysoeriol (**4**), apigenin-7-*O*-glucuronide (**5**) and acacetin (**6**), two caffeic acid sugar esters, verbascoside (**7**) and isoverbascoside (**8**), as well as one norsesquiterpene, blumenol A (**9**) were isolated or detected from the EtOAc and *n*-BuOH extract of the whole plants of *Striga asiatica*. Their structures were identified by ^{1}H & ^{13}C NMR, HR-LC-TOF-MS and co-injection with the reference standards. Among them, blumenol A (**9**) was firstly found from the Scrophulariaceae. Diosmetin (**1**) and isoverbascoside (**8**) were firstly reported from the genus *Striga*, while verbascoside (**7**) was reported from this plant for the first time. Based on our chemotaxonomic studies and the previous phytochemical studies on Scrophulariaceae, *Striga* could be tentatively treated as a member of the family Scrophulariaceae instead of Orobanchaceae.

1. Subject and source

Striga is a genus either in Scrophulariaceae (Wettstein, 1897; Institute of Botany, the Chinese Academy of Sciences, 1963; Hong et al., 1998) or in Orobanchaceae (Olmstead and Reeves, 1995; Young et al., 1999; Olmstead et al., 2001; Oxelman et al., 2005; Tank et al., 2006; The Angiosperm Phylogeny Group, 2009) based on different taxonomic treatments. It consists of about 20 species distributed in tropical and subtropical regions in Africa, Asia, and Oceania. In China, there are four native *Striga* species mainly in south part of China (Hong et al., 1998). *Striga asiatica* (L.) O. Kuntze is known as a hemiparasite that frequently affects important food crops such as sorghum, maize, and millet.

The sample of *S. asiatica* was collected in the fall 2010 from Jingxi County, Guangxi Zhuang Autonomous Region, China. The plant was identified by Prof. Chun-Lin Long (College of Life and Environmental Sciences, Minzu University of China, and Kunming Institute of Botany, Chinese Academy of Sciences). A voucher specimen (No. 2011444) has been deposited in the Ethnobotanical Laboratory, Minzu University of China.

2. Previous work

Previous phytochemical investigations of *S. asiatica* were quite limited. Only some flavonoids, mussaenosidic acid, isoaucubin and calceolarioside A had been isolated from the plant (Nakanishi et al., 1985; Zhang and Chen, 1995; Rank et al., 2004; Huang et al., 2010).

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3. Present study

The dried plant of *S. asiatica* (3 kg) was extracted with 80% EtOH for three times (each 10 L and 3 h) at room temperature. A greenish residue (799.6 g) was obtained after removal of the solvent under reduced pressure by rotary evaporation. Then the residue was suspended in water (3 L). The aqueous suspension was partitioned successively with petroleum ether, EtOAc and *n*-BuOH (each 3 times). After removal of the solvent, a dry EtOAc extract (60.4 g) was collected. The EtOAc exact was subjected to silica gel (200–300 mesh) column chromatography eluting with $CHCl_3$–MeOH gradient (100:0-1:1) to yield seven fractions (Fr.1–Fr.7). Fr.2 (0.7 g) was chromatographed on silica gel with a petroleum ether–acetone gradient (15:1-1:1) to yield blumenol A (**9**, 6.7 mg, Tan et al., 2006). Fr.3 (2.1 g) was got rid of the chlorophyll by using the gradient solvent system 50–90% aqueous MeOH to provide 4 fractions (Fr.3-1 to Fr.3-4). Fr.3-1 was further purified by high-speed counter-current chromatography (HSCCC) (chloroform-methanol-*n*-BuOH-water: 4:3:0.5:2.2, v/v, flow rate: 2 mL/min, revolution speed: 800 rpm) to obtain diosmetin (**1**, 15 mg, Xie et al., 2009). Fr.4 ($CHCl_3$–MeOH, 10:1, 5.3 g) was chromatographed on silica gel with a $CHCl_3$–acetone gradient (100:0-1:1-acetone neat) to yield apigenin (**2**, 379.3 mg, Nakanishi et al., 1985; Huang et al., 2010), luteolin (**3**, 301.4 mg, Zhang and Chen, 1995) and chrysoeriol (**4**, 215.4 mg, Huang et al., 2010). Fr.5 (2 g) was subjected to the Sephadex LH-20 eluting with MeOH to yield 3 fractions (Fr.5-1 to Fr.5-3). Fr.5-3 was further fractionated using semi-preparative HPLC [Waters (Milford, MA, USA) Alliance 2695 system equipped with 2695 separation module unit and 2996 PDA detector using a 250 × 10 mm, 5 μ Phenomenex column (Torrance, CA, USA), MeOH: water: 15:85-80:20, flow rate: 3 mL/min] and yielded acacetin (**6**, 6.9 mg, Yim et al., 2003). Fr.6 (1.6 g) was purified by repeated Sephadex LH-20 column chromatography eluting with MeOH to afford verbascoside (**7**, 283.7 mg, Jiang et al., 2002). Compound **5** and **8** were detected in *n*-BuOH extract (Table 1). They were determined to be apigenin-7-*O*-glucuronide (Huang et al., 2010) and isoverbascoside (Miyase et al., 1982).

The structures of the nine isolates (Fig. 1) were identified by a combination of spectroscopic methods (HPLC-HR-TOF-MS, ^1H and ^{13}C NMR) and comparisons with their literature data. The HPLC spectra of EtOAc and *n*-BuOH extracts were showed in Fig. 2. All the Blumenol A (**9**) was firstly found from Scrophulariaceae. Diosmetin (**1**), verbascoside (**7**) and isoverbascoside (**8**) were isolated and reported from *S. asiatica* for the first time. Diosmetin (**1**) and isoverbascoside (**8**) were firstly reported from the genus *Striga*, too.

4. Chemotaxonomic significance

Blumenol A (**9**) have previously been reported from other related families, such as Labiatae (i.e. Lamiaceae, Yang et al., 2006). However, we did not find it reported from Scrophulariaceae. In accord with the previous studies (Nakanishi et al.,

Table 1
HR-LC-TOF-MS analysis of the compounds isolated or detected from *S. asiatica*.[a]

No.	R.T. (min)	UV	$[M+H]^+$ or $[M-H]^-$ (M.F., ppm)	Adduct and fragmental ion exact masses $[M-X]^+$ or $[M-X]^-$ (M.F., ppm)	Identification	Ref.
1	22.2	280,330	301.0688 $[M+H]^+$ ($C_{16}H_{13}O_6$, −8.0); 299.0527 $[M-H]^-$ ($C_{16}H_{11}O_6$, −9.7)	345.0575 [M-H + HCOOH]$^-$ ($C_{17}H_{13}O_8$, −10.1); 599.1179 $[2M-H]^-$ ($C_{32}H_{23}O_{12}$, −1.8)	Diosmetin	Xie et al., 2009
2	21.9	280,330	271.0570 $[M+H]^+$ ($C_{15}H_{11}O_5$, −13.3); 269.0450 $[M-H]^-$ ($C_{15}H_9O_5$, 0.0)	315.0490 [M-H + HCOOH]$^-$ ($C_{16}H_{11}O_7$, −4.8); 539.0969 $[2M-H]^-$ ($C_{30}H_{19}O_{10}$, −1.0)	Apigenin (co-injection)	Nakanishi et al., 1985; Huang et al., 2010
3	20.4	279,330	287.0533 $[M+H]^+$ ($C_{15}H_{11}O_6$, −8.0); 285.0389 $[M-H]^-$ ($C_{15}H_9O_6$, -3.5);	571.0881$[2M-H]^-$ ($C_{30}H_{19}O_{12}$, 0.7)	Luteolin (co-injection)	Zhang and Chen, 1995
4	22.2	280,330	301.0690 $[M+H]^+$ ($C_{16}H_{13}O_6$, −7.3); 299.0525 $[M-H]^-$ ($C_{16}H_{11}O_6$, -10.4)	345.0571 $[M-H+HCOOH]^-$ ($C_{17}H_{13}O_8$, −11.3); 599.1184 $[2M-H]^-$ ($C_{32}H_{23}O_{12}$, −1.0)	Chrysoeriol	Huang et al., 2010
5	15.5	281,330	447.0920 $[M+H]^+$ ($C_{21}H_{19}O_{11}$, 2.5) 445.0782 $[M-H]^-$ ($C_{21}H_{17}O_{11}$, -1.6)	893.1798 $[2M+H]^+$ ($C_{42}H_{35}O_{22}$, 2.5) 491.0849 $[M-H+HCOOH]^-$ ($C_{22}H_{21}O_{13}$, 4.7); 891.1699 $[2M-H]^-$ ($C_{42}H_{35}O_{22}$, 8.9)	Apigenin-7-*O*-glucuronide (co-injection)	Huang et al., 2010
6	25.1	280,330	285.0957 $[M+H]^+$ ($C_{16}H_{13}O_5$, -2.1); 283.0608 $[M-H]^-$ ($C_{16}H_{11}O_5$, 0.7)	569.1403 $[2M+H]^+$ ($C_{32}H_{23}O_{10}$, −7.9) 329.0665 [M-H + HCOOH]$^-$ ($C_{17}H_{13}O_7$, 1.2); 567.1298 $[2M-H]^-$ ($C_{32}H_{23}O_{10}$, 1.2)	Acacetin	Yim et al., 2003
7	11.4	218,330	625.2180 $[M+H]^+$ ($C_{29}H_{37}O_{15}$, 7.7); 623.1973 $[M-H]^-$ ($C_{29}H_{35}O_{15}$, −0.5)	647.1962 $[M+Na]^+$ ($C_{29}H_{36}O_{15}Na$, 1.5); 479.1565 [M + H-mannopyranosyl]$^+$ ($C_{23}H_{27}O_{11}$, 2.5)	Verbascoside	Jiang et al., 2002
8	12.6	218,330	625.2125 $[M+H]^+$ ($C_{29}H_{37}O_{15}$, −1.1); 623.1986 $[M-H]^-$ ($C_{29}H_{35}O_{15}$, 1.4)	647.1946 $[M+Na]^+$ ($C_{29}H_{36}O_{15}Na$, −0.9); 479.1530 [M + H-mannopyranosyl]$^+$ ($C_{23}H_{27}O_{11}$, −4.8) 477.1377 [M − H-mannopyranosyl]$^-$ ($C_{23}H_{25}O_{11}$, −4.2)	Isoverbascoside	Miyase et al., 1982

[a] HR-TOF-MS analyses was performed using a LCT premier XE TOF mass spectrometer (Waters, Manifold, MA) equipped with an ESI interface and controlled by MassLynx V4.1 software. Mass spectra were acquired in both positive and negative modes over the range *m/z* 100–1000. The capillary voltages were set at 3000 V, and the cone voltage was 20 V.

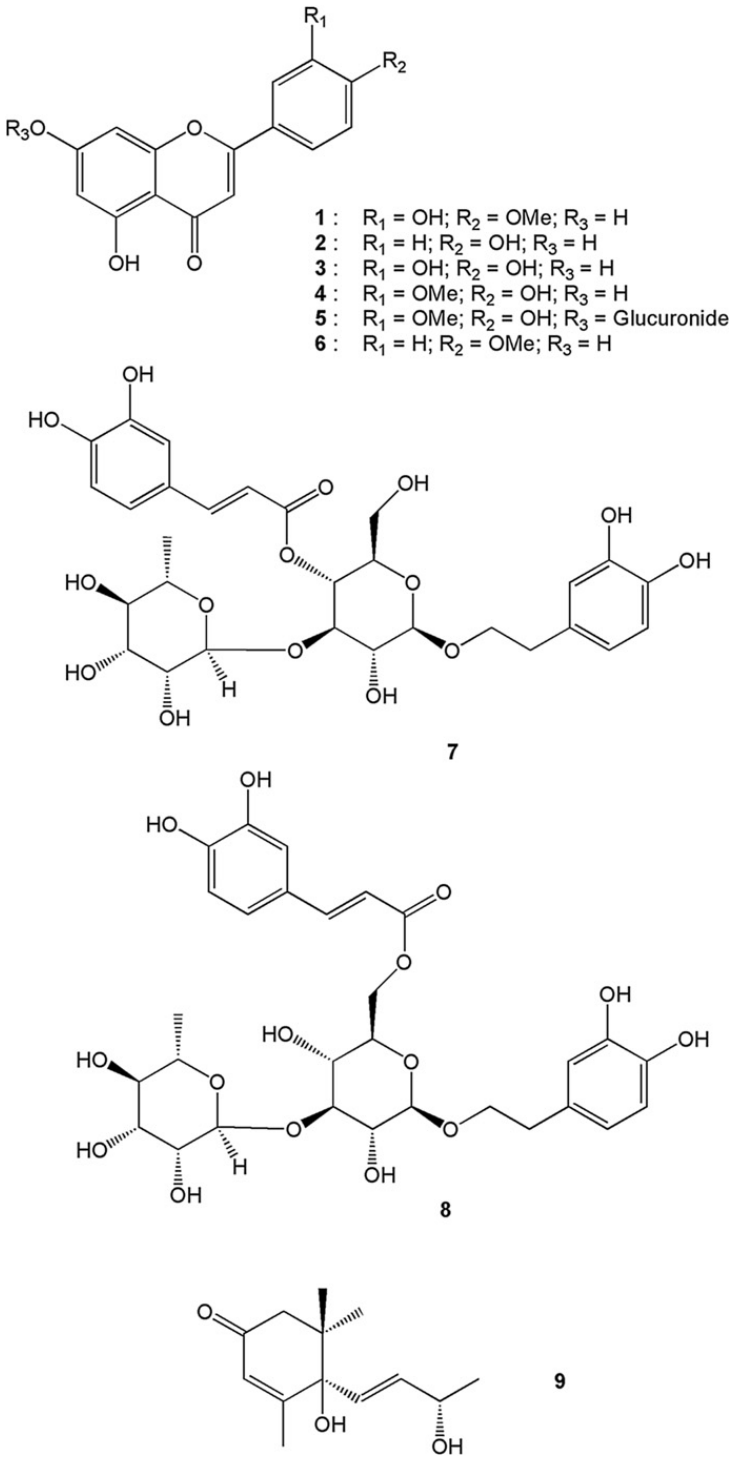

Fig. 1. Structures of compounds 1–9.

1985; Zhang and Chen, 1995), flavonoids were the major constituents of *S. asiatica*. Apigenin (**2**), luteolin (**3**) and acacetin (**6**) are characteristic flavonoids of *Striga*. Acacetin (**6**) has been reported from *Striga lutea* Lour. (Hiremath and Hanumantharao, 1997). Apigenin (**2**) and luteolin (**3**) were also isolated from *Striga orobanchioides* Benth. (Hiremath et al., 1996). Verbascoside (**7**) is a characteristic constituent in most taxa in Lamiales (Jensen, 1992). *Striga gesnerioides* Willd. contained verbascoside (7) (Rank et al., 2004) and it is now being reported for the first time in *S. asiatica*. Diosmetin (**1**) and isoverbascoside (**8**) are widespread in plants but so far they have not been reported in the genus *Striga*. This is the first report of the norsesquiterpene, blumenol A (**9**) in a member of the Scrophulariaceae family which could be of systematic importance. However, whether norsesquiterpenes may be regarded as chemotaxonomic markers of species of *Striga* remains to be established.

Traditionally, *Striga* was treated as a member in the family of Scrophulariaceae base on their morphological and anatomical characteristics (Institute of Botany, the Chinese Academy of Sciences, 1963). However, plant taxonomists have argued its

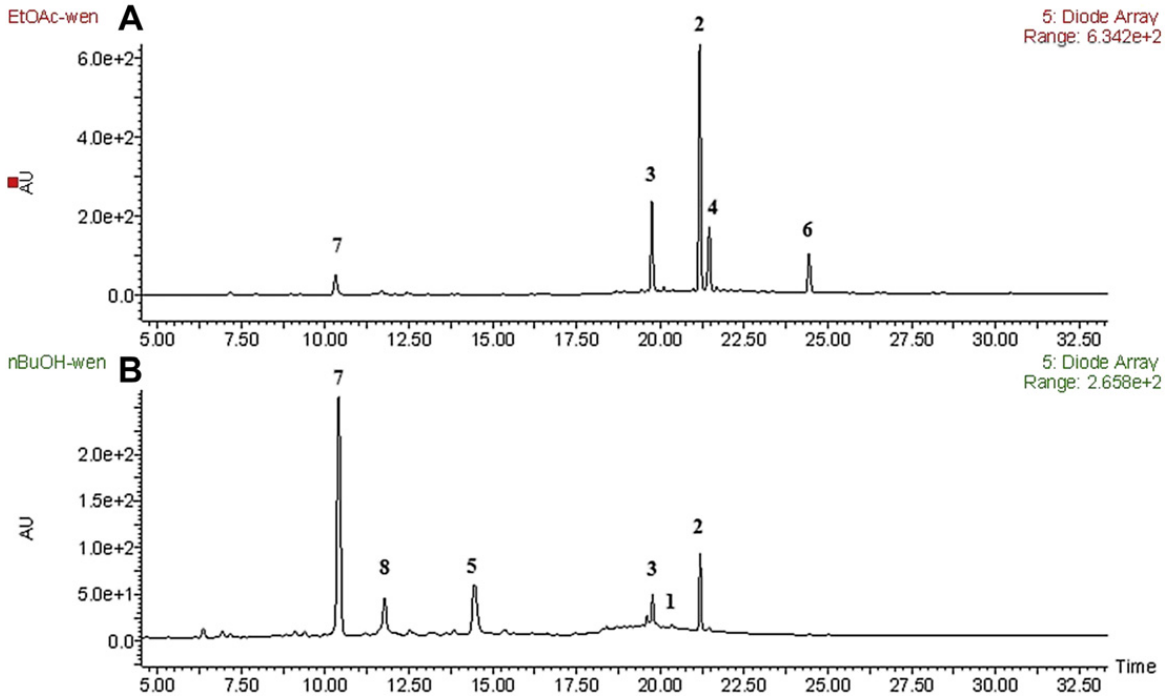

Fig. 2. HPLC spectrum of the HR-LC-TOF-MS A: EtOAc fraction; B: *n*-BuOH fraction. Analyses were performed using Waters (Milford, MA, USA) Alliance 2695 system equipped with 2996 PDA detector using a 100 × 2.5 mm, 2.5 μ C18 column (Phenomenex, USA). The mobile phase consisted of solvents (A) 0.5% aqueous formic acid solution and (B) MeCN. Gradient conditions were performed as follow: from 15 to 30% B in 15 min, from 30 to 60% B until 20 min, from 60 to 100% B until 45 min, followed by maintaining 100% B for 10 min. The flow rate and the injection volume were 0.2 mL/min and 15 μL, respectively. The UV results were monitored using a wavelength range of 210–500 nm.

phylogenic position for many years. In the past, taxonomists relied on its parasitic habit together with its morphological characteristics to classify the plants in Orobanchaceae or Scrophulariaceae. DNA sequence data suggest a new classification system for the Lamiales (Olmstead and Reeves, 1995; Olmstead et al., 2001; Oxelman et al., 2005; Tank et al., 2006) that suggests that *Striga* should be placed in the Orobanchaceae not Scrophulariaceae. Young et al. (1999) believed that

Table 2
The chemical constituents reported in Scrophulariaceae (until June of 2012).

Subfamily/Tribe/ Genus	Species	Chemical compounds	References
Scrophularioideae			
Verbasceae			
Verbascum	*Verbasum phlomoides* L.	Apigenin[a], luteolin, diosmin, tamarixetin 7-rutinoside, tamarixetin 7-glucoside	Klimek et al., 2010
	Verbasum lychnitis L.	Apigenin, luteolin, acacetin, 3',4',5-trihydroxy-7-methoxyflavone, luteolin 7-glycoside, luteolin 5-glucoside,crocetin, aucuboside, methylcatechol, isocatechol, patuletin	Serdyuk et al., 1976
	Verbasum sinaiticum L.	Luteolin, chrysoeriol, sinaiticin	Afifi et al., 1993
	Verbasum thapsus L.	Luteolin, 7,3 ,4'-trimethylluteolin, verbacoside	Mehrotra et al., 1989
Paulownieae			
Brandisia	*Brandisia hancei* Hook.f.	Luteolin, acteoside, isoacteoside, 2'-*O*-acetylacteoside, brandioside, arenarioside	Kong et al., 1999
Paulownia	*Paulownia tomentosa* Thunb.	Apigenin, luteolin, 5, 4'-dihydroxy-7, 3'-dimenthoxyflavanone, 5-hydroxy-7, 3', 4'-trimenthoxyflavanone, diplacone, mimulone homoeriodictyol, 3α-hydroxyurs-12-en-28-oicacid, maslinic acid, pomolic acid, 2α, 3α-dihydroxyurs-12-en-28-oicm acid, ursolic acid, daucosterol, β-sitosterol	Du et al., 2004; Zhang et al., 2011
Scrophularieae			
Scrophularia	*Scoparia striata* Boiss.	Auercetine, isorhamnetin-3-*O*-rutinoside, nepitrin, acteoside, cinnamic acid	Monsef-Esfahani et al., 2010
Gratioleae			
Scoparia	*Scoparia dulcis* L.	7-*O*-methylscutellarein, scutellarein I, scutellarein-7-*O*-β-D-glucuronide	Ramesh et al., 1979
Bacopa	*Bacopa monnieri* L.	Apigenin, bacopaside XI, bacopaside XII, bacopaside IV, bacopaside V, bacoside A, bacopaside I, bacoside A_3, bacopaside II, bacopaside X, bacopasaponin C	Bhandari et al., 2009a,b

(*continued on next page*)

Table 2 (*continued*)

Subfamily/Tribe/ Genus	Species	Chemical compounds	References
Gratiola	*Gratiola officinalis* L.	Apigenin, apigenin 7-*O*-glucuronide, chrysoeriol 7-*O*-glucuronide, luteolin 7-*O*-glucuronide, schaftoside, isoschaftoside, 6-hydroxyluteolin 7-*O*-glucuronide, isoscutellarein 8-glucuronide, hypolaetin 8-glucuronide, 6-hydroxychrysoeriol 7-*O*-glucuronide, 8-hydroxychrysoeriol 8-glucuronide, 8-hydroxychrysoeriol 7-*O*-sophoroside	Litvinenko et al., 1969; Renée et al., 1993
Lindenbergia	*Lindenbergia urticaefolia* Lehm.	Apigenin, *β*-sitosterol palmitate, *β*-sitosterol, *β*-sitosterol-*β*-D-glucoside, mannitol	Jain and Gupta, 1986
Adenosma	*Adenosma caeruleum* R.Br.	Apigenin 7-*O*-*β*-D-glucuronopyranoside, apigenin 7-*O*-*β*-D-glucopyranoside, crenatoside, verbascoside, cistanoside F, campneoside I, and campneoside II	De Abreu et al., 2009
Lancea	*Lancea tibetica* Hook.f.	Apigenin, 5,4′-dihydroxyflavone, phillyrin, simplexoside, sesaminol 2′-*O*-*β*-D-glucoside, phillygenol, lantibeside, tibeticoside A, 2-(3,4-dihydroxyphenyl)ethyl 3-*O*-*α*-L-rhamnopyranosyl-4-O-[(*E*)-3-(3,4-dihy-droxyphenyl) propenoyl]-*β*-D-glucopyranoside, lantibeside B, lantibeside C, lantibeside D, lantibetin	Li et al., 2008
Picria	*Picria feltarrae* L.	Apigenin, apigenin-7-*O*-*β*-D-glucuronide, apigenin-7-*O*-L-rhamnopyranosyl (1-2)-*β*-D-glucuronide, picfeltarraegenin X, acteoside (2*E*)-,2-propenoic acid, 3-(4-hydroxy-3-methoxyphenyl)-decosyl ester, p-hydroxybenzyl alcohol, triacontanol, *β*-sitosterol, daucosterol, picfeltarraegenin IV	Liu et al., 2004; Huang et al., 2010
Torenia	*Torenia fournieri* Linden.	Luteolin-7-*O*-beta-glucoside, apigenin-7-*O*-alpha-rhamnosyl-(1→6)-*β*-glucoside, acteoside, apigetrin	
Mimulus	*Mimulus ringens* L.	Apigenin, luteolin, quercetin, kaempferol glycosides	Windler et al., 1976
	Mimulus alatus L.	Apigenin, luteolin, quercetin, kaempferol glycosides	Windler et al., 1976
Antirrhineae			
Linaria	*Linaria canadensis* (L.) Dum	Apigenin, luteolin, diosmetin, genkwanin, luteolin 7-*O*-glucoside, luteolin 7-*O*-glucuronide, genkwanin 4′-*O*-rutinoside, quercetin 7-*O*-rutinoside, 4,6-di-(7-deoxyiridolactonyl)-D-glucopyranose, 3-acetyl-4,6-di-(7-deoxyiridolactonyl)-D-glucopyranose	Mizuochi et al., 2011
Rhynanthoideae			
Digitalieae			
Digitalis	*Digitalis lanata* Ehrh.	Apigenin, pectolinarigenin, desmethoxycentaureidin	Hiermann and Kartnig, 1977
Veroniceae			
Picrorhiza	*Picrorhiza scrophulariiflora* Pennell.	Luteolin, luteolin-7-*O*-*β*-D-glucoside, hexacosanol, catechin, gallic acid, isoferulic acid, vanillic acid, scroside G	Huang et al., 2009
Veronicastrum	*Veronicastrum axillare* Sieb.	Luteolin, acacetin, aucubin, daucosterol, arbutin, mannitol, *p*-dihydroxyl benzene, *β*-sitosterol	Liu et al., 1999
Scrofella	*Scrofella chinensis* Maxim.	Diosmetin, 3,5-dihydroxy-7,4'-dimethoxyflavon, 5, 6,7-trihydroxy-4'-methoxyflavon, *β*-sitosterol, *β*-sitosterol-3-*O*-glycoside, 4-methoxylbenzoic acid, 1,4-benzenediol	Shen and Tian, 2004
Veronica	*Veronica linariifolia* Pall.	Apigenin, luteolin, apigenin-7-*O*-*β*-D-glucuronide methyl ester, 4',5,7-trihydroxy-3',6- dimethoxyflavone-7-*O*-*β*-D-glucopyranoside, apigenin-7-*O*-*β*-D-glucuronopyranoside ethyl ester, apigenin-7-*O*-*β*-D-butyl glucuronate	Hong et al., 2008
	Veronica chamaedrys L.	Apigenin, luteolin, chrysoeriol, luteolin 7,4'-dimethyl ether, scutellarein 6,4'-dimethyl ether	Nikolova and Asenov, 2006
Lagotis	*Lagotis yunnanensis* W. W. Smith	Apigenin, luteolin, chrysoeriol, lagotisoside A, artselaeroside A, anisic acid, *β*-sitosterol, cinnamic acid, 3,4-dimethoxy-cinnamic acid, vanillin, daucosterol	Yang et al., 2003
	Lagotis glauca Gaertn.	Apigenin, luteolin, chryseriol, quercetin, rutin, jaceosidin, pectolinarigenin, hispidulin, eupafolin, tricin, morin	Zhang et al., 1999
	Lagotis brevituba Maxim.	Apigenin, chrysoeriol, luteolin-7-*O*-*β*-D-glucoside, chrysoeriol-7-*O*-*β*-D-glucoside, apigenin-7-*O*-*β*-D-glucoside, uracil, succinic acid, *β*-sitosterol	Xi et al., 2010
Buchnerieae			
Striga	*Striga asiatica* (L.) O. Kuntze	Apigenin, acacetin, luteolin, acacetin 7-methyl ether, chrysoeriol, luteolin 3′, 4′-dimethyl ether, luteolin 7,3′, 4′-trimethyl ether, apigenin-7-galacturonide, apigenin-7-*O*-*β*-glucopyranuronide, quercitrin, acacetin-7-*O*-*β*-D-glucuronide 5,7-dihydroxy-6-prenyl-2',4',5', 8-tetramethoxyisoflavone	Nakanishi et al., 1985; Huang et al., 2010; Zhang and Chen, 1995
Sopubia	*Sopubia delphinifolia* G.		

Table 2 (*continued*)

Subfamily/Tribe/ Genus	Species	Chemical compounds	References
Buchnera	*Buchnera hispida* Buch.	5,6,7-trimethoxyflavone 4'-*O*-*β*-D-glycoside, scutellarein	Saxena and Bhadoria, 1990; Mohammad et al., 1994
Rhinantheae			
Melampyrum	*Malampyrum arvense* L.	Apigenin, luteolin, luteolin 7-*O*-*β*-glucopyranoside, aucubin, melampyroside, mussaenoside, mussaenosidic acid, 8-*epi*-loganin, dehydrodiconiferyl alcohol 9-*O*-*β*-glucopyranoside, benzoic acid, *β*-Sitosterol, fatty acid	Kirmizibekmez et al., 2011
Euphrasia	*Euphrasia brevipila* Burnat.	Apigenin, luteolin, diosmetin, cinaroside, cosmosiin, aucubin, ferulic, caffeic acids	Petrichenko et al., 2006
Odontites	*Odontites serotina* (Lam.) Dum.	Apigenin, luteolin, luteolin-7-*O*-*β*-D-glucoside, apigenin-7-*O*-*β*-D-glucoside, aucubin, aucubin 6-*β*-coumarate, catalpol, caffeic acid	Degot et al., 1986
Rhinanthus	*Rhinanthus angustifolius* C.	Apigenin, luteolin, apigenin 7-*O*-glucoside, scutellarein 7-*O*-glucoside, 5,6,7-trihydroxy-4'-methoxyflavone 7-*O*-glycoside, 5,6,4'-trihydroxy-7-methoxyflavone, 6-hydroxyluteolin 7-*O*-glucoside, 6-hydroxyluteolin, luteolin 7-*O*-glucoside	Toth et al., 1986
Pedicularis	*Pedicularis dolichocymba* Hand.	Apigenin, gardoside methyl ester, 7-*O*-acetylgardoside methyl ester, verbascoside, leucosceptoside A, jionoside D, martynoside, uridine, adenosine, benzyl alcohol-*O*-*β*-D-xylopyranosyl-(1→2) -*β*-D-glucopyranoside, 2-phenylethyl *O*-*β*-D-xylopyranosyl-(1→2)-*β*-D-glucopyranoside, lariciresinol-4'-*O*-*β*-D-glucopyranoside	Chu et al., 2007
	Pedicularis tricolor Hand.	Apigenin, luteolin, chrysoeriol, 5,7,4'-trihydroxy-3', 5'-dimethoxy flavones, 3,5,4'-trihydroxy-3', 5'-dimethoxyflavone-7-*O*-*β*-D-glucopyranoside, 3,5,4',5'–trtrahydroxy-3'-methoxy-flavone-7-*O*-*β*-D-glucopyranoside,3,5,3' 4'-trtrahydroxy-flavone-7-*O*-*β*-D-glucopyranoside, actoside, martynoside, methyl 3, 4-dihydroxybenzoate, benzyl 2-*O*-*β*-D-glucopyranosyl-*β*-D-glucopyranoside	Yang et al., 2006; Jozsef et al., 1981
Cymbaria	*Cymbaria dahurica* L.	Apigenin-7-*O*-glucuronide, chrysoeriol-7-*O*-glucuronide, tricin-7-*O*-glucoside	
Siphonostegia	*Siphonostegia chinensis* Benth.	Apigenin, luteolin, 5,3'-dihydroxy-6,7,4'-trimethoxyflavone, 5,7-dihydroxy-3',4' -dimethoxyflavone	Zhang et al., 2002

[a] The compounds in blue colour are flavonids.

Orobanchaceae should contain the parasitic Scrophulariaceae, the traditional Orobanchaceae, and *Lindenbergia* (Young et al., 1999). The molecular based APG III system system places *Striga* in Orobanchaceae (The Angiosperm Phylogeny Group, 2009).

The chemotaxonomic data for the genus support the traditional classification that *Striga* should remain in the Scrophulariaceae. The phytochemical studies of Orobanchaceae, such as *Cistanche*, report the presence of iridoid glycoside, phenylpropanoid glycosides and monoterpene (Kobayashi et al., 1984, 1985; Xie et al., 2006). In contrast, most of the flavonoids detected from *Striga* are rarely obtained from the Orobanchaceae family. The flavonoid compounds reported from Scrophulariaceae family include apigenin, luteolin, acacetin, chrysoeriol and their derivatives (Table 2). The phytochemical studies of Scrophulariaceae reveal that most of the genera, except Hemiphragmeae, contain flavonoids. The flavonoid patterns in the species of Lamiaceae and Scrophulariaceae are very homogenous (Nikolova and Asenov, 2006). This suggests a close phylogenetic relationship between these families (Nikolova and Asenov, 2006). In terms of phylogeny, the flavonoids presented by *Striga* are consistent with Scrophulariaceae. Therefore, our phytochemical and chemotaxonomic studies support the taxonomic systems of Wettstein (Wettstein, 1897) that *Striga* should belong to the family Scrophulariaceae.

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