© 2012 Boletín Latinoamericano y del Caribe de Plantas Medicinales y Aromáticas 11 (6): 474 - 497
ISSN 0717 7917
www.blacpma.usach.cl

Revision | Review

Phytoecdysteroids from *Silene* plants: distribution, diversity and biological (antitumour, antibacterial and antioxidant) activities

[Fitoecdiesteroides de plantas Silene: distribución, diversidad y actividades biológicas (antitumorales, antibacterianas y antioxidantes)]

Nilufar Z. MAMADALIEVA

Laboratory of the Chemistry of Glycosides, Institute of the Chemistry of Plant Substances AS RUz, Mirzo Ulugbek Str. 77, Tashkent 100170, Uzbekistan.

UNESCO - L'Oréal International fellow 2011

Contactos | Contacts: Nilufar Z. MAMADALIEVA - E-mail address: nmamadalieva@yahoo.com

Abstract

Silene is a genus of the Caryophyllaceae family, contains more than 700 species, which are widely distributed in Northern Hemisphere, but also in Africa, Asia and South American. Phytochemical investigations of *Silene* species have revealed that many components from this genus are highly bioactive. More than 400 compounds has been isolated, among them major are phytoecdysteroids. The paper reviews the biological (antitumour, antibacterial and antioxidant) activities and the phytoecdysteroids of genus *Silene*. We summarized the phytoecdysteroids content referring to 171 species from the genus *Silene* and list 93 phytoecdysteroids isolated over the past few decades. There are also reports on the mentioned folk and traditional effects of *Silene* plants.

Keywords: *Silene*, phytoecdysteroids, plants, distribution, flora, traditional uses, pharmacological properties

Resumen

Silene es un género de la familia Caryophyllaceae, conteniendo más de 70 especies, ampliamente distribuidas no solo en el hemisferio norte, sino que también en Africa, Asia y sud América. Investigaciones fotoquímicas de las especies de *Silene* han revelado que muchos componentes de este género son altamente bioactivos. Más de 400 compuestos han sido aislados, entre ellos los mayoritarios correspondientes a fitoecdiesteroides. El manuscrito revisa las actividades biológicas (antitumorales, antibacterianas y antioxidantes) y los fitoecdiesteroides del género *Silene*. Resumimos el contenido de fitoecdiesteroides en 171 espcies del género *Silene* y listamos 93 fitoecdiesteroides aislados desde hace unas pocas décadas. Hay también reportes mencionados acerca de los efectos tradicionales y folclóricos de la plantas del género *Silene*.

Palabras Clave: *Silene*; fitoecdiesteroides; plantas; distribución; flora; usos tradicionales; propiedades farmacológicas.

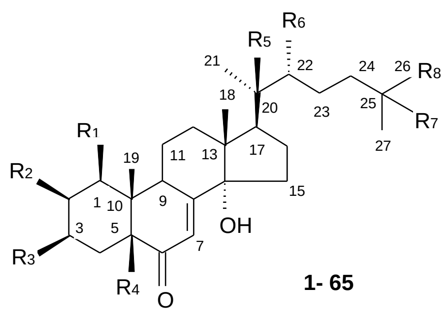
Recibido | Received: August 4, 2012.
Aceptado en versión corregida | Accepted in revised form: August 15, 2012.
Publicado en línea | Published online: November 30, 2012.
Este artículo puede ser citado como / This article must be cited as: Nilufar Z. Mamadalieva. 2012. Phytoecdysteroids from *Silene* plants: distribution, diversity and biological (antitumour, antibacterial and antioxidant) activities. **Bol Latinoam Caribe Plant Med Aromat** 11(6): 474 – 497.

INTRODUCTION

The genus *Silene*, which belongs in the family of the Caryophyllaceae and distributed mainly in the Northern Hemisphere, but also in Africa, Asia and South America. Genus of *Silene* includes more than 700 species (which allocated to 39 sections) of annuals, biennials, and perennials with a worldwide distribution and its taxonomy appears very complex. Most of species are hermaphrodite, but a few are dioecious or gynodioecious (Grauter, 1995). Common names of *Silene* include campion (shared with the related genus *Lychnis*) and catchfly. Red campion (*S. dioica*), white campion (*S. latifolia, S. alba*) and bladder campion (*S. vulgaris*) are common wildflowers throughout Europe.

In this review article, the phytoecdysteroids isolated from the genus *Silene* are listed, and the phytochemical investigation in this genus is summarized. The structures of phytoecdysteroids are shown below, i.e., their names (**Figure 1**) and the corresponding plant sources are collected in **Table 1**. The traditional and medicinal uses of *Silene* plants and biological (antitumour, antibacterial and antioxidant) activities of phytoecdysteroids isolated from these plants are also discussed.

Figure 1
Chemical structures of phytoecdysteroids isolated from *Silene* plants

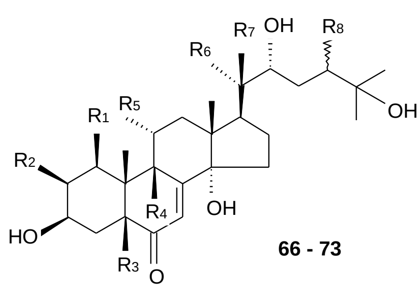


1- 65

N	Name	Empiric formula	CAS Registry Number	Substituents in steroidal core				Substituents in side-chain			
				R$_1$	**R$_2$**	**R$_3$**	**R$_4$**	**R$_5$**	**R$_6$**	**R$_7$**	**R$_8$**
1	Brahuisterone	$C_{27}H_{44}O_6$	169238-28-2	H	H	OH	OH	H	OH	OH	CH_3
2	2-Deoxy-20,26-dihydroxyecdysone	$C_{27}H_{44}O_7$	397248-04-3	H	H	OH	H	OH	OH	OH	CH_2OH
3	22-Deoxy-20,26-dihydroxyecdysone	$C_{27}H_{44}O_7$	128552-88-5	H	OH	OH	H	OH	H	OH	CH_2OH
4	2-Deoxyecdysone	$C_{27}H_{44}O_5$	31575-91-4	H	H	OH	H	H	OH	OH	CH_3
5	2-Deoxyecdysone-3-acetate	$C_{29}H_{46}O_6$	105888-75-3	H	H	OAc	H	H	OH	OH	CH_3
6	2-Deoxyecdysone-22-acetate	$C_{29}H_{46}O_6$	76026-42-1	H	H	OH	H	H	OAc	OH	CH_3
7	2-Deoxyecdysone-22-benzoate	$C_{34}H_{48}O_6$	114317-61-2	H	H	OH	H	H	OBz	OH	CH_3
8	2-Deoxyecdysone-22-glucoside	$C_{33}H_{54}O_{10}$	627511-32-4	H	H	OH	H	H	OGlu	OH	CH_3
9	2-Deoxy-20-hydroxyecdysone	$C_{27}H_{44}O_6$	17942-08-4	H	H	OH	H	OH	OH	OH	CH_3
10	2-Deoxy-20-hydroxyecdysone-3-acetate	$C_{29}H_{46}O_7$	98149-16-7	H	H	OAc	H	OH	OH	OH	CH_3
11	5α-2-Deoxy-20-hydroxyecdysone-3-acetate	$C_{29}H_{46}O_7$	188247-16-7	H	H	OAc	H (α)	OH	OH	OH	CH_3
12	2-Deoxy-20-hydroxyecdysone-22-acetate	$C_{29}H_{46}O_7$	117048-09-6	H	H	OH	H	OH	OAc	OH	CH_3
13	2-Deoxy-20-hydroxyecdysone-25-acetate	$C_{29}H_{46}O_7$	478809-55-1	H	H	OH	H	OH	OH	OAc	CH_3
14	2-Deoxy-20-	$C_{34}H_{48}O_7$	345958-46-5	H	H	OBz	H	OH	OH	OH	CH_3

	hydroxyecdysone-3-benzoate										
15	2-Deoxy-20-hydroxyecdysone-22-benzoate	$C_{34}H_{48}O_7$	128529-85-1	H	H	OH	H	OH	OBz	OH	CH_3
16	2-Deoxy-20-hydroxyecdysone-3-crotonate	$C_{31}H_{48}O_7$	200867-02-3	H	H	$OCOC_2H_2CH_3$	H	OH	OH	OH	CH_3
17	2-Deoxy-20-hydroxyecdysone-3,22-diacetate	$C_{31}H_{48}O_8$	102942-11-0	H	H	OAc	H	OH	OAc	OH	CH_3
18	2-Deoxy-20-hydroxyecdysone-22-glucoside	$C_{33}H_{54}O_{11}$	478062-03-2	H	H	OH	H	OH	O-β-D-Glu	OH	CH_3
19	2-Deoxy-20-hydroxyecdysone-25-glucoside	$C_{33}H_{54}O_{11}$		H	H	OH	H	OH	OH	O-β-D-Glu	CH_3
20	2-Deoxyintegristerone A	$C_{27}H_{44}O_7$	117048-08-5	OH	OH	OH	H	OH	OH	OH	CH_3
21	5α-2-Deoxyintegristerone A	$C_{27}H_{44}O_7$	482662-85-1	OH	OH	OH	H (α)	OH	OH	OH	CH_3
22	22-Deoxyintegristerone A	$C_{27}H_{44}O_7$	128529-87-3	OH	OH	OH	H	OH	H	OH	CH_3
23	5α-22-Deoxyintegristerone A	$C_{27}H_{44}O_7$	128529-88-4	OH	OH	OH	H (α)	OH	H	OH	CH_3
24	2-Deoxypolypodine B-3-glucoside	$C_{33}H_{54}O_{12}$	397248-06-5	H	H	O-β-D-Glu	OH	OH	OH	OH	CH_3
25	2-Deoxy-5,20,26-trihydroxyecdysone	$C_{27}H_{44}O_8$	1039035-94-3	H	H	OH	OH	OH	OH	OH	CH_2OH
26	20,26-Dihydroxyecdysone (Podecdysone C)	$C_{27}H_{44}O_8$	19458-46-9	H	OH	OH	H	OH	OH	OH	CH_2OH
27	20,26-Dihydroxyecdysone-2,22-diacetate	$C_{31}H_{48}O_{10}$	809239-25-6	H	OAc	OH	H	OH	OAc	OH	CH_2OH
28	20,26-Dihydroxyecdysone-3,22-diacetate	$C_{31}H_{48}O_{10}$	50907-59-0	H	OH	OAc	H	OH	OAc	OH	CH_2OH
29	Ecdysone	$C_{27}H_{44}O_6$	3604-87-3	H	OH	OH	H	H	OH	OH	CH_3
30	Ecdysone-22-sulfate	$C_{27}H_{44}O_9S$	93552-65-9	H	OH	OH	H	H	OSO_3H	OH	CH_3
31	Ecdysteroside	$C_{39}H_{64}O_{17}$	209850-88-4	H	OH	O-α-D-Gal (1→6) α-D-Gal	H	OH	OH	OH	CH_3
32	5α-20-Hydroxyecdysone	$C_{27}H_{44}O_7$	35241-82-8	H	OH	OH	H (α)	OH	OH	OH	CH_3
33	5α-20-Hydroxyecdysone-22-benzoate	$C_{34}H_{48}O_8$	113814-96-3	H	OH	OH	H (α)	OH	OBz	OH	CH_3
34	20-Hydroxyecdysone	$C_{27}H_{44}O_7$	5289-74-7	H	OH	OH	H	OH	OH	OH	CH_3
35	20-Hydroxyecdysone-2-acetate	$C_{29}H_{46}O_8$	19536-25-5	H	OAc	OH	H	OH	OH	OH	CH_3
36	20-Hydroxyecdysone-3-acetate	$C_{29}H_{46}O_8$	22961-68-8	H	OH	OAc	H	OH	OH	OH	CH_3
37	20-Hydroxyecdysone-22-acetate	$C_{29}H_{46}O_8$	22799-02-6	H	OH	OH	H	OH	OAc	OH	CH_3
38	20-Hydroxyecdysone-20-benzoate	$C_{34}H_{48}O_8$	114317-60-1	H	OH	OH	H	OBz	OH	OH	CH_3
39	20-Hydroxyecdysone-22-benzoate	$C_{34}H_{48}O_8$	103654-38-2	H	OH	OH	H	OH	OBz	OH	CH_3
40	20-Hydroxyecdysone-22-benzoate-25-glucoside	$C_{40}H_{58}O_{13}$	128552-87-4	H	OH	OH	H	OH	OBz	O-β-D-Glu	CH_3
41	20-Hydroxyecdysone -2,3-diacetate-22-benzoate	$C_{38}H_{52}O_{10}$		H	OAc	OAc	H	OH	OBz	OH	CH_3
42	20-Hydroxyecdysone-22,25-dibenzoate	$C_{41}H_{52}O_9$	148031-28-1	H	OH	OH	H	OH	OBz	OBz	CH_3
43	20-Hydroxyecdysone-3-	$C_{33}H_{54}O_{12}$	128365-93-5	H	OH	O-β-D-	H	OH	OH	OH	CH_3

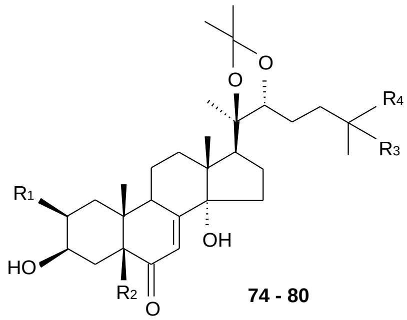
	glucoside					Glu					
44	20-Hydroxyecdysone-25-glucoside	$C_{33}H_{54}O_{12}$	116424-80-7	H	OH	OH	H	OH	OH	O-β-D-Glu	CH_3
45	26-Hydroxyintegristerone A	$C_{27}H_{44}O_9$		OH	OH	OH	H	OH	OH	OH	CH_2OH
46	26-Hydroxypolypodine B	$C_{27}H_{44}O_9$	121043-41-2	H	OH	OH	OH	OH	OH	OH	CH_2OH
47	Inokosterone	$C_{27}H_{44}O_7$	15130-85-5	H	OH	OH	H	OH	OH	H	CH_2OH
48	Integristerone A	$C_{27}H_{44}O_8$	66450-91-7	OH	OH	OH	H	OH	OH	OH	CH_3
49	Integristerone A-25-acetate	$C_{29}H_{46}O_9$	269739-15-3	OH	OH	OH	H	OH	OH	OAc	CH_3
50	Polypodine B	$C_{27}H_{44}O_8$	18069-14-2	H	OH	OH	OH	OH	OH	OH	CH_3
51	Ponasterone A	$C_{27}H_{44}O_6$	13408-56-5	H	OH	OH	H	OH	OH	H	CH_3
52	Sileneoside A	$C_{33}H_{54}O_{12}$	81655-86-9	H	OH	OH	H	OH	O-α-D-Gal	OH	CH_3
53	Sileneoside B	$C_{39}H_{64}O_{17}$	84699-93-4	H	OH	O-β-D-Gal	H	OH	O-β-D-Gal	OH	CH_3
54	Sileneoside C	$C_{33}H_{54}O_{13}$	83207-65-2	OH	OH	OH	H	OH	O-α-D-Gal	OH	CH_3
55	Sileneoside D	$C_{33}H_{54}O_{12}$	93552-68-2	H	OH	O-β-D-Gal	H	OH	OH	OH	CH_3
56	Silenoside E (Blechnoside A)	$C_{33}H_{54}O_{10}$	104406-79-3	H	H	O-β-D-Glu	H	H	OH	OH	CH_3
57	5α-Silenoside E	$C_{33}H_{54}O_{10}$	176166-62-4	H	H	O-β-D-Glu	H (α)	H	OH	OH	CH_3
58	Sileneoside F	$C_{33}H_{54}O_{11}$	170663-52-2	H	H	O-β-D-Glu	OH	H	OH	OH	CH_3
59	Sileneoside G	$C_{39}H_{64}O_{17}$	241478-02-4	H	OH	O-α-D-Glu	H	OH	O-α-D-Gal	OH	CH_3
60	Sileneoside H	$C_{35}H_{56}O_{14}$	289622-72-6	OH	OH	OH	H	OH	O-α-D-Gal	OAc	CH_3
61	Taxisterone	$C_{27}H_{44}O_6$	19536-24-4	H	OH	OH	H	OH	H	OH	CH_3
62	Tomentesterone A	$C_{36}H_{50}O_7$	178405-18-0	H	H	OH	H (α)	H	OAc	OBz	CH_3
63	Tomentesterone B	$C_{34}H_{48}O_6$	181939-54-8	H	H	OH	H (α)	H	OH	OBz	CH_3
64	Viticosterone E	$C_{29}H_{46}O_8$	22033-96-1	H	OH	OH	H	OH	OH	OAc	CH_3
65	Viticosterone E-22-benzoate	$C_{36}H_{50}O_9$	118201-53-9	H	OH	OH	H	OH	OAc	OAc	CH_3



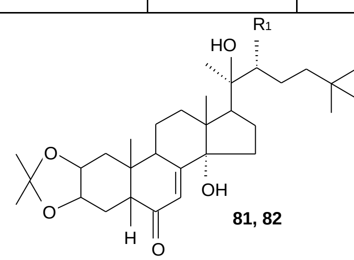
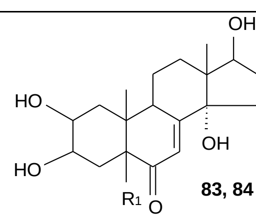
66 - 73

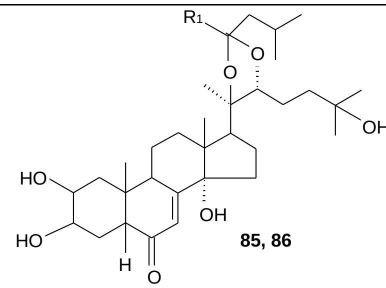
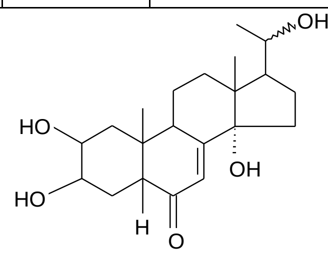
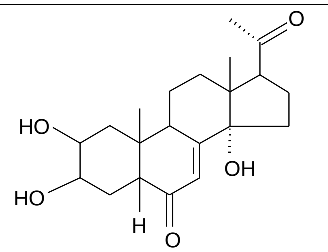
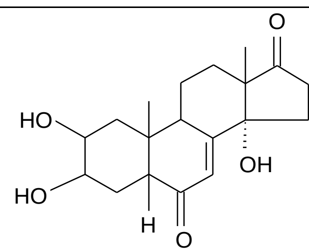
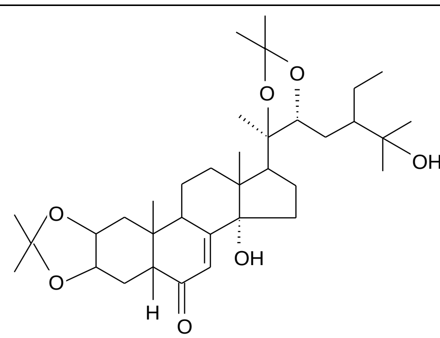
N	Name	Empiric formula	CAS Registry Number	Substituents in steroidal core					Substituents in side-chain		
				R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8
66	24(28)-Dehydromakisterone A	$C_{28}H_{44}O_7$	68556-61-6	H	OH	H	H	H	CH_3	OH	CH_2
67	2-Deoxy-21-hydroxyecdysone	$C_{27}H_{44}O_6$	232280-38-5	H	H	H	H	H	CH_2OH	H	H
68	5α-2-Deoxy-21-hydroxyecdysone	$C_{27}H_{44}O_6$	232280-39-6	H	H	H (α)	H	H	CH_2OH	H	H
69	9α,20-Dihydroxyecdysone	$C_{27}H_{44}O_8$	157977-59-8	H	OH	H	OH (α)	H	CH_3	OH	H
70	9β,20-Dihydroxyecdysone	$C_{27}H_{44}O_8$	790701-24-5	H	OH	H	OH	H	CH_3	OH	H
71	Makisterone A	$C_{28}H_{46}O_7$	20137-14-8	H	OH	H	H	H	CH_3	OH	CH_3

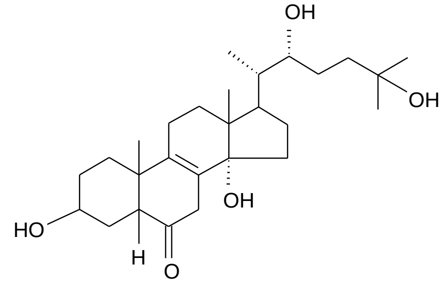
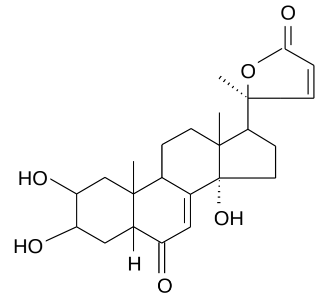
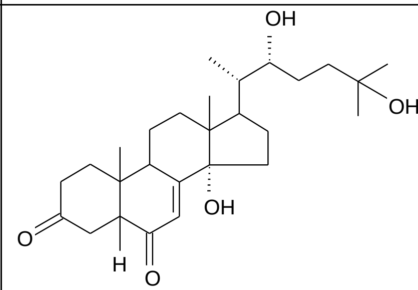
72	Nusilsterone	$C_{27}H_{44}O_9$	102099-20-7	OH	OH	H	H	H	CH_3	OH	OH
73	Turkesterone	$C_{27}H_{44}O_8$	41451-87-0	H	OH	H	H	OH	CH_3	OH	H



74 - 80

N	Name	Empiric formula	CAS Registry Number	Substituents in steroidal core		Substituents in side-chain	
				R_1	R_2	R_3	R_4
74	2-Deoxy-20-hydroxyecdysone-20,22-acetonide	$C_{30}H_{48}O_6$	142735-52-2	H	H	OH	CH_3
75	5α-2-Deoxy-20-hydroxyecdysone-20,22-acetonide	$C_{30}H_{48}O_6$	188246-96-0	H	H (α)	OH	CH_3
76	2-Deoxy-5,20,26-trihydroxyecdysone-20,22-acetonide	$C_{30}H_{48}O_8$	1039036-00-4	H	OH	OH	CH_2OH
77	20,26-Dihydroxyecdysone-20,22-acetonide	$C_{30}H_{48}O_8$	245323-26-6	OH	H	OH	CH_2OH
78	20-Hydroxyecdysone-20,22-acetonide	$C_{30}H_{48}O_7$	22798-96-5	OH	H	OH	CH_3
79	20-Hydroxyecdysone 20,22-acetonide-25-acetate	$C_{32}H_{50}O_8$		OH	H	OAc	CH_3
80	5,20,26-Trihydroxyecdysone-20,22-acetonide	$C_{30}H_{48}O_9$	1039035-97-6	OH	OH	OH	CH_2OH
81	20-Hydroxyecdysone-2,3-acetonide	$C_{30}H_{48}O_7$	113866-76-5	R_1 = OH	 **81, 82**		
82	20-Hydroxyecdysone-2,3-acetonide-22-benzoate	$C_{37}H_{52}O_8$	103654-40-6	R_1 = OBz			
83	5α-Dihydrorubrosterone	$C_{19}H_{28}O_5$	232280-44-3	R_1 = H (α)	 **83, 84**		
84	5β-Dihydrorubrosterone	$C_{19}H_{28}O_5$	232280-43-2	R_1 = H			

85	20, 22-Acetal isovaleric aldehyde-5β-cholest-7-en-2β,3β,14α,20R,22R,25-hexahydroxy-6-on	$C_{32}H_{52}O_7$	404589-60-2	R_1 = H (α)	 85, 86
86	20,22-Acetal epiisovaleric aldehyde-5β-cholest-7-en-2β,3β,14α,20R,22R,25-hexahydroxy-6-on	$C_{32}H_{52}O_7$	404589-62-4	R_1 = H	
87	Dihydropoststerone	$C_{21}H_{32}O_5$	128574-64-1		
88	Poststerone	$C_{21}H_{30}O_5$	10162-99-9		
89	Rubrosterone	$C_{19}H_{26}O_5$	19466-41-2		
90	Makisterone C-2,3;20,22-diacetonide	$C_{35}H_{56}O_7$	1146696-54-9		

91	Praemixisterone	$C_{27}H_{44}O_5$	74396-17-1	
92	Sidisterone	$C_{24}H_{32}O_6$	176391-32-5	
93	Silenosterone	$C_{27}H_{42}O_5$	74396-16-0	

RESULTS AND DISCUSSION

Chemical constituents

Chemical investigations of the genus *Silene* have led to the isolation of phytoecdysteroids, triterpene glycosides (Gaidi *et al*., 2002), terpenoids, benzenoids, flavonoids (Darmograi, 1977), anthocynanins, N-containing compounds (Dotterl *et al.*, 2005), fatty acids (Kucukboyaci *et al*. 2010; Mamadalieva *et al*., 2010a; Mamadalieva *et al*., 2010b), amino acids (Terrab *et al*., 2007), polysaccharides (Ovodova *et al*., 2000), sugars (Mogosanu *et al*., 2011), sterols, vitamins, organic acids and microelements (Eshmirzayeva *et al.*, 2005; Arnetoli *et al.*, 2008).

Phytoecdysteroids

Phytoecdysteroids are contentedly widespread in the plant world. They are isolated from the main types of higher plants **-** ferns, gymnosperms and angiosperms, but their function in plants are yet studied insufficiently. One can conclude that the role of ecdysteroids in various plants and plant families may differ: when the ecdysteroid content is low, these exert a determinative effect on the plant growth and development; when it is high (several percent), these may be involved in the biochemical processes of storage, transportation, and metabolism of sterols. In this case, such metabolic products are not excluded that can defense the plant against the harmful factors of the environment (Baltaev, 2000). High concentrations of phytoecdysteroids have found in the reproductive organs, the anthers, apical leaves, and roots. Up to date, phytoecdysteroids isolated from more than 400 species of the plants and fungus belonging to 52 families (Mamadalieva, 2012a). As can be seen, phytoecdysteroids is the predominant constituents within the genus *Silene* (**Table 1**). Given the complexity of ecdysteroid cocktails existing in many *Silene* species, it has been proposed that ecdysteroids have a chemotaxonomic value in this genus (Zibareva *et al*., 2009). *Silene* plants accumulate high levels of phytoecdysteroids and have therefore been exploited as an industrial source for the production of phytoecdysteroids. The qualitative and quantitative composition of phytoecdysteroid cocktails depends considerably on the plant species, but possibly also on soil climatic conditions and on the developmental stage of the plant.

More than 170 *Silene* species have been analyzed for their phytoecdysteroid content, and 140 of them were found to be positive and 93 different ecdysteroids (ca. 25% of the known phytoecdysteroids) have been detected from these plants (**Table 1**). Some of them contain a high concentration of 20- hydroxyecdysone, such as *Silene otites* (almost 1%) and *Silene multiflora* (1.9%) (Bathori *et al*., 1987). In the **Table 1** we can see, that some species of *Silene* genus characterized by the absence of phytoecdysteroids. Zibareva *et al*., (2009) explaned that by the assumption that some sections of *Silene* (for example, Siphonomorpha, Chloranthae, Coronatae, Graminiformes, Otites, Silene, Dipterosperma, Lasiocalycinae, Holopetalae) consist of only ecdysteroid-containing species, whereas other sections (Behen, Atocion, Psammophilae, Odontopetalae, etc.) contain only ecdysteroid-negative species. In these sections, it is possible, with high probability, to predict ecdysteroid presence or absence in as yet uninvestigated species.

The major phytoecdysteroids identified in *Silene* plants include: 20-hydroxyecdysone, polypodine B, 2-deoxy-20-hydroxyecdysone, 2-deoxyecdysone, inokosterone, integristerone A and ecdysone. Natural derivatives of phytoecdysteroids are also considered as phytoecdysteroids in the definite sense. *Silene* spp. plants are characterized by the highest diversity of ecdysteroid derivatives, such as acetates, acetonides, benzoates, cinnamates, coumarates, crotonates, glycosil-ferulates, glucosides, galactosides, ramnosides, xylosides, sulfates, etc. The presence of furan, epoxy and lactone ring contains derivatives of phytoecdysteroids is typical for this genus (Lafont *et al.*, 2002).

Table 1
Distribution of phytoecdysteroids in the genus of *Silene*

Plant species	Isolated phytoecdysteroids	Reference
Silene acaulis (L) Jacg.	34	Zibareva, 1995; Zibareva, 2000; Zibareva *et al.*,2003a
S. alba (Miller) E.H.L. Krause	-	Zibareva, 2000; Zibareva *et al.*, 2003a
S. alpestris Jacg.	-	Zibareva, 2000; Zibareva *et al.*, 2003a
S. altaica Pers.	34, 50	Bathori *et al.*, 1995; Zibareva, 1999; Zibareva, 2000
S. ambigua Turcz.	34	Zibareva, 2009
S. antirrhina L.	9, 34, 50, 51	Mamadalieva *et al*., 2004b; Meng *et al.*, 2001; Zibareva *et al.*, 2003a; Zibareva, 2009
S. apetala Willd.	34	Zibareva *et al.*, 2003a; Zibareva *et al.*, 2003b
S. aprica Turel	34	Munkhzhargal et al., 2010
S. armeria L.	34	Bathori *et al.*, 1995; Zibareva, 1997; Zibareva, 2000; Zibareva *et al.*, 2003a; Zibareva *et al.*, 2003b
S. asterias Griseb.	-	Zibareva, 2000; Zibareva *et al.*, 2003a
S. bashkirorum Janish	34	Zibareva, 2000
S. bellidifolia Juss. ex Jacq.	34	Zibareva, 2000; Zibareva and Yeryomina, 2002; Zibareva *et al.*, 2003a
S. bellidioides	-	Zibareva *et al.*, 2003a
S. bergiana Lindm	34	Zibareva *et al.*, 2003b
S. boryi Boiss.	-	Zibareva, 2000
S. borystenica	34	Zibareva *et al.*, 2003b
S. bourgeaui H. Christ.	34	Zibareva, 2009
S. brachypoda Rouy	34, 50	Zibareva, 2000
S. brahuica Boiss.	1, 6, 4, 9, 70, 30, 34, 48-60,	Abubakirov, 1982; Abubakirov, 1984; Bathori *et al.*,

	64	1995; Dzhukharova *et al.*, 1991; Dzhukharova *et al.*, 1993; Dzhukharova *et al.*, 1994; Dzhukharova *et al.*,1995; Sadikov & Saatov, 1998; Sadikov & Saatov, 1999; Saatov *et al.*, 1981; Saatov *et al.*, 1982a; Saatov *et al.*, 1982b; Saatov *et al.*, 1984a; Saatov *et al.*, 1984b; Saatov *et al.*, 1986b; Saatov *et al.*, 1993; Saatov *et al.*, 1999
S. bupleroides L.	-	Zibareva, 2000
S. burchelli Otth.	34	Zibareva *et al.*, 1998; Zibareva *et al.*, 2003a
S. campanula Pers.		Zibareva, 2000
S. campanulata S. Watson	34, 50	Zibareva, 1999; Zibareva *et al.*, 1998
S. caramanica Boiss.	34, 50	Zibareva, 1999; Zibareva *et al.*, 1998
S. caroliniana	-	Zibareva *et al.*, 2003a
S. catholica (L) Aiton fil.	34, 50	Bathori *et al.*, 1995; Zibareva, 1999; Zibareva, 2000; Zibareva, 2003b
S. caucasica Boiss.	34, 50	Zibareva, 1998; Zibareva, 1999; Zibareva *et al.*, 1998
S. chamarensis Turcz.	34	Munkhzhargal et al., 2010; Revina *et al.*, 1988; Saatov *et al.*, 1993
S. chlorantha Willd.	34	Bathori *et al.*, 1995; Sviridova *et al.*, 1995; Zibareva, 1995; Zibareva, 1999; Zibareva, 2000
S. chlorifolia Smith.	9, 34, 50, 51	Bathori *et al.*, 1995; Zibareva, 1995; Zibareva, 1999; Zibareva, 2000; Zibareva, 2003b ; Mamadalieva *et al.*, 2004b; Meng *et al.*, 2001; Zibareva, 2009
S. chlorifolia cordifolia All.	-	Pongracz *et al*., 2003b
S. ciliata Pourret	34, 50	Bathori *et al.*, 1995; Zibareva, 1995; Zibareva, 1999; Zibareva, 2000
S. ciliate var graefteri (P).	34	Zibareva, 2000
S. clandestina	+	Zibareva *et al.*, 2003a
S. claviformis	4, 9, 34, 48, 85, 86	Sadikov *et al.*, 2001
S. coeli-rosa (L.) Godron in Gren.	34	Bathori *et al.*, 1995; Zibareva, 2000; Zibareva, 2009; Zibareva *et al.*, 2003a
S. colorata Poiret.	34	Pongracz *et al*., 2003b; Zibareva, 1995; Zibareva, 1999; Zibareva, 2000; Zibareva *et al.*, 2003a; Zibareva & Yeryomina, 1996
S. colorata ssp. *trichocalysina*	34	Zibareva, 1995; Zibareva, 1999; Zibareva, 2000
S. compacta Fisher.	-	Pongracz *et al*., 2003b; Zibareva, 2000
S. conica L.	-	Pongracz *et al*., 2003b; Zibareva, 1997; Zibareva, 2000; Zibareva *et al.*, 2003a
S. conoidea L.	-	Zibareva, 2000
S. coronaria (L.) Clairv	34	Zibareva, 1995; Zibareva, 1999; Zibareva *et al.*, 2003a
S. cretica L.	9, 29, 34, 50	Mamadalieva *et al.*, 2004b; Meng *et al.*, 2001; Zibareva, 1997; Zibareva, 2009; Zibareva *et al.*, 1997a; Zibareva *et al.*, 2003a; Zibareva *et al.*, 2003b; Zibareva & Yeryomina, 1996
S. cucubalus Wibel.	+	Pongracz *et al*., 2003b

S. damboldtiana Greuter et Melzh.	34, 50	Zibareva, 1999; Zibareva *et al.*, 1998
S. densiflora (L.) Wib. Drurv.	34	Sviridova *et al.*, 1995; Zibareva, 1999; Zibareva, 2000; Zibareva *et al.*, 1998
S. dichotoma Ehrh.	-	Zibareva, 2000
S. dinarica Sprengel.	-	Zibareva, 2000
S. dioica (L.) Clairv.	34, 92	Girault *et al.*, 1996; Lafont and Horn, 1989; Saatov *et al.*, 1993; Zibareva, 1997; Zibareva, 2000; Zibareva *et al.*, 2003a
S. disticha Willd.	9, 29, 34, 47, 50, 51	Lafont and Horn, 1989; Mamadalieva *et al.*, 2004b; Meng *et al.*, 2001; Zibareva, 1995; Zibareva, 1997; Zibareva, 2009; Zibareva *et al.*, 2003a; Zibareva *et al.*, 2003b; Zibareva & Yeryomina, 1996.
S. divaricata Clemente	-	Zibareva, 2000
S. echinata Otth.	29, 34, 50, 51	Mamadalieva *et al.*, 2004b; Meng *et al.*, 2001; Zibareva. 2000; Zibareva, 2009; Zibareva *et al.*, 2003a; Zibareva *et al.*, 2003b
S. elegans L.	34	Zibareva, 2009
S. fabaria (L.) Sm.	-	Zibareva, 2000
S. fabariodes Husskn.	+	Pongracz *et al*., 2003b; Zibareva, 2000
S. fetissovii Lazkov	34	Zibareva *et al.*, 2003b
S. firma Siebold et Zucc.	34	Zibareva, 1999; Zibareva & Yeryomina, 1996
S. flavescens Waldst et Kit	34	Bathori *et al.*, 1995; Zibareva, 1999
S. foliosa Maxim.	34	Novozhilova *et al.*, 2007; Zibareva *et al.*, 2003b
S. fortunei	+	Gaidi *et al.*, 2002
S. fridvaldszkyana Hampe	4, 9, 26, 34, 45, 46, 48, 50, 66	Louden *et al.*, 2002; Mamadalieva *et al.*, 2004b; Sviridova *et al.*, 1995; Zibareva, 1996; Zibareva, 1997; Zibareva *et al.*, 1997a; Zibareva *et al.*, 2003a; Zibareva *et al.*, 2003b; Zibareva *et al.*, 2009
S. fruticosa L.	34	Zibareva, 2000; Zibareva *et al.*, 1997a
S. fruticulosa L.	-	Pongracz *et al*., 2003b
S. fuscata Link in Brot.	-	Zibareva, 2000
S. gallica L.	34	Bathori *et al.*, 1995; Bergamasco & Horn, 1983; Zibareva, 2000; Zibareva *et al.*, 2003a
S. gallica var. quiquivulnera (L) Koch.	34	Zibareva, 1999; Zibareva, 2000; Zibareva *et al.*, 2003
S. gebleriana Schrenk.	34	Zibareva *et al.*, 2003b
S. gigantea L.	4, 9, 19, 34, 48	Zibareva, 1999; Zibareva, 2000; Zibareva *et al.*, 2009;
S. goulimyi Turrill.	34	Zibareva, 2000
S. graefferi Guss.	34	Zibareva *et al.*, 2003b
S. graminifolia Otth.	4, 34	Munkhzhargal *et al*., 2010; Revina *et al.*, 1988; Saatov *et al.*, 1993; Zibareva, 1997; Zibareva *et al.*, 2009; Zibareva and Yeryomina, 1996
S. guntensis B. Fredtsch	9, 34, 41	Mamadalieva *et al.*, 2011

S. hifacensis Rouy ex willk.	34	Zibareva, 2000
S. holopetala Lebed.	34	Zibareva *et al.*, 2003b
S. ichebogda Glub.	34	Munkhzhargal *et al.*, 2010
S. inaperta L.	-	Zibareva, 2000
S. incurvifolia Kar et Kir.	34	Zibareva et al., 2003b
S. inflata Sm.	+	Pongracz *et al*., 2003b
S. italica (L.) Pers.	9, 29, 34, 50, 51	Mamadalieva *et al.*, 2004b, Meng *et al.*, 2001; Sviridova *et al.*, 1995; Zibareva, 1996; Zibareva, 1997; Zibareva, 2009; Zibareva *et al.*, 2003a
S. italica ssp. *nemoralis*	9, 18, 20-22, 29, 32, 34, 48, 50, 61, 66, 69, 70	Bathori *et al.*, 2000a; Bathori *et al.*, 2002a; Bathori *et al.*, 2002b; Pongracz *et al.*, 2003; Simon *et al.*, 2004; Zibareva, 1996; Zibareva, 1997; Zibareva, 2000; Zibareva *et al.*, 2003b
S. jenisseensis Willd.	34	Munkhzhargal *et al.*, 2010; Revina *et al.*, 1988; Saatov *et al.*, 1993; Zibareva, 1997; Zibareva *et al.*, 1997a
S. jundzillii	+	Zibareva, 2009
S. keiskei	+	Zibareva *et al.*, 2003a
S. kungessana B. Fedtsch	34	Zibareva *et al.*, 2003b
S. laeta (Aiton) Godron in Gren.	-	Zibareva, 2000
S. laciniata	+	Zibareva *et al.*, 2003a
S. latifolia (Gilib) Aschers	4, 9, 34	Abubakirov, 1982; Abubakirov, 1984; Bathori *et al.*, 1995; Saatov *et al.*, 1982a; Saatov *et al.*, 1982b; Saatov *et al.*, 1993; Zibareva *et al.*, 2003a
S. linicola C.C.Gmelin.	9, 29, 34, 48, 50, 64, 73	Mamadalieva *et al.*, 2002b; Mamadalieva *et al.*, 2004b; Zibareva, 1997; Zibareva *et al.*, 1997a; Zibareva *et al.*, 2003a; Zibareva & Yeryomina, 1996
S. longicalycina Kom.	34	Abubakirov, 1982; Abubakirov, 1984; Bathori *et al.*, 1995; Saatov *et al.*, 1982a; Saatov *et al.*, 1982b; Saatov *et al.*, 1993
S. longicilia (Brot.) Otth. in DC	34	Zibareva, 2009
S. longiflora Ehrh.	+	Pongracz *et al*., 2003b
S. maritima	-	Zibareva *et al.*, 2003a
S. maritime (With.) A. & Love	+	Pongracz *et al*., 2003b
S. mellifera Boiss. et Reuter	34, 50	Zibareva, 1996; Zibareva, 1999; Zibareva, 2000; Zibareva *et al.*, 1997a; Zibareva *et al.*, 2003; Zibareva *et al.*, 2009
S. melzheimeri Greuter	34	Zibareva, 2009
S. micropetala Lag.	34	Bathori *et al.*, 1995; Saatov *et al.*, 1993; Zibareva, 1997; Zibareva & Yeryomina, 1996
S. mollissima (L.) Pers.	34	Zibareva *et al.*, 2003b
S. mongolica Maxim	34	Munkhzhargal *et al*., 2010
S. multicaulis Guss.	34	Bathori *et al.*, 1995; Zibareva, 2000

S. multiflora (Waldst. et Kit) Pers	34	Bathori, 1998; Revina *et al.*, 1988; Zibareva *et al.*, 2003a
S. nemoralis Waldst. et Kit.	34	Sviridova *et al.*, 1995; Zibareva, 1999
S. noctiflora L.	-	Pongracz *et al*., 2003b; Zibareva, 2000; Zibareva *et al.*, 2003a
S. nutans L.	3, 15, 22, 23, 26, 34, 46, 48, 50, 52, 61, 72	Baltaev *et al.*, 1984; Baltaev *et al.*, 1985a; Baltaev *et al.*, 1985b; Bathori, 1998; Bathori *et al.*, 1986a; Bathori *et al.*, 1986c; Bathori *et al.*, 1987; Bathori *et al.*, 1995; Buckman *et al.*, 1986; Davis *et al.*, 1993; Girault *et al.*, 1990; Lafont *et al.*, 1993; Louden *et al.*, 2002; Ramazanov *et al.*, 1997; Ramazanov *et al.*, 2007; Raynor *et al.*, 1989; Read *et al.*, 1990; Revina *et al.*, 1988; Saatov *et al.*, 1993; Sviridova *et al.*, 1995; Wilson & Morden, 1999; Zibareva, 1997; Zibareva, 2000; Zibareva, 2009; Zibareva *et al.*, 1997a; Zibareva *et al.*, 2003a
S. obovata Schischk.	34	Zibareva *et al.*, 2003b
S. odoratissima Bunge	34	Zibareva *et al.*, 2003b
S. olgae (Maxim.) Rohrb.	-	Novozhilova *et al.*, 2007
S. oligantha Boiss.	34	Zibareva *et al.*, 2003b
S. orphanidis Boiss.	-	Zibareva, 2000
S. otites (L.) Wibel.	4, 6, 9-12, 15-17, 20, 26, 29, 34-37, 39, 40, 43, 44, 48, 64, 66-68, 71, 83, 84, 87-89, 92	Bathori, 1986; Bathori, 1998; Bathori *et al.*, 1986a; 1 Bathori *et al.*, 986b; Bathori *et al.*, 1988; Bathori *et al.*, 1995; Bathori *et al.*, 1997; Bathori *et al.*, 1999; Bathori *et al.*, 2000a; Bathori *et al.*, 2001b; Bathori *et al.*, 2003; Bathori & Kalasz, 2001; Davis *et al.*, 1993; Girault *et al.*, 1990; Girault *et al.*, 1996; Large *et al.*, 1992; Louden *et al.*, 2002; Raynor *et al.*, 1989; Saatov *et al.*, 1993; Wilson, 2000; Wilson *et al.*, 1990; Wilson *et al.*, 1998; Wilson *et al.*, 1999; Wilson & Morden, 1999; Zibareva, 2000; Zibareva, 2009; Zibareva *et al.*, 1997a; Zibareva *et al.*, 1998
S. otites ssp. *hungarica*	+	Bathori *et al.*, 1987; Zibareva *et al.*, 2003a
S. otites var. *parviflorus*	34	Zibareva, 1995; Zibareva, 1999; Zibareva, 2000
S. paradoxa L.	34, 50	Zibareva, 1995; Zibareva, 1999; Zibareva, 2000; Zibareva *et al.*, 1998
S. parnassica Boiss.	34, 50	Zibareva, 1995; Zibareva, 1997; Zibareva, 1999; Zibareva, 2000; Zibareva *et al.*, 1997b
S. patula Desf.	34	Zibareva, 1995; Zibareva, 1999; Zibareva, 2000; Zibareva *et al.*, 1997b
S. paucifolia	+	Volodin *et al.*, 2002; Zibareva, 2009
S. pendula L.	+	Pongracz *et al*., 2003b; Zibareva *et al.*, 2003a
S. polaris	-	Zibareva, 1997
S. portensis L.	9, 29, 34, 50, 51	Mamadalieva *et al.*, 2004b; Meng *et al.*, 2001; Zibareva, 1995; Zibareva, 1999; Zibareva, 2000; Zibareva, 2009; Zibareva *et al.*, 1997b; Zibareva *et al.*, 2003a; Zibareva *et al.*, 2003b

S. praemixta M. Pop	4, 9, 10, 29, 34, 64, 91, 93	Abubakirov, 1980; Abubakirov, 1982; Abubakirov, 1984; Saatov *et al.*, 1979a; Saatov *et al.*, 1979b; Saatov *et al.*, 1982a; Saatov *et al.*, 1982b; Saatov *et al.*, 1985; Saatov *et al.*, 1993
S. procumbens Murr.	-	Zibareva, 2000
S. pseudotites Bess. ex Reichenb	2, 4, 8, 9, 20, 21, 24, 29, 34, 47, 50, 51, 67, 92	Mamadalieva *et al.*, 2004b; Meng *et al.*, 2001; Zibareva, 1999; Zibareva, 2000; Zibareva, 2009; Zibareva *et al.*, 2003b
S. psevdovelutina Rothm	34	Zibareva, 1999; Zibareva, 2000
S. pusilla Waldst.	+	Dinan *et al.*, 2001; Zibareva *et al.*, 2003a
S. pygmaea Adams	34	Bathori *et al.*, 1995; Zibareva, 1999
S. quinquevulnera L.	34	Zibareva *et al.*, 2003b
S. radicosa Bois et Heldr	29, 34, 50, 51	Mamadalieva *et al.*, 2004b; Meng *et al.*, 2001; Zibareva, 2000; Zibareva, 2009; Zibareva *et al.*, 1998
S. regia	34, 47, 50, 51	Zibareva, 2009
S. reichenbachii Vis.	34	Zibareva, 2000; Zibareva *et al.*, 2003b
S. repens Patrin.	4, 9, 34, 48, 50	Munkhzhargal *et al.*, 2010; Novozhilova *et al.*, 2007; Revina *et al.*, 1988; Saatov *et al.*, 1993; Zibareva, 2000; Zibareva *et al.*, 2009
S. requienii Otth.	-	Pongracz *et al*., 2003b; Zibareva, 2000
S. roemeri Friv.	4, 9, 34, 50, 66	Meng *et al.*, 2001; Zibareva, 2000; Zibareva *et al.*, 1998; Zibareva *et al.*, 2003a; Zibareva *et al.*, 2003b
S. rubella L.	34	Zibareva, 2000; Zibareva *et al.*, 1998
S. rupestris L.	+	Pongracz *et al*., 2003b; Zibareva *et al.*, 2003a
S. saxatilis Sims.	34	Zibareva, 2009
S. saxifraga L.	34	Zibareva *et al.*, 2003a; Zibareva *et al.*, 2003b
S. scabriflora Brot.	34	Zibareva, 2009
S. scabrifolia Kom.	4, 5, 9, 33, 34, 39, 42, 48, 52, 55, 78, 81, 82	Saatov *et al.*, 1986a; Saatov *et al.*, 1986c; Saatov *et al.*, 1987a; Saatov *et al.*, 1987b; Saatov *et al.*, 1990; Saatov *et al.*, 1993; Saatov *et al.*, 1999; Zibareva, 2009; Zibareva *et al.*, 2003a
S. schafta S.G.Gmel. ex Hohen	34	Saatov *et al.*, 1993; Zibareva *et al.*, 2003a; Zibareva *et al.*, 2003b
S. schischkinii (M.Pop) Vved.	34	Zibareva *et al.*, 2003b
S. schmuckeri Wettst.	34, 50	Bathori et al., 1995; Zibareva, 1999; Zibareva, 2000; Zibareva *et al.*, 2009
S. schumacheri	34	Bathori *et al.*, 1995
S. schwarzenbergeri Pers.	-	Zibareva, 2000
S. secundiflora Otth.	34	Zibareva, 1997; Zibareva & Yeryomina, 1996
S. sendtneri Boiss.	34, 50	Bathori *et al.*, 1995; Zibareva, 1995; Zibareva, 1999; Zibareva, 2000; Zibareva *et al.*, 2003a
S. sericea All.	34	Zibareva *et al.*, 2003b
S. sieberi Fenzl.	34	Zibareva, 2000
S. sobolevskajae Czer.	34	Ramazanov *et al.*, 1997c; Revina *et al.*, 1988; Saatov *et al.*, 1993; Zibareva, 1999
S. supina Bieb.	15, 34, 48, 50, 52, 55	Ramazanov *et al.*, 1997; Revina *et al.*, 1988; Zibareva, 1999; Zibareva, 2009

S. spergulifolia (Willd) Bieb.	34	Zibareva *et al.*, 2003b
S. squamigera Boiss	34	Zibareva & Yeryomina, 2002; Zibareva *et al.*, 2003a; Zibareva *et al.*, 2003b
S. stenophylla Ledeb.	34	Zibareva *et al.*, 2003b
S. stylosa Bunge	34	Zibareva *et al.*, 2003b
S. succulenta Forskal.	-	Zibareva, 2000
S. sussamyrica Lazkov	34	Zibareva, 2009; Zibareva *et al.*, 2003b
S. tatarica (L.) Wild.	15, 31, 34, 38, 48, 50, 52, 55	Baltaev, 1998; Baltaev *et al.*, 1987; Bathori *et al.*, 1995; Bathori & Mathe, 1996; Girault *et al.*, 1990; Ramazanov *et al.*, 2007; Saatov *et al.*, 1993; Zibareva, 1997; Zibareva, 1999; Zibareva, 2009; Zibareva & Yeryomina, 1996; Zibareva *et al.*, 2003a
S. thessalonica Boiss et Heldr.	34	Zibareva *et al.*, 1997a; Zibareva *et al.*, 2003a
S. tomentella Schischk.	4, 34, 48, 50, 62-64	Ramazanov *et al.*, 1995; Ramazanov *et al.*, 1996; Ramazanov *et al.*, 2007
S. turchaninova Lazkov	34	Zibareva, 2009; Zibareva *et al.*, 2003b
S. turgida L.	34	Munkhzhargal *et al.*, 2010; Revina *et al.*, 1988
S. undulata	+	Zibareva *et al.*, 2003a
S. uniflora	-	Zibareva *et al.*, 2003a
S. uralensis (Rupr.) Bocquet	34	Zibareva, 2009
S. vallesia L.	+	Zibareva, 2000; Zibareva *et al.*, 2003a
S. virginica	+	Zibareva *et al.*, 2003a
S. viridiflora L.	9, 20, 24-28, 34, 46, 48, 50, 52, 55, 61, 74-77, 79, 80, 90	Mamadalieva, 2007; Mamadalieva *et al.*, 2003; Mamadalieva *et al.*, 2004a; Mamadalieva *et al.*, 2004b; Mamadalieva *et al.*, 2009; Mamadalieva *et al.*, 2010a; Ramazanov *et al.*, 1997c; Toth *et al.*, 2008; Zibareva, 1995; Zibareva, 1997; Zibareva *et al.*, 1997a; Zibareva *et al.*, 2003a
S. viscosa (L.) Pers.	34	Munkhzhargal *et al.*, 2010; Volodin *et al.*, 2002; Zibareva, 2009
S. vulgaris (Moench.) Garcke	-	Zibareva, 1997; Zibareva, 2000; Zibareva *et al.*, 2003a
S. waldsteinii Griseb.	-	Zibareva, 2000
S. wallichiana Klotsch	4, 7, 9, 13, 14, 34, 39, 48, 64, 65	Abubakirov, 1982; Abubakirov, 1984; Bathori *et al.*, 1995; Mamadalieva *et al.*, 2000; Mamadalieva *et al.*, 2002a; Saatov *et al.*, 1987c; Saatov *et al.*, 1988; Saatov *et al.*, 1990; Saatov *et al.*, 1993; Saatov *et al.*, 1999
S. wolgensis	34	Zibareva *et al.*, 2003b
S. zawadskii Herbich.	34	Bathori *et al.*, 1995; Zibareva, 2000; Zibareva, 2009; Zibareva *et al.*, 2003a

(-) - denotes no phytoecdysteroid content; (+) - phytoecdysteroids were detected but not identified.

Traditional uses of Silene plants

Some plants of this genus such as *S. acaulis, S. multifida* and *S. regia* as ornamental plants and have beautiful flowers and have been cultured as garden plants in many countries (Erturk *et al*., 2006). The root of *S. latifolia* is used as a soap substitute for washing clothes etc. The soap is obtained by simmering the root in hot water (Uphof, 1968; Usher, 1974). Also *S.*

acaulis and *S. conoidea*, used as fodder as well as substitute for soap (Ahmad *et al*., 1998; Nasir and Ali 1986).

The use of edible wild species *S. acaulis, S. cucubalis* and *S. vulgaris* has been reported by several authors (Fernald *et al*., 1996; Hadjichambis *et al*., 2007; Guarrera, 2003; Alarcon *et al*., 2006). Several ethnobotanical studies reveal that especially young shoots and the leaves of *S. vulgaris* is very much appreciable in the traditional gastronomy of Turkey, Italy, Austria, Germany and Spain (Hadjichambis *et al*., 2007).

Traditional medicinal uses of Silene plants

The plant of *S. acaulis* has been used in the treatment of children with colic (Moerman, 1998). Some of members of this genus are used in folk medicine, mainly as an emollient and used as fumigant (Ali, 1998). Juice of *S. cucubalis* L. is prescribed in ophthalmia (Chadha, 1972). The flowers of *S. nigrescens* used in Tibetan medicine in the treatment for hearing loss, blocking otic canal and volvulus (Tsarong Tsewang, 1994). The seeds of *S. dioica* have also been used to cure snakebites [http://en.wikipedia.org]. *S. szechuensis* Williams has been used in Chinese medicine as antipyretic, analgesic, diuretic (Zhang *et al*., 1997). *S. vulgaris* also widely used in medicine as antianemic (Conforti *et al*., 2011), sedative, anti-inflammatory and antitoxic agent (Ballero and Fresu, 1993, Golovko and Bushneva, 2007). The plant *S. undulata* Aiton is used as a medicine in treating many diseases particularly fevers and delirium (Sobiecki, 2008). Root barks of *S. undulata* (syn. *S. capensis*) is used by the Zulu and Xhosa of Africa people as an oneirogenic agent (Hirst, 1997; Hirst, 2005; Sobiecki, 2008). Other *Silene* species such as *S. bellidioides* Sond and *S. pilosellifolia* Cham. & Schltdl. used by the Zulus and taken as a love charm emetic, treatment of scrofula, to combat sleepiness, in tonic baths after severe illness, to produce dreams relating to the ancestral spirits in South Africa (Sobiecki, 2008).

Biological activities of phytoecdysteroids

Biological investigations on phytoecdysteroids have indicated their anabolic (Syrov, 2000), adaptogenic, tonic (Syrov and Kurmukov, 1977), cardiotonic (Kurmukov and Yermishina, 1991), hypoglycemic, hypolipidemic, hepatoprotective (Kurtepova *et al*., 2001; Syrov *et al*., 1983) and other activities. Drugs derived from phytoecdysteroids can regulate mineral, carbohydrate, lipid and protein metabolism (Dinan and Lafont, 2006). Also these compounds appear in many plants mostly as a protection agent (toxins or antifeedants) against herbivore insects (Kubo and Klocke, 1983). Several reviews dealing with mentioned pharmacological effects of phytoecdysteroids have been reviewed recently (Slama and Lafont, 1995; Bathori, 2002; Lafont and Dinan, 2003; Bathori and Pongracz, 2005; Dinan and Lafont, 2006) and we will describe in this paper only antitumour, antibacterial and antioxidant effects of phytoecdysteroids.

Antitumour activity

There are some data on the inhibition effect of sarcoma and other types of cancer cells growth by phytoecdysteroids. Burdette and Richards (1961) observed proliferation-inhibitory effects on sarcoma cells *in vitro*, which they used extract from silkworm pupae containing ecdysteroids. But later investigations with individual phytoecdysteroids showed no effects (Burdette, 1974). Also, El-Mofti (1987, 1994) reported that ecdysone was able to induce neoplastic lesions in toads and mice; other researchers reported that ecdysteroid-containing extract of *Silene viridiflora* exerted antitumour activity *in vivo* (Zibareva, 2003). Some phytoecdysteroids isolated from *Ajuga* species showed antitumour activities in a mouse-skin model in vivo in a two-stage carcinogenesis trial, using 7,12-dimethylbenz[a]anthracene as initiator and 12-O-tetradecanoylphorbol-13-acetate (TPA) as the promoter (Takasaki *et al*., 1999). However, Lagova and Valueva (1981) reported that 20-hydroxyecdysone was mainly ineffective in preventing tumour growth in mice, but it stimulated the growth of mammary gland carcinomas. Also in the our *in vitro* experiments phytoecdysteroid 2,3-diacetate-22-benzoate-20-hydroxyecdysone showed a moderate inhibition against HeLa and HepG-2 cells [IC_{50} values (127.97 ± 11.34) and (106.76 ± 7.81) µM, respectively], while 2-deoxy-20-hydroxyecdysone was most active against MCF-7 cells [IC_{50} (126.54 ± 12.09) µM]. As compared to doxorubicin (IC_{50} between 0.28 to 1.07 µg/mL) the phytoecdysteroids showed moderate cytotoxicity (Mamadalieva *et al.,* 2011).

Compare the results from others and our experiments are difficult, because of used different tumor models, phytoecdysteroids and assay methods. Most likely, since phytoecdysteroids structurally resemble sex hormones, they may bind to steroid hormone receptors in mammals and stimulate the growth of hormone-dependent tumours.

Antibacterial activity

We studied the antimicrobial activity of different extracts and phytoecdysteroids from *Silene* plans towards the pathogenic microorganisms. The plant extracts obtained from *S. wallichiana* were tested at various concentrations ranging from 0.6 – 5 mg/ml and the evaluated MIC values (Mamadalieva *et al*., 2012b). The *Acinetobacter* sp, *Enterococcus faecalis*, *Klebsiella oxytoca, Pantoea agglomerans, Proteus rettgeri*, *Pseudomonas aeruginosa* and *Staphylococcus aureus* strains were inhibited by the methanol extract of *S. wallichiana* at MIC = 2.5 mg/ml, while *Escherichia coli* and *Klebsiella pneumoniae* was inhibited at MIC = 1.25 mg/ml. The butanol extract of *S. wallichiana* showed activity against the pathogenic bacterium *Acinetobacter sp., E. coli*, *K. pneumoniae, P. agglomerans, P. aeruginosa* (MIC = 2.5 mg/ml), and *P. rettgeri* (MIC = 1.25 mg/ml), although with weaker action respect to the methanol extract. The chloroform extract had minimum activity against all bacterial strains and only inhibited *Citrobacter freundii, E. coli* (MIC = 2.5 mg/ml) and *P. aeruginosa* (MIC = 1.25 mg/ml). The *S. wallichiana* aqueous extract also showed low antimicrobial activity against two strains only, *E. coli* and *P. aeruginosa* (MIC = 2.5 and 1.25 mg/ml, respectively). But pure phytoecdysteroids (viticosterone E, 20-hydroxyecdysone-22-benzoate, 2-deoxy-20-hydroxyecdysone, 2-deoxyecdysone, 20-hydroxyecdysone and integristerone A) isolated from *S. wallichiana* exhibited very low activity against the bacteria (Mamadalieva *et al*., 2012b).

The $CHCl_3$ extract of *S. brachuica* inhibited growth of three Gram-negative (*Enterococcus faecalis, Proteus rettgeri,* and *Pseudomonas aeruginosa*) and one Gram-positive (*Micrococcus luteus*) bacterial strain. The $CHCl_3$ extract of *S. viridiflora* was active against *M. luteus, P. rettgeri, Klebsiella pneumoniae*, and *P. aeruginosa*, whereas the extract of *S. wallichiana* exhibited activity against only pathogenic bacteria *M. luteus* and *P. aeruginosa* (Mamadalieva *et al.,* 2010b). Also preliminary screening of the $CHCl_3$ extract from the aerial part of *S. guntensis* found that it exhibited antibacterial effects against *Escherichia coli, P. aeruginosa,* and *Acinetobacter* sp. (Mamadalieva *et al.,* 2010c).

In another our experiments the phytoecdysteroids of *A. turkestanica* had weak antimicrobial activity against Gram-positive bacteria, *Candida glabrata*, except *S. pyogenes*. Only cyasterone showed activity (MIC > 0.5 mM and MMC > 0.5 mM) against *C. glabrata* (Mamadalieva *et al*., 2012c).

From above mentioned results, we can conclude that antibacterial activity is more consistent in total extracts respect to the single tested phytoecdysteroids. In addition, this finding was consistent with the previous results of Ahmad *et al*., (1996), Volodin *et al.,* (1999) and Shirshova *et al*., (2006), who claimed that most likely such compounds are not the major molecules responsible for the antibacterial activity of the plant extracts. Ahmad *et al*., (1996) and Shirshova *et al*., (2006) reported that some natural phytoecdysteroids, including 20-hydroxyecdysone, inokosterone, and ecdysone, did not exhibit antimicrobial activity with respect to most standard test microbe cultures. However, introduction of the acetyl group into the 20-hydroxyecdysone molecule significantly increased the antibacterial activity with respect to microbes inducing inflammatory and purulent processes (Shirshova *et al*., 2006). In our case, besides phytoecdysteroids, extracts exhibiting antibacterial activity were related to the chemical nature of the solvents which play a key role in the extraction of different chemical compounds from the plant material.

Antioxidant activity

Drugs derived from phytoecdysteroids exhibit antioxidant properties and have a similar effect with vitamin D_3 (Kuzmenko *et al*., 1997). Miliauskas and coworkers (2005) reported mild radical scavenging activity for 20-hydroxyecdysone. These observations are contradictory to what was found in other studies (Osynskaya *et al*., 1992).

The radical scavenging ability of the extracts and phytoecdysteroids of *S. guntensis* were evaluated by us using the reaction with the stable DPPH radical (Mamadalieva *et al*., 2011). In our experiments phytoecdysteroids were ineffective for DPPH radical scavenging activity (IC_{50} value > 100 μg/mL) compared to that for quercetin (3.37 μg/mL). Maximum scavenging activity of DPPH was observed with the water extract (IC_{50} 68.90 μg/mL) of *S. guntensis*, followed by the activity of the n-butanol, methanol, and chloroform extracts with IC_{50} values of 69.12, 122.48, and 148.28 μg/mL, respectively. The activity of 20-hydroxyecdysone, 2-deoxy-20-hydroxyecdysone, and 2,3-diacetate-22-benzoate-20-hydroxyecdysone were 144.75, 157.29, and 291.38 μg/mL, respectively.

However, we assume that the antioxidant effect of these extracts might be attributed to some coeluting phenolic compounds other than phytoecdysteroids. It is known that the presence of the ortho arrangement of two hydroxyl groups on the aromatic ring and 2,3-double bond in conjugation with 4-oxo function is essential for the antiradical activity of flavonoids. More effective is the ortho-arrangement of hydroxyl groups on the aromatic ring B (quercetin). Ecdysteroids are polyhydroxylated steroids, contain 7,8-double bond and 6-oxo function. The latter explanation seems to be more convincing, since the structure of ecdysteroid molecules is unlikely to exert an antioxidant effect, as compared to the common antioxidative flavonoids (Lu and Yeap, 2001).

CONCLUSION

This review summarizes and characterizes the diversity and distribution of phytoecdysteroids found from a wide range of *Silene* species. The plants of the genus *Silene* are well known as rich sources of phytoecdysteroids. Almost quarter of the known phytoecdysteroids have been detected from *Silene* plants. The studies on chemical constituents in recent years have disclosed many different activities for phytoecdysteroids, such as anabolic, adaptogenic, tonic and other activities. Plants of this genus may serve as a potential source for dietary supplements for humans as food supplements for sportsmens or for use as additives in medicine and cosmetics. From the above is obvious, that phytoecdysteroids could serve as new lead molecules having great expectations in the development of new classes of pharmaceuticals and dietary supplements.

ACKNOWLEDGMENTS

I would particularly like to express my gratitude to Dr. Mohamed L. Ashour for his help in collecting references for this paper.

REFERENCES

Abubakirov NK. 1980. New phytoecdysones. In: Frontiers in Bioorganic Chemistry and Molecular Biology; ***Proceedings of an International Conference***.

Abubakirov NK. 1982. Ecdysteroids of flowering plants (Angiospermae). ***Proceedings of the Indian National Science Academy*** 48: 122 - 138.

Abubakirov NK. 1984. Insect moulting hormones in plants from Central Asia. ***Uzbekistan Academy of Sciences Series: Chemistry*** 4: 49 - 53 [in Russian].

Ahmad VU, Khaliq-uz-Zaman SM, Ali MS, Perveen S, Ahmed W. 1996. An antimicrobial ecdysone from *Asparagus dumosus*. ***Fitoterapia*** 67: 88 - 91.

Ahmad VU, Ali Z, Ali MS, Zahid M. 1998. Chemical contituentes of *Silene conoidea*. ***Fitoterapia*** 69: 406 - 408.

Ali Z. 1998. **Phytochemical studies of the chemical constituents of the *Silene conoidea* and *Stocksia conoidea*.** Doctoral thesis, Univ of Karachi, Pakistan.

Alarcon R, Ortiz LT, Garcıa P. 2006. Nutrient and fatty acid composition of wild edible bladder campion populations [*Silene vulgaris* (Moench.) Garcke]. ***Int J Food Sci Technol*** 41: 1239 - 1242.

Arnetoli M, Montegrossi G, Buccianti A, Connelli C. 2008. Determination of organic acids in plants of *Silene paradoxa* L. by HPLC. ***J Agric Food Chem*** 13: 789 - 795.

Ballero J, Fresu I. 1993. Le piante di uso officinale nella Barbagia di Seui (Sardegna Centrale). ***Fitoterapia*** 64: 141 - 150.

Baltaev U, Belov Y, Chumachenko MN, Abubakirov NK. 1984. High-performance liquid chromatography of phytoecdysteroids from *Melandrium nutans*. ***Chem Nat Comp*** 20: 300 - 301.

Baltaev U, Rashkes YA, Darmograi VN, Belov YP, Abubakirov NK. 1985a. Phytoecdysteroids of *Silene nutans*. II. 22-Deoxyecdysterone and its mass spectral characteristics. ***Chem Nat Comp*** 21: 59 - 62.

Baltaev U, Rashkes YV, Abubakirov NK. 1985b. Phytoecdysteroids of *Silene nutans*. III. Nusilsterone. ***Chem Nat Comp*** 21: 489 - 491.

Baltaev UA, Darmograi VN, Abubakirov NK. 1987. Phytoecdysteroids of plants of the genus *Silene*. XIV. Ecdysterone 20-*O*-benzoate from *Silene tatarica*. ***Chem Nat Comp*** 23: 706 - 708.

Baltaev UA. 1998. Ecdysteroside, a phytoecdysteroid from *Silene tatarica*. ***Phytochemistry*** 47: 1233 - 1235.

Baltaev UA. 2000. Phytoecdysteroids: Structure, Sources, and Biosynthesis in Plants. ***Russian J Bioorganic Chem*** 26: 799 - 831.

Báthori M. 1986. **HPLC analysis of ecdysteroids of *Silene otites* (L) Wib.** In: Chromatography ‘84 (Eds. Kalasz H. and Ettre L.S.) Akademiai Kiado, Budapest, Hungary.

Báthori M, Szendrei K, Herke I. 1986a. The ecdysteroids of *Silene otites* L. Wib. ***Herba Hungarica*** 25: 105 - 117.

Báthori M, Szendrei K, Herke I. 1986b. Application of combined chromatographic techniques in the screening and purification of ecdysteroids. ***Chromatographia*** 21: 234 - 238.

Báthori M, Szendrei K, Miklós P, Pelczer I, Solymosi P. 1986c. **Ecdysteroids from *Silene nutans* L.** In: Chromatography '85 (Eds. Kalász H. and Ettre L.S.) Akademiai Kiado, Budapest, Hungary.

Bathori M, Mathe I, Solymosi P, Szendrei K. 1987. Phytoecdysteroids in some species of Caryophyllaceae and Chenopodiaceae. ***Acta Botanica Hungarica*** 33: 1938 - 1945.

Báthori M, Szendrei K, Kalász H, Lafont R, Girault JP. 1988. Thin-layer chromatography of ecdysteroids originated from *Silene otites*. ***Chromatographia*** 25: 627 - 630.

Báthori M, Lafont R, Girault JP, Máthé I. 1995. Occurrence of phytoecdysteroids in *Silene* species. **J Toxicol Toxin Rev** 14: 223.

Bathori M, Mathe I. 1996. Droplet counter-current chromatography to isolate ecdysteroids from the herba of *Silene tatarica* (L.) Pers. ***Acta Pharmaceutica Hungarica*** 66: 125-131 [in Hungarian, with English abstract].

Báthori M, Girault JP, Kalász H, Máthé I, Lafont R. 1997. New minor ecdysteroids from *Silene otities* (L.) Wib. ***J Pharmac Biomed Anal*** 16: 327 - 336.

Báthori M. 1998. Purification and characterization of plant ecdysteroids of *Silene* species. ***Trends in Analytical Chemistry*** 17: 372 - 383.

Báthori M, Girault JP, Kalász H, Máthé I, Dinan LN, Lafont R. 1999. Complex phytoecdysteroid cocktail of *Silene otites* (Caryophyllaceae). ***Arch Insect Biochem Physiol*** 41: 1 - 8.

Báthori M, Girault JP, Máthé I, Lafont R. 2000a. Isolation of 5α- and 5β-dihydrorubrosterone from *Silene otites* L. (Wib.). ***Biomed Chromatography*** 14: 464 - 467.

Báthori M, Blunden G, Kalász H. 2000b. Two-dimensional thin-layer chromatography of plant ecdysteroids. ***Chromatographia*** 52: 815 - 817.

Báthori M, Kalász H. 2001. Separation methods for phytoecdystroids. ***LC-GC Europe*** 14: 626 - 633.

Bathori M, Lafont R, Girault JP, Mathe I. 2001. Structural diversity of ecdysteroids of *Lychnis flos-cuculi*. ***Acta Pharmaceutica Hungarica*** 71: 157-167 [in Hungarian, with an English abstract].

Báthori M. 2002. Phytoecdysteroids effects on mammalians, isolation and analysis. ***Mini Rev Med Chem*** 2: 285 - 293.

Báthori M, Pongrácz Z, Tóth G, Simon A, Kandra L, Kele Z, Ohnmacht R. 2002a. Isolation of a new member of the ecdysteroid glycoside family: 2-deoxy-20-hydroxyecdysone 22-*O*-β-D-glucopyranoside. ***J Chromatographic Sci*** 40: 409 - 415.

Báthori M, Kalász H, Pongrácz Z, Máthé I, Kálman A, Argay G. 2002b. 5alpha- and 5beta-2-deoxyintegristerone A, a 5alpha and 5beta isomer pair of ecdysteroids isolated from the *Silene* genus. ***Biomed Chromatography*** 16: 373 - 378.

Báthori M, Kalász H, Janicsák G, Pongrácz Z, Vámos J. 2003. Thin-layer chromatography of phytoecdysteroids. ***J Liquid Chromatograph Related Technol*** 26: 2629 - 2649.

Bathori M, Pongracz Z. 2005. Phytoecdysteroids-from isolation to their effects on humans. ***Current Med Chem*** 12: 153 - 172.

Bergamasco R, Horn DHS. 1983. **Distribution and role of insect hormones in plants.** In: Endocrinology of Insects, A.R. Liss, New York, USA.

Buckman D, Starnecker G, Tomaschko KH, Wilhelm E, Lafont R, Girault JP. 1986. Isolation and identification of major ecdysteroids from the pycnogonid *Pycnogonum litorale* (Strom) (Arthropoda, Pantopoda). ***J Comp Physiol B*** 156: 759 - 765.

Burdette WJ. 1974. **Invertebrate hormones and tumors.** In: Invertebrate Endocrinology and Hormonal Heterophylly (Ed Burdette WJ), Springer, Berlin, Germany.

Burdette WJ, Richards RC. 1961. Alteration of growth of mammalian cells *in vitro* by ecdysone extract. ***Nature*** 189: 666 - 668.

Chadha YR. 1972. **The wealth of India**. Publications and Ifromation Directore, Hillside Road, New Delhi, India.

Conforti F, Marrelli M, Carmela C, Menichini F, Valentina P, Uzunov D, Statti GA, Duez P, Menichini F. 2011. Bioactive phytonutrients (omega fatty acids, tocopherols, polyphenols), *in vitro* inhibition of nitric oxide production and free radical scavenging activity of noncultivated Mediterranean vegetables. ***Food Chem*** 129: 1413 - 1419.

Darmograi V N. 1977. Flavonoids of the plants of the Genera *Silene* and Otites Adans family Caryophyllaceae. ***Chem Nat Comp*** 13: 102 - 103

Davis P, Lafont R, Large T, Morgan ED, Wilson ID. 1993. Micellar capillary electrophoresis of the ecdysteroids. ***Chromatographia*** 37: 37 - 42.

Dinan L, Savchenko T, Whiting P. 2001. On the distribution of phytoecdysteroids in plants. ***Cellular and Molecular Life Sciences*** 58: 1121 - 1132.

Dinan L, Lafont R. 2006. Effects and applications of arthropod steroid hormones (ecdysteroids) in mammals. ***J Endocrinol*** 191: 1 - 8.

Dotterl S, Wolfe LM, Jurgens A. 2005. Qualitative and quantitative analyses of flower scent in *Silene latifolia*. ***Phytochemistry*** 66: 203 - 213.

Dzhukharova MK, Saatov Z, Gorovits MB, Abubakirov NK. 1991. Phytoecdysteroids of *Silene* plants. XVIII. 2-Deoxyecdysterone 20,22-monoacetonide from *Silene brahuica*. ***Chem Nat Comp*** 27: 207 - 209.

Dzhukharova MK, Tashkhodzhaev B, Saatov Z, Abdullayev ND. 1993. Phytoecdysteroids from plants of the genus *Silene*. XIV. Brahuisterone from *Silene brahuica*. ***Chem Nat Comp*** 29: 484 - 489.

Dzhukharova MK, Saatov Z, Abdullaev ND, Abubakirov NK. 1994. Phytoecdysteroids of *Silene* plants. XV. Sileneoside F - 3-*O*-β-D-glucopyranoside of brahuisterone from *Silene brahuica*. ***Chem Nat Comp*** 30: 680 - 683.

Dzhukharova MK, Saatov Z, Abdullaev ND. 1995. Phytoecdysteroids of *Silene* plants. XVI. 5α-Sileneoside E from *Silene brahuica*. ***Chem Nat Comp*** 31: 207 - 210.

El-Mofty M, Sadek I, Soliman A, Mohamed A, Sakre S. 1987. α-Ecdysone, a new bracken fern factor responsible for neoplasm induction in the Egyptian toad (Bufo regularis). ***Nutrition and Cancer*** 9: 103 - 107.

El-Mofty MM, Sakre SA, Rizk AM, Moussa EA. 1994. Induction of breast and lung neoplastic lesions in mice by alpha-ecdysone. ***Oncology Reports*** 1: 435 - 438.

Erturk O, Kati H, Yayli N, Demurbaug Z. 2006. Antimicrobial Properties of *Silene multifida* (Adams) Rohrb. Plant Extracts. ***Turk J Biol*** 30: 17 - 21.

Eshmirzaeva NE, Khidyrova NK, Khodzhaeva M, Mezhlumyan LG, Shakhidoyatov KhM. 2005. Chemical coposition of *Silene viridiflora*. ***Chem Nat Comp*** 41: 451 - 453.

Fernald Merritt Lyndon, Alfred Charles Kinsey and Reed C. Rollins. 1996. **Bladder – Campion, Maiden's Tears, Snappery, *Silene cucubalis* (or *latifolia*).** Edible Wild Plants of Eastern North America. Dover Publications. New York City, USA.

Gaidi G, Miyamoto T, Laurens V, Lacaille-Dubois MA. 2002. New acylated triterpene saponins from *Silene fortune* that modulate lymphocyte proliferation. ***J Nat Prod*** 65: 1568 - 1572.

Girault JP, Báthori M, Kalász H, Máthé I, Lafont R. 1996. Sidisterone, a C24 ecdysteroid from *Silene dioica* and *Silene otites*. ***J Nat Prod*** 59: 522 - 524.

Girault JP, Báthori M, Varga E, Szendrei K, Lafont R. 1990. Isolation and identification of new ecdysteroids from the Caryophyllaceae. ***J Nat Prod*** 53: 279 - 293.

Golovko VA, Bushneva OA. 2007. Stabilizing Effect of Silene Pectin Polysaccharide on Electrical Activity of the Sinoatrial Area in Frog Heart. ***Bulletin of Experimental Biology and Medicine*** 143: 284 - 286.

Grauter WS. 1995. Caryophyllaceae in Greece: a subgeneric and sectional classification. ***Taxon*** 44: 543 - 581.

Guarrera PM. 2003. Food medicine and minor nourishment in the folk traditions of Central Italy (Marche, Abruzzo and Latium). ***Fitoterapia*** 74: 515 - 544.

Hadjichambis AC, Paraskeva-Hadjichambi D, Della A, Giusti ME, De Pasquale C, Lenzarini C, Censorii E, Gonzales-Tejero MR, Sanchez-Rojas CP, Ramiro-Gutierrez JM, Skoula M, Johnson C, Sarpaki A, Hmamouchi M, Jorhi S, El-Demerdash M, El-Zayat M, Pieroni A. 2007. Wild and semi-domesticated food plant consumption in seven circum-Mediterranean areas. ***Int J Food Sci Nut*** 1 - 32.

Hirst M. 2005. Dreams and Medicines: The Perspective of Xhosa Diviners and Novices in the Eastern Cape, South Africa. ***Indo-Pacific J Phenomenology*** 5: 1 - 22.

Hirst M. 1997. **A river of metaphors: interpreting the Xhosa diviner's myth.** In: McAllister, P., ed., Culture and the commonplace: anthropological essays in honour of David

Hammond-Took. Witwatersrand University Press, Johannesburg, South Africa.

http://en.wikipedia.org

Kucukboyaci N, Ozcelik B, Adiguzel N, Goren AC. 2010. Fatty acid compositions of *Silene vulgaris* and *S. cserei* subsp. *aeoniopsis* seeds and their antimicrobial activities. ***Chem Nat Comp*** 46: 188 - 191.

Kubo I, Klocke J. 1983. Isolation of phytoecdysones as insect ecdysis inhibitors and feeding deterrents. ***American Chemical Society Symposium Series*** 208: 329 - 346.

Kurmukov AG, Yermishina OA. 1991. Effect of ecdysterone on experimental arrhythmias, changes in hemodynamics and contractility of the myocardium produced by a coronary artery occlusion. ***Farmakologiia I Toksikologiia*** (Moscow) 54: 27 - 29 [in Russian, with an English abstract].

Kurtepova TA, Syrov VN, Khushbaktova ZA, Saatov Z. 2001. Hypoglycemic activity of the total ecdysteroid extract from *Ajuga turkestanica*. ***Pharmac Chem J*** 35: 608 - 609.

Kuzmenko AI, Morozova RP, Nikolenko IA, Korniets GV, Kholodova YD. 1997. Effects of vitamin D3 and ecdysterone on free-radical lipid peroxidation. ***Biochemistry*** 62: 609 - 612.

Lafont R, Horn DS. 1989. **Phytoecdysteroids: structures and occurrence.** Ecdysone from chemistry to mode of action. New York, USA.

Lafont R, Porter CJ, Williams E, Read H, Morgan ED, Wilson ID. 1993. The application of off-line HPTLC-MSMS to the identification of ecdysteroids in plant and arthropod samples. ***J Planar Chromatograph*** 6: 421 - 424.

Lafont R, Harmatha J, Marion-Poll F, Dinan L, Wilson ID. 2002. **Ecdybase – The Ecdysone Handbook,** 3rd ed. (continuously updated). Available at: http:ecdybase.org

Lafont R., Dinan L. 2003. Practical uses for ecdysteroids in mammals including humans: and update. ***J Insect Sci*** 3: 1 - 30.

Large T, Lafont R, Morgan ED, Wilson ID. 1992. Micellar capillary electrophoresis of ecdysteroids. ***Analytical Proceedings*** 29: 386 - 388.

Lagova ND, Valueva IM. 1981. Effect of ecdysterone isolated from *Rhaponticum carthamoides* on the growth of experimental toumours. ***Experimental Oncology*** 3: 69 - 71.

Louden D, Handley A, Lafont R, Taylor S, Sinclair I, Lenz E, Orton T, Wilson ID. 2002. HPLC analysis of ecdysteroids in plant extracts using superheated deuterium oxide with multiple on-line spectroscopic analyis (UV, IR, ^{1}H NMR and MS). ***Analytical Chemistry*** 74: 288 - 294.

Lu Y, Yeap FL. 2001. Antioxidant activities of polyphenols from sage (*Salvia officinalis*). ***Food Chem*** 75: 197 - 202.

Mamadalieva NZ, Ramazanov NS, Dinan LN, Saatov Z. 2000. Phytoecdysteroids of plants of the genus *Silene*. 2-Dehydro-20-hydroxyecdysone 3-*O*-benzoate from *Silene wallichiana*. ***Chem Nat Comp*** 36: 513 - 515.

Mamadalieva NZ, Saatov Z, Kachala VV, Shashkov AS. 2002a. Phytoecdysteroids of plants of the *Silene* genus. 2- Deoxyecdysterone 25-acetate from *Silene wallichiana*. ***Chem Nat Comp*** 38: 179 - 181.

Mamadalieva NZ, Zibareva LN, Saatov Z. 2002b. Phytoecdysteroids of *Silene linicola*. ***Chem Nat Comp*** 38: 268 - 271.

Mamadalieva NZ, Zibareva LN, Saatov Z, Lafont R. 2003. Phytoecdysteroids of *Silene viridiflora*. ***Chem Nat Comp*** 39: 199 - 203.

Mamadalieva NZ, Zibareva LN, Evrard-Todeschi N, Girault JP, Maria A, Ramazanov NS, Saatov Z, Lafont R. 2004a. New minor ecdysteroids from *Silene viridiflora*. ***Collection of Czechoslovak Chemical Communications*** 69: 1675 - 1680.

Mamadalieva NZ, Zibareva LN, Lafont R, Dinan L, Saatov Z. 2004b. Phytoecdysteroids from the *Silene* genus. ***Chem Nat Comp*** 40: 574 - 578.

Mamadalieva NZ. 2007. **7th International Symposium on the Chemistry of Natural Compounds.** 16-18 October, Tashkent. Uzbekistan.

Mamadalieva NZ, Egamberdieva D, Zhanibekov AA, Triggiani D, Tiezzi A. 2009. Chemical components of *Silene viridiflora* and their biological properties. ***Chem Nat Comp*** 45: 589 - 591.

Mamadalieva NZ, Janibekov AA, Lafont R, Girault JP. 2010a. Two minor phytoecdysteroids of the plant *Silene viridiflora*. ***Nat Prod Communications*** 5: 1579 - 1582.

Mamadalieva NZ, Ulchenko NT, Yuldasheva NK, Egamberdieva DR, Zhanibekov AA, Dzhukharova MKh, Glushenkova AI. 2010b. Fatty-acid composition and antibacterial activity of $CHCl_3$ extracts of three plants of the genus *Silene*. ***Chem Nat Comp*** 46: 95 - 96.

Mamadalieva NZ, Ulchenko NT, Yuldasheva NK, Zhanibekov AA, Egamberdieva DR, Glushenkova AI. 2010c. Neutral lipids and biological activity of the $CHCl_3$ extract of the aerial part of *Silene guntensis*. ***Chem Nat Comp*** 46: 621 - 622.

Mamadalieva NZ, El-Readi MZ, Janibekov AA, Tahrani A, Wink M. 2011. Phytoecdysteroids of *Silene guntensis* and their *in vitro* cytotoxical and antioxidant activity. ***Zeitschrift fur Naturforschung C*** 66: 215 - 224.

Mamadalieva NZ. 2012a. **Phytoecdysteroids: chemistry and occurrence.** V.6, pp. 1-509. In Azimova S.S, Vinogradova V.I: Natural compounds: Plant Sources, Structure and Properties. Ed. 1st Edition. Springer Science+Business Media, ISBN 978-0-387-49139-4. Due: October 28, 2012. (in press)

Mamadalieva NZ, Egamberdieva D, Tiezzi A. 2012b. *In vitro* biological activities of the components from *Silene wallichiana*. ***Medicinal and Aromatic Plant Science and Biotechnology*** (accepted)

Mamadalieva NZ, El-Readi MZ, Ovidi E, Ashour ML, Hamoud R, Sagdullaev SS, Azimova SS, Tiezzi A, Wink M. 2012c. Antiproliferative, antimicrobial and antioxidant activities of the chemical constituents of *Ajuga turkestanica* (Lamiaceae) from Uzbekistan. ***Phytopharmacology*** (accepted)

Meng Y, Whiting P, Zibareva L, Bertho G, Girault JP, Lafont R, Dinan L. 2001. Identification and quantitative analysis of the phytoecdysteroids in *Silene* species (Caryophyllaceae) by high-performance liquid chromatography: novel ecdysteroids from *S. pseudotites*. ***J Chromatography A*** 935: 309 - 319.

Miliauskas G, van Beek TA, de Waard P, Venskutonis RP, Sudhölter EJR. 2005. Identification of radical scavenging compounds in Rhaponticum carthamoides by means of LC-DAD-SPE-NMR. ***J Nat Prod*** 68: 168 - 172.

Moerman D. **Native American Ethnobotany**. 1998. Timber Press, Oregon, USA.

Mogosanu GD, Grumezescu AM, Mihaiescu DE, Istrati D, Mogosanu DE, Alice Buteica S. 2011. Identification of sugars from *Silene albae* herba using GC–MS technique. ***U.P.B. Sci Bull Series B*** 73: 101 - 108.

Munkhzhargal N, Zibareva LN, Lafont R, Pribytkova LN, Pisareva SI. 2010. Investigation of Ecdysteroid Content and Composition of *Silene repens* Indigenous in Mongolia and Introduced into Western Siberia. ***Russian J Bioorganic Chem*** 36: 923 - 928.

Nasir E, Ali SI. 1986. **Flora of Pakistan.** Fakhri Printing Press, Karachi, Pakistan.

Novozhilova EB, Rybin VG, Boltenkov EV. 2007. **New phytoecdysteroids containing species from family of Caryophyllaceae**. Abstract of the III Russian Conference "New advances on chemistry and chemical engineering of plant materials". Barnaul, Publ. Altay Univ, Russia, [in Russian].

Osynskaya LF, Saad LM, Kholodova YuD. 1992. Antiradical properties and antioxidative activity of ecdysterone. ***Ukr Biokhim Zh*** 64: 114 - 117.

Pongrácz Z, Báthori M, Tóth G, Simon A, Mák M, Máthé I. 2003a. 9α,20-Dihydroxyecdysone, a new natural ecdysteroid from *Silene italica* ssp. *nemoralis*. ***J Nat Prod*** 66: 450 - 451.

Pongrácz Z, Báthori M, Máthé I, Janicsak G, Miklossy VV. 2003b. Proc. Int. Conference on MAP. ***Acta Hort*** 597: 131 - 135.

Ramazanov NS, Maksimov ES, Saatov Z, Abdullaev ND. 1995. Phytoecdysteroids of the genus *Silene*. XVII. Tomentesterone A from *Silene tomentella*. ***Chem Nat Comp*** 31: 600 - 603.

Ramazanov NS, Maksimov ES, Saatov Z, Abdullaev ND. 1996. Phytoecdysteroids of *Silene* plants. XVIII. Tomentesterone B from *Silene tomentella*. ***Chem Nat Comp*** 32: 47 - 49.

Ramazanov NS, Sultanov SA, Saatov Z, Nigmantullaeva NM. 1997. Phytoecdysteroids of *Silene* plants and dynamics of their content. ***Chem Nat Comp*** 33: 558 - 562.

Ramazanov NS, Mamadalieva NZ, Bobaev ID. 2007. Phytoecdysteroids from five species of the genus *Silene*. ***Chem Nat Comp*** 43: 117 - 118.

Raynor MW, Kithinji JP, Bartle KD, Games DE, Mylchreest IC, Lafont R, Morgan ED, Wilson ID. 1989. Packed column supercritical fluid chromatography and linked supercritical fluid chromatography-mass spectrometry for the analysis of phytoecdysteroids from *Silene nutans* and *Silene otites*. ***J Chromatography*** 464: 292 - 298.

Read H, Wilson ID, Lafont R. 1990. **A note on overpressure thin-layer chromatography of ecdysteroids.** In: Chromatography and isolation of insect hormones and pheromones (Eds. McCaffery A.R. and Wilson I.D.), Plenum Press, New York, USA.

Revina TA, Revushkina AS, Rakitin AV. 1988. Ecdysteroid-containing species in flora of the Altai mountains. ***Rastitelny Resursy*** 34: 565 - 570 [in Russian].

Saatov Z, Usmanov BZ, Abubakirov NK. 1979a. Phytoecdysones of *Silene praemixta*. I. Silenosterone. ***Chem Nat Comp*** 15: 700 - 703.

Saatov Z, Usmanov BZ, Abubakirov NK. 1979b. Phytoecdysones of *Silene praemixta*. II. Praemixisterone. ***Chem Nat Comp*** 15: 703 - 705.

Saatov Z, Gorovits MB, Abdullaev ND, Usmanov BZ, Abubakirov NK. 1981. Phytoecdysteroids of *Silene* plants. III. Silenoside A - a new ecdysteroid glycoside from *Silene brahuica*. ***Chem Nat Comp*** 17: 534 - 539.

Saatov Z, Gorovits MB, Abdullaev ND, Usmanov BZ, Abubakirov NK. 1982a. Phytoecdysteroids of *Silene* plants. V. Silenoside B - digalactoside of ecdysterone from *Silene brahuica*. ***Chem Nat Comp*** 18: 578 - 582.

Saatov Z, Gorovits MB, Abdullaev ND, Usmanov BZ, Abubakirov NK. 1982b. Phytoecdysteroids of *Silene* plants. IV. Silenoside C - integristerone A galactoside from *Silene brahuica*. ***Chem Nat Comp*** 18: 193 - 196.

Saatov Z, Abdullaev ND, Gorovits MB, Abubakirov NK. 1984a. Phytoecdysteroids of *Silene* plants. VI. Ecdysone 22-sulphate - a new ecdysteroid from *Silene brahuica*. ***Chem Nat Comp*** 20: 441 - 444.

Saatov Z, Abdullaev ND, Gorovitz MB, Abubakirov NK. 1984b. Phytoecdysteroids of *Silene* plants. VII. Silenoside D - 3-*O*-α-D-galactopyranoside of ecdysterone from *Silene brahuica*. ***Chem Nat Comp*** 20: 700 - 703.

Saatov Z, Gorovits MB, Abdullaev ND, Usmanov BZ, Abubakirov NK. 1985. Phytoecdysteroids from *Silene* plants. VIII. 2-Deoxyecdysterone 3-acetate from *Silene praemixta*. ***Chem Nat Comp*** 21: 56 - 58.

Saatov Z, Gorovits MB, Melibaev S, Abubakirov NK. 1986a. Phytoecdysteroids of *Silene* plants. IX. Ecdysterone 22-benzoate from *Silene scabrifolia*. ***Chem Nat Comp*** 22: 71 - 73.

Saatov Z, Abdullaev ND, Gorovits MB, Abubakirov NK. 1986b. Phytoecdysteroids of *Silene* plants. X. Silenoside E - 2-deoxyecdysone-3-*O*-β-D-glucopyranoside from *Silene brahuica*. ***Chem Nat Comp*** 22: 297 - 300.

Saatov Z, Gorovits MB, Abubakirov NK. 1986c. Phytoecdysteroids from *Silene* plants. XI. 2-Deoxyecdysone 3- acetate from *Silene scabrifolia*. ***Chem Nat Comp*** 22: 409 - 411.

Saatov Z, Gorovits MB, Abdullaev ND, Abubakirov NK. 1987a. Phytoecdysteroids of plants of the genus *Silene*. XII. 5α-Ecdysterone 22-*O*-benzoate from *Silene scabrifolia*. ***Chem Nat Comp*** 23: 563 - 565.

Saatov Z, Gorovits MB, Abubakirov NK. 1987b. Phytoecdysteroids of plants of the genus *Silene*. XIII. Ecdysterone 20,22-monoacetonide from *Silene scabrifolia*. ***Chem Nat Comp*** 23: 643.

Saatov Z, Gorovits MB, Abubakirov NK. 1987c. Phytoecdysteroids in plants of the genus *Silene*. XV. 2-Deoxyecdysone 22-*O*-benzoate from *Silene wallichiana*. ***Chem Nat Comp*** 23: 708 - 711.

Saatov Z, Gorovits MB, Abubakirov NK. 1988. Phytoecdysteroids of the *Silene* genus. XVI. Viticosterone E 22-*O*-benzoate from *Silene wallichiana*. ***Chem Nat Comp*** 24: 463 - 465.

Saatov Z, Abdullaev ND, Gorovits MB, Abubakirov NK. 1990. Phytoecdysteroids of *Silene* plants. XVII. Ecdysterone 22,25-di-*O*-benzoate from *Silene scabrifolia*. ***Chem Nat Comp*** 26: 301 - 303.

Saatov Z, Gorovits MB, Abubakirov NK. 1993. Phytoecdysteroids in plants of the genus *Silene*. ***Chem Nat Comp*** 23: 551 - 553.

Saatov Z, Agzamkhodzhaeva DA, Syrov VN. 1999. Distribution of phytoecdysteroids in plants of Uzbekistan and the possibility of using drugs based on them in neurological practice. ***Chem Nat Comp*** 35: 186 - 191.

Sadikov ST, Saatov Z. 1998. Phytoecdysteroids of plants of the genus *Silene* XIX. Structure of silenoside G. ***Chem Nat Comp*** 34: 602 - 604.

Sadikov ZT, Saatov Z. 1999. Phytoecdysteroids of plants of the genus *Silene*. XX. Integristerone A 25-acetate from *Silene brahuica*. ***Chem Nat Comp*** 35: 440 - 441.

Sadikov ZT, Saatov Z, Girault JP, Lafont R. 2000. Silenoside H, a new phytoecdysteroid from *Silene brahuica*. ***J Nat Prod*** 63: 987 - 988.

Sadikov Z, Saatov Z, Garcia M, Girault JP, Lafont R. 2001. Ecdysteroids from *Silene claviformis*. ***Chem Nat Comp*** 37: 262 - 265. Correction: ***Chem Nat Comp*** 37: 580.

Simon A, Pongrácz Z, Tóth G, Mák M, Máthé I, Báthori M. 2004. A new ecdysteroid with unique 9α-OH and four other ecdysteroids from *Silene italica* ssp. *nemoralis*. ***Steroids*** 69: 389 - 394.

Shirshova TI, Politova NV, Burtseva SA, Beshlei IV, Volodin VV. 2006. Antimicrobial activity of natural ecdysteroids from *Serratula coronata* L. and their acyl derivatives. ***Pharmac Chem J*** 40: 268 - 271.

Slama K, Lafont R. 1995. Insect hormones - ecdysteroids : their presence and actions in vertebrates. ***Eur J Entomology*** 92: 355 - 377.

Sobiecki JF. 2008. A review of plants used in divination in southern Africa and their psychoactive effects. ***Southern African Humanities*** 20: 333 - 351.

Sviridova TP, Zibareva LN, Kritskaja SV. 1995. **Biological and chemical specialities of species of the genus *Silene* L. grown in the south of the Tomsk Region.** Abstract of the International Conference "Specialities of acclimitization of perennial plants accumulating biologically active substances", Krasnodar, Russia, [in Russian].

Syrov VN, Kurmukov AG. 1977. Tonic properties of ecdysterone isolated from Rhaponticumcarthamoides. ***Doklady Akademii Nauk UzSSR*** 12: 27 - 30 [in Russian].

Syrov VN. 2000. Comparative experimental investigation of the anabolic activity of phytoecdysteroids and steranabols. ***Pharmac Chem J*** 34: 193 - 197.

Syrov VN, Khushbaktova ZA, Abzalova MK, Sultanov MB. 1983. Hypolipidemic and antiatherosclerotic properties of phytoecdysteroids. ***Doklady Akademiia Nauk UzSSR*** 9: 44 - 45 [in Russian].

Takasaki M, Tokuda H, Nishino H, Konoshima T. 1999. Cancer chemopreventive agents (antitumour promoters) from *Ajuga decumbens*. ***J Nat Prod*** 62: 972 - 975

Terrab A, Garcia-Castano JL, Romero JM, Bergano R, De Vega C, Talavera S. 2007. Analysis of amino acids in nectar from *Silene colorata* Poiret (Caryophyllaceae). ***Bot J Linnean Soc*** 155: 49 - 56.

Toth N, Simon A, Toth G, Kele Z, Hunyadi A, Bathori M. 2008. 26-Hydroxylated ecdysteroids from *Silene viridiflora*. ***J Nat Prod*** 71: 1461 - 1463.

Tsarong Tsewang J. 1994. **Tibetan Medicinal Plants.** Tibetan Medical Publications, India.

Uphof JCTh. 1968. **Dictionary of Economic Plants.** Second edition. 591 pp. Cramer, Wiirzburg, Germany. Hafner Publishing Co., New York, USA.

Usher G. 1974. **A Dictionary of Plants Used by Man.** Constable, London, UK.

Volodin VV, Shirshova TI, Burtseva SA, Melnik MV. 1999. Biological activity of 20-hydroxyecdysone and its acetates. ***Rastitelny Resursy*** 2: 76 - 81.

Volodin V, Chadin I, Whiting P, Dinan L. 2002. Screening plants of European North-East Russia for ecdysteroids. ***Biochem System Ecol*** 30: 525 - 578.

Wilson ID, Lafont R, Kingston RG, Porter CJ. 1990. Thin layer chromatography-tandem mass spectrometry directly from the adsorbent: application to phytoecdysteroids of *Silene otites*. ***J Planar Chromatography*** 3: 359 - 361.

Wilson ID, Morgan ED, Lafont R, Wright B. 1998. High-performance liquid chromatography coupled to nuclear magnetic resonance spectroscopy - application to the ecdysteroids of *Silene otites*. ***J Chromatography A*** 799: 333 - 336.

Wilson ID, Morden W. 1999. Practical applications of HPTLC and HPTLC-MS/MS. ***LC.GC International*** 12: 72 - 80.

Wilson ID, Morgan ED, Lafont R, Shockor JP, Lindon JC, Nicholson JK, Wright B. 1999. High performance liquid chromatography coupled to nuclear magnetic resonance spectroscopy and mass spectrometry applied to plant products: identification of ecdysteroids from *Silene otites*. ***Chromatographia*** 49: 374 - 378.

Wilson ID. 2000. Multiple hyphenation of liquid chromatography with nuclear magnetic resonance spectroscopy, mass spectrometry and beyond. ***J Chromatography A*** 892: 315 - 327.

Zhang R, Zou C, He Y, Tan N, Zhou J. 1997. Three new cyclopeptides from *Silene szechuensis*. ***Acta Botanica Yunnanica*** 19: 304 - 310.

Zibareva LN. 1995. **Study of peculiarities to accumulate ecdysteroids in plants of the *Silene* L. genus.** In: Abstracts of the International Conference "Fundamental and Applied Problems of Environmental Protection", 2: 97.

Zibareva LN. 1996. **The chromatographic detection of ecdysteroids in plants.** 10th Internat. sympos. «Advances and applications of chromatography in industry». Bratislava. 34

Zibareva LN, Yeryomina VI. 1996. Dynamics of the contents of ecdysteroids in species of the genus *Silene* L. Grown in the Siberian botanical garden (Tomsk city). ***Rastitelny Resursy*** 32: 106 - 110 [in Russian, with an English abstract].

Zibareva LN. 1997. The prognosis of the presence of ecdysteroids among the species *Silene* L. and *Chenopodium* L. To their contents in the seeds. ***Rastitelny Resursy*** 33: 89 - 92 [in Russian, with an English abstract].

Zibareva LN, Yeryomina VI, Ivanova NA. 1997a. New ecdysteroidiferous species of the genus *Silene* L and the dynamics of ecdysteroid contents in them. ***Rastitelny Resursy*** 33: 73 - 76 [in Russian, with and English abstract].

Zibareva LN, Yeryomina VI, Zibarev PV. 1997b. The method of detection and quantity definition of phytoecdysteroids in plant objects. ***Pat. Russ. Fed.***, 26.01.94. № 2082168. Bull., № 17 [in Russian].

Zibareva LN, Ebel AL, Gashkova LP. 1998. **International meeting «Physiology-biochemically aspects of study of herbal plants»** Novosibirsk. 28

Zibareva LN. 1999. Occurrence of phytoecdysteroids in *Silene* L. genus and dynamics of their contents**.** ***Rastitelny Resursy*** 35: 79 - 87 [in Russian, with an English abstract].

Zibareva L. 2000. Distribution and levels of phytoecdysteroids in plants of the genus *Silene* during development. ***Arch Insect Biochem Physiol*** 43: 1 - 8.

Zibareva LN, Yeryomina VI. 2002. 20-Hydroxyecdysone distribution of different parts of *Silene bellidifolia* Juss. ex Jacq. и *S. squamigera* Boiss., cultivating in Siberian Botanical garden (Tomsk). ***Rastitelny Resursy*** 38: 81 - 85 [in Russian, with and English abstract].

Zibareva L, Volodin V, Saatov Z, Savchenko T, Whiting P, Lafont R, Dinan L. 2003a. Distribution of phytoecdysteroids in the Caryophyllaceae. ***Phytochemistry*** 64: 499 - 517.

Zibareva LN, Eremina VI. Ivanova NA, Lazkov GA. 2003b. Distribution of phytoecdysteroids in the tribe of Sileneae Dumort. fam. Caryophyllaceae. ***Rastitelny Resursy*** 39: 45 - 53 [in Russian, with an English abstract].

Zibareva L. 2003. **Phytoecdysteroids of the family Caryophyllaceae.** PhD thesis, Tomsk University, Russia.

Zibareva LN. 2009. Phytoecdysteroids of Caryophyllaceae Juss. ***Contemporary Problems of Ecology*** 2: 476 - 488.

Zibareva LN, Yeryomina VI, Munkhjargal N, Girault JP, Dinan L, Lafont R. 2009. The phytoecdysteroid profiles of 7 species of *Silene* (Caryophyllaceae). **Arch Insect Biochem Physiol** 72: 234 - 248.