蝇子草属植物化学成分及药理作用研究进展

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摘　要：蝇子草属植物资源丰富，全球超过 400 种，是世界上最大的属之一，在民间具有悠久的用药历史。该属化学成分复杂，包括蜕皮激素、三萜皂苷、生物碱等多种类结构，具有抗菌、抗溃疡、抗肿瘤、免疫调节、镇痛抗炎、抗心律失常等药理作用。但目前关于蝇子草属植物综述性报道较少，通过对 CNKI、PubMed 等数据库，对近 30 年关于蝇子草属化学成分及药理作用相关研究的文献展开综述，为后续深入研究蝇子草属植物提供参考。

关键词：蝇子草属；蜕皮激素；三萜皂苷；镇痛抗炎；抗菌

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Advances on chemical constituents and pharmacological activities of *Silene*

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Abstract: *Sliene* is one of the largest genera in the world with abundant plant resources and over 400 species, which has a long history of medicines in the folk. The chemical constituents of the genus *Sliene* are complex, including ecdysteroids, triterpenoid saponins, alkaloids, and other structures, which have the pharmacological activities of antibacterial, anti-ulcer, anti-tumor, immune regulation, analgesic, anti-inflammatory, anti-arrhythmia, etc. However, there are currently few articles about the genera of *Silene*. This paper reviewed the literatures on the chemical constituents and pharmacological effects of *Silene* in the past 30 years through CNKI, PubMed, and other databases to provide references for the further study on the genera of *Silene*.

Key words: *Sliene* L.; ecdysteroids; triterpenoid saponins; analgesic; antibacterial

石竹科蝇子草属 *Silene* L.植物在全球已经发现约 400 种，主要分布北半球温带以及非洲和南美洲地区，我国有 112 种、2 亚种、17 变种，广布长江流域和北部各省，目前已研究报道的蝇子草属植物有 *S. italica* L.、*S. otites* L.、*S. nutans* L.、*S. tatarira* L.、*S. wallichiana* L.、*S. tomentella* L.、*S. viridiflora* L.、*S. supina* L.、*S. repens* L.、*S. jenisseensis* L.、*S. viscidula* L.、*S. scabrifolia* L.、*S. brahuica* L.、*S. cretacea* L.等 35 种。该属植物化学成分复杂，植物蜕皮激素类含量高、结构丰富，具有化学分类学价值。蝇子草属中九子参 *S. rubicunda* L.和瓦草 *S. viscidula* L.为云南等地民间常用药，用药历史悠久，常用来治疗风湿骨痛、痈肿和肿痛等证。现代药理研究表明，蝇子草属植物具有抗心律失常、抗溃疡、抗菌、抗肿瘤、中枢抑制、免疫调节等作用。目前国内外对于蝇子草属的研究较少，对该属植物的药效物质基础研究不够全面，因此本文对蝇子草属现有的文献进行总结，主要包括化学成分和药理作用的综述，为后续研究该属植物提供参考。

1　化学成分

蝇子草属植物化学成分丰富，近 30 年来，共从 29 个蝇子草属植物中总结化合物 159 种，新化合物

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89 种，主要是蜕皮激素和三萜皂苷，其他类型化合物有黄酮、生物碱、甾醇等。

1.1 蜕皮激素及其苷类

蜕皮激素类化合物是蝇子草属中重要的一类化合物，蝇子草属被认为是新的蜕皮激素类似物很好的来源。苷元部分甾体母核上有多个羟基取代，C6 上有羰基，C7 有双键，A/B 环大多为顺式稠合，个别为反式，且反式者无蜕皮活性或活性减弱。目前共从蝇子草属植物中分离得到 86 个蜕皮激素及其衍生物类化合物，其中包括 40 个新化合物，其中，Dzhukarova 课题组从 *S. brahuica* L.地上部位分离出 2 个新化合物蝇子草甾苷 F（sileneoside F）[1]和 5α-2-去氧-α-蜕皮素-3-*O*-β-*D*-吡喃葡萄糖苷（5α-2-deoxy-α-ecdysone-3-*O*-β-*D*-glucopyranoside）[2]，地下部位分离出 1 个新化合物 2-去氧-20-羟基蜕皮素-20,22-单缩丙酮（2-deoxy-20-hydroxyecdysone-20,22-monoacetonide）。Ramazonov 课题组从 *S. mmentella* L.植物中分离出 2 个新化合物短绒蝇子草甾酮（tomentesterone）A[3]和 B[4]，并对蝇子草属的 4 种植物 *S. viridiflora* L.、*S. supina* L.、*S. nutans* L.和 *S. tatarica* L.测定了 6 种蜕皮激素类化合物积累与植物发育阶段的动态关系[5]。Bathori 从蝇子草属的 3 种植物（*S.nutans* L.、*S. otites* L.和 *S.tatarica* L.）中共分离得到 8 个新化合物[6]。Mamadalieva 等[7]在不同时间分别从 *S.wallichiana* 中分离出 2 个新化合物。Saatov 课题组经过对蝇子草属植物 *S. wallichiana* L.、*S. tatarica* L.、*S. brahuica* L.和 *S. scabrifolia* L.的研究共发现 6 个新化合物[8-13]。Meng 等[14]对蝇子草属 10 个含蜕皮激素的植物进行了分离和鉴定，并利用高效液相色谱法对 6 个主要化学成分的含量进行了测定，有助于了解蜕皮激素类化合物在蝇子草属植物中的分布。具体见表 1 和图 1，表 2 和图 2。

表 1 蝇子草属植物中的蜕皮激素类成分

Table 1 Ecdysteroids isolated from genus *Silene*

编号	化合物名称	来源	文献
1	20-hydroxyecdysone	A～R	15
2	2-deoxy-20-hydroxyecdysone	B、C、D、H、I、J、K、M	7,16-22
3	5α-20-hydroxyecdysone	A	23
4	5α-2-deoxy-20-hydroxyecdysone	B	7
5	α-ecdysone	C、J、M、R	9,15,16,22
6	2-deoxy-α-ecdysone	B、D、G、H、I、J、K、L、M、N、R	3,7,8,15,17-22,24
7	5α-2-deoxy-α-ecdysone	B、G、J	1,3,11
8*	9β,20-dihydroxyecdysone	A	23
9	9α,20-dihydroxyecdysone	A	23
10	integristerone A	A～J	3,5,7,10,16,17,19,23,25
11*	2-deoxy-integristerone A	K、R	15,21
12	5α-2-deoxy-integristerone A	A、R	15,23
13*	22-deoxy-integristerone A	A、E	6,23
14*	5α-22-deoxy-integristerone A	E	6
15	1-epi-integristerone A	S	26
16*	integristerone A 25-*O*-acetate	J	27
17*	2-deoxy-20-hydroxyecdysone 22-*O*-acetate	K	6
18*	20-hydroxyecdysone 22-*O*-benzoate 25-*O*-β-*D*-glucopyranoside	K	6
19	22-deoxy-20,26-dihydroxyecdysone	E	6
20	2-deoxy-20-hydroxyecdysone 22-*O*-benzoate	F	6
21	22-deoxy-20-hydroxyecdysone	E	28
22*	ecdysterone 22-*O*-benzoate	B、E、F、H、K、N	7,25,29,13,21
23	ecdysterone 20-*O*-benzoate	F	29
24	ecdysterone 25-*O*-benzoate	N	13
25	5α-ecdysterone 22-*O*-benzoate	N	13
26*	2-deoxy-20-hydroxyecdysone 3-*O*-benzoate	B	7
27*	2-deoxy-20-hydroxyecdysone 22-*O*-benzoate	E	25
28*	2-deoxy-20-hydroxyecdysone 25-*O*-acetate	B	30
29*	2-deoxy-20-hydroxyecdysone 3-*O*-acetate	M	22
30	2-deoxy-20-hydroxyecdysone 3,22-diacetate	K、M	22,31
31*	5α-2-deoxy-20-hydroxyecdysone 3-*O*-acetate	K	31
32*	2-deoxy-20-hydroxyecdysone 3-*O*-crotonate	K	31
33*	2-deoxy-20,26-dihydroxyecdysone	R	15
34*	2-deoxy-α-ecdysone 22-*O*-β-*D*-glucopyranoside	R	15
35*	2-deoxy-α-ecdysone 22-*O*-benzoate	B	11
36*	2-deoxy-α-ecdysone 3-*O*-acetate	N	8

续表 1

编号	化合物名称	来源	文献
37	2-deoxy-α-ecdysone 3-*O*-acetate 22-*O*-benzoate	B	11
38*	2-deoxy-α-ecdysone 3,22-diacetate	N	8
39*	2-deoxy-α-ecdysone 22-*O*-acetate	G、J、K、N	2,3,6,8
40	5α-2-deoxy-α-ecdysone 22-*O*-acetate	G	3
41*	α-ecdysone 22-sulphate	J	9
42*	5α-2-deoxy-α-ecdysone 3-*O*-β-*D*-glucopyranoside	J	1
43	polypodin B	C、E、F、G、H、I、J、P、Q、R	3,5,10,15,16,19,25,28
44	26-hydroxypolypodin B	H、I	18,32
45*	2-deoxypolypodin B 3-*O*-β-*D*-glucopyranoside	R	15
46	viticosterone E	B、C、G、I、J、M	3,11,16,32,10,22
47*	viticosterone E 22-*O*-benzoate	B	12
48	viticosterone E 2,3-diacetate 22-*O*-benzoate	B	12
49	sileneoside A	H、J、T	5,10,18
50*	sileneoside B	J	10
51	sileneoside C	J	10
52	sileneoside D	F、G、H、J	3,5,10,33
53*	sileneoside E	J	20
54*	sileneoside F	J	1
55*	sileneoside G	J	34
56*	sileneoside H	J	35
57*	3-*O*-[α-*D*-galactopyranosyl-(1→6)-α-*D*-galactopyranosyl]-20-hydroxyecdysone	F	33
58*	tomentesterone A	G	25
59*	tomentesterone B	G	25
60	tomentesterone B 3,22-diacetate	G	4
61	25S-inocosterone	Q、R	15
62	ponasterone A	D、R	15,17
63	brahuisterone	J	1
64*	ecdysterone 22,25-di-*O*-benzoate	N	36
65	2,22-diacetate-20,26-dihydroxyecdysone	H	18
66	20,26-dihydroxyecdysone	I	32
67	20-hydroxyecdysone-2-*O*-acetate	I	32
68	26-hydroxyintegristerone A	I	32
69	3,22-diacetate-20,26-dihydroxyecdysone	H	18
70*	ecdysterone 20,22-monoacetonide	N	13
71	ecdysterone 2,3;20,22-diacetonide	N	13
72	ecdysterone 2,3-monoacetonide 22-*O*-benzoate	N	36
73	ecdysterone 2,3-monoacetonide	N	36
74*	2-deoxy-20-hydroxyecdysone 20,22-monoacetonide	J	2
75	2-deoxy-21-hydroxyecdysone	R	15
76*	nusilsterone	E	37
77*	5β-cholest-7-ene-2β,3β,14α,20R,22R,25-hexahydroxy-6-on-20,22-acetal isovaleric aldehyde	O	38
78*	5β-cholest-7-ene-2β,3β,14α,20R,22R,25-hexahydroxy-6-on-20,22-acetal epiisovaleric aldehyde	O	38
79*	dihydropoststerone	K	6
80	dacryhainansterone	D	17
81	abutasterone	S	26
82	stachysterone A	S	26
83	15-hydroxystachysterone A	S	26
84	tukesterone	C、I	16,32
85	sidisterone	R	15
86*	20-hydroxyecdysone 20,22-monoacetonide 25-acetate	H	39

*表示从蝇子草属植物中分离得到的新化合物 A-*S. italica* L. B-*S. wallichiana* L. C-*S. linicola* L. D-*S. jenisseensis* L. E-*S. nutans* L. F-*S. tatarira* L. G-*S. tomentella* L. H-*S. viridiflora* L. I-*S. repens* L. J-*S. brahuica* L. K-*S. otites* L. L-*S. cretaceae* L. M-*S. praemixta* L. N-*S. scabrifolia* L. O-*S. claviformis* L. P-*S. radicosa* L. Q-*S. regia* L. R-*S. pseudotites* L. S-*S. viscidula* L. T-*S. supina* L. U-*S. rubicunda* L. V-*S. vulgaris* L. W-*S. fortunei* L. X-*S. szeehuensis* L. Y-*S. saxatilis* L. Z-*S. armeria* L. a-*S. gallica* L. b-*S. seoulensis* L. c-*S. saxatilis* L.，下同

*denotes a new compound isolated from *Silene* A-*S. italica* L. B-*S. wallichiana* L. C-*S. linicola* L. D-*S. jenisseensis* L. E-*S. nutans* L. F-*S. tatarira* L. G-*S. tomentella* L. H-*S. viridiflora* L. I-*S. repens* L. J-*S. brahuica* L. K-*S. otites* L. L-*S. cretaceae* L. M-*S. praemixta* L. N-*S. scabrifolia* L. O-*S. claviformis* L. P-*S. radicosa* L. Q-*S. regia* L. R-*S. pseudotites* L. S-*S. viscidula* L. T-*S. supina* L. U-*S. rubicunda* L. V-*S. vulgaris* L. W-*S. fortunei* L. X-*S. szeehuensis* L. Y-*S. saxatilis* L. Z-*S. armeria* L. a-*S. gallica* L. b-*S. seoulensis* L. c-*S. saxatilis* L.，same as below

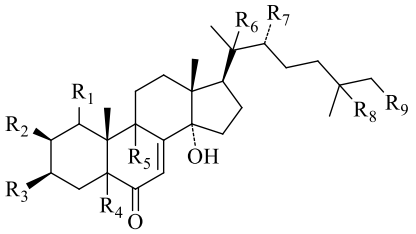

图 1　蝇子草属植物中蜕皮甾醇类成分的母核结构

Fig. 1　Structures of ecdysteroids in genus *Silene*

1.2　三萜皂苷类

三萜皂苷是蝇子草属植物中极性较大的一类化合物，苷元部分都是五环三萜类，基本母核为齐墩果烷型，基本碳架是多氢菲的五环母核，环的构型为 A/B 环，B/C 环，C/D 环均为反式，而 D/E 环为顺式，C-3 和 C-28 位一般连有较多数目的糖基。目前从本属植物中共分离得到 55 个化合物，45 个为新发现的化合物。Fu 等[40-41]对云南九子参根中

表 2　蝇子草属植物中的蜕皮激素类成分的结构

Table 2　Structure of ecdysteroids isolated from genus *Silene*

编号	取代基								
	R1	R2	R3	R4	R5	R6	R7	R8	R9
1	H	OH	OH	β-H	α-H	OH	OH	OH	H
2	H	H	OH	β-H	α-H	OH	OH	OH	H
3	H	OH	OH	α-H	α-H	OH	OH	OH	H
4	H	H	OH	α-H	α-H	OH	OH	OH	H
5	H	OH	OH	β-H	α-H	H	OH	OH	H
6	H	H	OH	β-H	α-H	H	OH	OH	H
7	H	H	OH	α-H	α-H	H	OH	OH	H
8	H	OH	OH	β-H	β-OH	OH	OH	OH	H
9	H	OH	OH	β-H	α-OH	OH	OH	OH	H
10	β-OH	OH	OH	β-H	α-H	OH	OH	OH	H
11	β-OH	H	OH	β-H	α-H	OH	OH	OH	H
12	β-OH	H	OH	α-H	α-H	OH	OH	OH	H
13	β-OH	H	OH	β-H	α-H	OH	H	OH	H
14	β-OH	H	OH	α-H	α-H	OH	H	OH	H
15	α-OH	OH	OH	β-H	α-H	OH	OH	OH	H
16	β-OH	OH	OH	β-H	α-H	OH	OH	OAc	H
17	H	H	OH	β-H	α-H	OH	OAc	OH	H
18	H	OH	OH	β-H	α-H	OH	OBz	β-*O*-Glc	H
19	H	OH	OH	β-H	α-H	OH	H	OH	OH
20	H	H	OH	β-H	α-H	OH	OBz	OH	H
21	H	OH	OH	β-H	α-H	OH	H	OH	H
22	H	OH	OH	β-H	α-H	OH	OBz	OH	H
23	H	OH	OH	β-H	α-H	OBz	OH	OH	H
24	H	OH	OH	β-H	α-H	OH	OH	OBz	H
25	H	OH	OH	α-H	α-H	OH	OBz	OH	H
26	H	H	OBz	β-H	α-H	OH	OH	OH	H
27	H	H	OH	β-H	α-H	OH	OBz	OH	H
28	H	H	OH	β-H	α-H	OH	OH	OBz	H
29	H	H	OAc	β-H	α-H	OH	OH	OH	H

续表 2

编号	取代基								
	R1	R2	R3	R4	R5	R6	R7	R8	R9
30	H	H	OAc	β-H	α-H	OH	OAc	OH	H
31	H	H	OAc	α-H	α-H	OH	OH	OH	H
32	H	H	a	β-H	α-H	OH	OH	OH	H
33	H	H	OH	β-H	α-H	OH	OH	OH	OH
34	H	H	OH	β-H	α-H	H	β-*O*-Glc	OH	H
35	H	H	OH	β-H	α-H	H	OBz	OH	H
36	H	H	OAc	β-H	α-H	H	OH	OH	H
37	H	H	OAc	β-H	α-H	H	OBz	OH	H
38	H	H	OAc	β-H	α-H	H	OAc	OH	H
39	H	H	OH	β-H	α-H	H	OAc	OH	H
40	H	H	OH	α-H	α-H	H	OAc	OH	H
41	H	H	OH	β-H	α-H	H	b	OH	H
42	H	H	β-*O*-Glc	α-H	α-H	H	OH	OH	H
43	H	OH	OH	β-OH	α-H	OH	OH	OH	H
44	H	OH	OH	β-OH	α-H	OH	OH	OH	OH
45	H	H	β-*O*-Glc	β-OH	α-H	OH	OH	OH	H
46	H	OH	OH	β-H	α-H	OH	OH	OAc	H
47	H	OH	OH	β-H	α-H	OH	OBz	OAc	H
48	H	OAc	OAc	β-H	α-H	OH	OBz	OAc	H
49	H	OH	OH	β-H	α-H	OH	α-*O*-Gal	OH	H
50	H	OH	α-*O*-Gal	β-H	α-H	OH	α-*O*-Gal	OH	H
51	β-OH	OH	OH	β-H	α-H	OH	α-*O*-Gal	OH	H
52	H	OH	α-*O*-Gal	β-H	α-H	OH	OH	OH	H
53	H	H	β-*O*-Glc	β-H	α-H	H	OH	OH	H
54	H	H	β-*O*-Glc	α-H	α-H	H	OH	OH	H
55	H	OH	α-*O*-Gal	β-H	α-H	OH	α-*O*-Glc	OH	H
56	β-OH	OH	OH	β-H	α-H	OH	α-*O*-Gal	OAc	H
57	H	OH	c	β-H	α-H	OH	OH	OH	H
58	H	H	OH	β-H	α-H	H	OAc	OBz	H
59	H	H	OH	β-H	α-H	H	OH	OBz	H
60	H	H	OAc	β-H	α-H	H	OAc	OBz	H
61	H	OH	OH	β-H	α-H	OH	OH	OH	OH
62	H	OH	OH	β-H	α-H	OH	OH	H	H
63	H	H	OH	β-OH	α-H	H	OH	OH	H
64	H	OH	OH	β-H	α-H	OH	OBz	OBz	H
65	H	OAc	OH	β-H	α-H	OH	OAc	OH	OH
66	H	OH	OH	β-H	α-H	OH	OH	OH	OH
67	H	OAc	OH	β-H	α-H	OH	OH	OH	H
68	β-OH	OH	OH	β-H	α-H	OH	OH	OH	OH
69	H	OH	OAc	β-H	α-H	OH	OAc	OH	OH

a-巴豆盐酸　b-盐酸盐　c-3-*O*-[α-*D*-葡萄糖(1→6)-α-*D*-葡萄糖]

a-crotonate　b-sulfate　c-3-*O*-[α-*D*-gal(1→6)-α-*D*-gal]

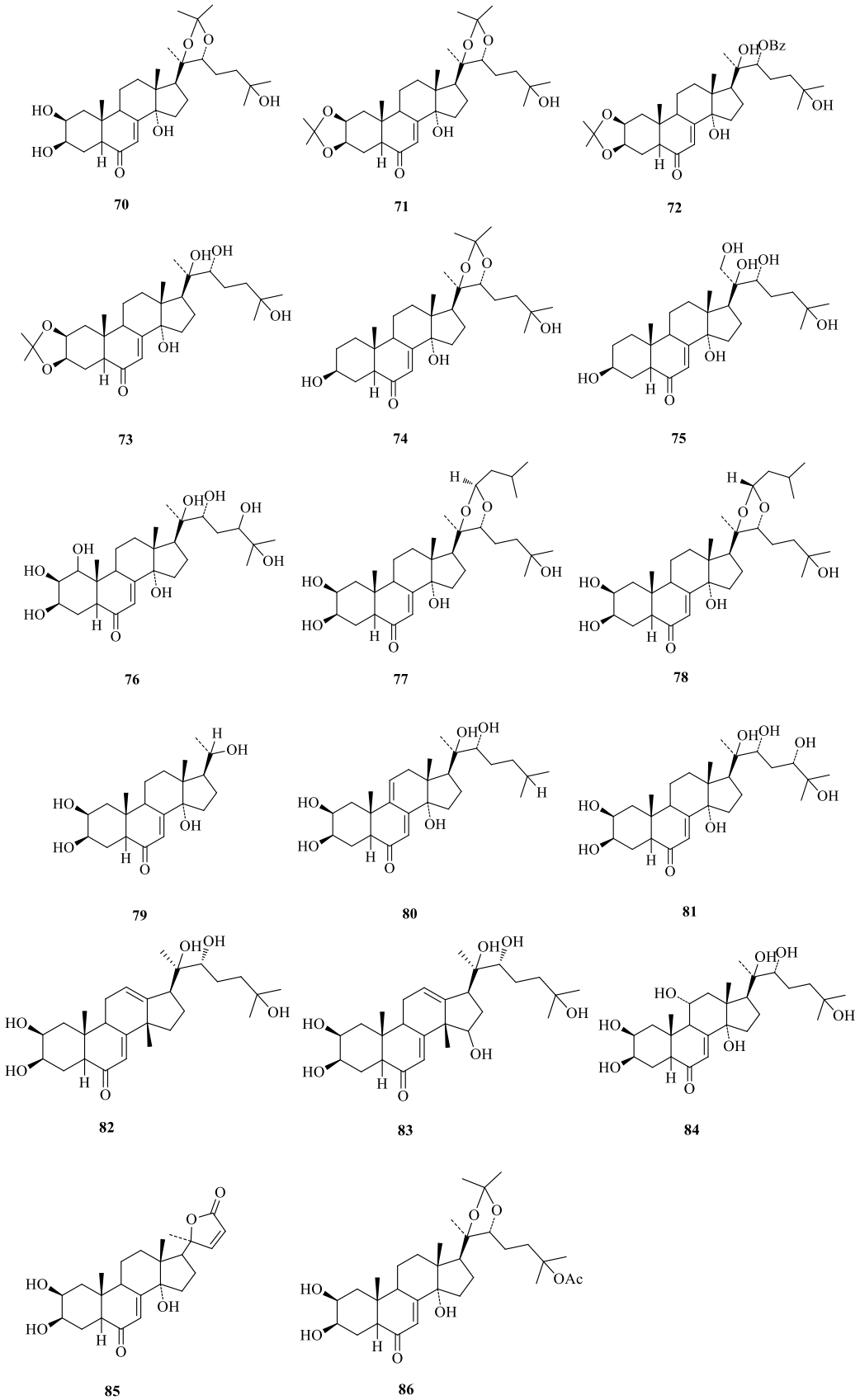

图 2 蝇子草属植物中蜕皮甾醇类成分

Fig. 2 Structures of ecdysteroids isolated from in genus *Silene*

水溶性部位分离出 9 个新化合物九子参皂苷（silenorubicoside）A～I（**87**～**95**），谭宁华等[42]从九子参中得到 4 个糖链上带乙酰基的新三萜皂苷-乙酰九子参皂苷（rubicunoside）A～D（**111**～**114**）。Takahashi 等[43]对日本产高雪轮 *S. armeria* L.中分离出一系列的三萜皂苷，其中代表性的有 7 个新化合物高雪轮皂苷（armeroside）A～G（**116**、**123**、**125**～**128**、**130**）。Bechkri 等[44]对采自阿尔及利亚东北部的高卢蝇子草 *S. gallica* L. 中得到 11 个新三萜皂苷高卢蝇子草皂苷（silenegallisaponin）A～K（**131**～**141**），具体见表 3 和图 3，表 4 和图 4。

表 3　蝇子草属植物中的三萜皂苷类成分

Table 3　Triterpenoid saponins isolated from genus *Silene*

编号	化合物名称	来源	文献
87*	silenorubicoside A	U	40
88*	silenorubicoside B	U	40
89*	silenorubicoside C	U	40
90*	silenorubicoside D	U	40
91*	silenorubicoside E	U	41
92*	silenorubicoside F	U	41
93*	silenorubicoside G	U	41
94*	silenorubicoside H	U	41
95*	silenorubicoside I	U	41
96*	silenoside A	V	45
97*	silenoside B	V	45
98*	silenoside C	V	45
99*	3-*O*-[β-*D*-galactopyranosyl-(1→2)-β-*D*-glucuronopyranosyl]-28-*O*-[β-*D*-glucuronopyranosyl-(1→2)-α-*L*-rhamnopyranosyl-(1→2)-β-*D*-4-*O*-trans-p-methoxycinnamoyl-fucopyranosyl] quillaic acid	D	46
100*	3-*O*-[β-*D*-galactopyranosyi-(1→2)-β-*D*-glucuronopyranosyl]-28-*O*-[β-*D*-glucuronopyranosyl-(1→2)-α-*L*-rhamnopyranosyl-(1→2)-β-*D*-4-*O*-*cis*-*p*-methoxycinnamoyl fucopyranosyl] quillaic acid	D	46
101	3-*O*-[β-*D*-galactopyranosyi-(1→2)-β-*D*-glucuronopyranosyl]-28-*O*-[β-*D*-glucuronopyranosyl-(1→2)-α-*L*-rhamnopyranosyl-(1→2)-β-*D*-fucopyranosyl] quillaic acid	D	46
102	3-*O*-[β-*D*-galactopyranosyi-(1→2)-β-*D*-glucuronopyranosyl]-28-*O*-quillaic acid	D、W、Z	46,47,43
103*	3-*O*-[β-*D*-galactopyranosyi-(1→2)-β-*D*-glucuronopyranosyl]-28-*O*-{[α-*L*-arabinopyranosyl-(1→2)-α-*L*-arabinopyranosyl-(1→3)-β-*D*-xylopyranosyl-(1→4)-α-*L*-rhamnopyranosyl-(1→2)]-[β-*D*-glucopyranosyl-(1→3)]-4-*O*-acetyl-β-*D*-fucopyranosyl]} quillaic acid	W	48
104*	sinocrassuloside VI	X	49
105*	sinocrassuloside VII	X	49
106*	3-*O*-[β-*D*-galactopyranosyl-(1→2)-β-*D*-glucuronopyranosyl]-28-*O*-{[α-*L*-arabinopyranosyl-(1→2)-α-*L*-arabinopyranosyl-(1→3)-β-*D*-xyl-opyranosyl-(1→4)-α-*L*-rhamnopyranosyl-(1→2)]-[6-*O*-acetyl-β-*D*-glucopyranosyl-(1→3)]-4-*O*-acetyl-β-*D*-fucopyranosyl]} quillaic acid	W	47
107*	jenisseensoside E	W	47
108*	jenisseensoside F	W	47
109	jenisseensoside C	W	47
110	jenisseensoside D	W	47
111*	rubicunoside A	U	50
112*	rubicunoside B	U	42
113*	rubicunoside C	U	42
114*	rubicunoside D	U	42
115	3-*O*-β-*D*-galactopyranosyl-(1→2)-[β-*D*-xylopyranosyl-(1→3)]-β-*D*-glucuronopyranosyl-quillaic acid	Z	43
116*	armeroside A	Z	43
117*	viscidulosido A	S	51
118*	viscidulosido B	S	51
119*	silenoviscoside D	S	51
120	sinocrassuloside VIII	S	51
121	sinocrassuloside IX	S	51
122	dianchinenoside D	Z	43

续表 3

编号	化合物名称	来源	文献
123*	armeroside B	Z	43
124	sinocrassuloside I	Z	43
125*	armeroside C	Z	43
126*	armeroside D	Z	43
127*	armeroside E	Z	43
128*	armeroside F	Z	43
129	saponarioside K	Z	43
130*	armeroside G	Z	43
131*	silenegallisaponin A	a	44
132*	silenegallisaponin B	a	44
133*	silenegallisaponin C	a	44
134*	silenegallisaponin D	a	44
135*	silenegallisaponin E	a	44
136*	silenegallisaponin F	a	44
137*	silenegallisaponin G	a	44
138*	silenegallisaponin H	a	44
139*	silenegallisaponin I	a	44
140*	silenegallisaponin J	a	44
141*	silenegallisaponin K	a	44

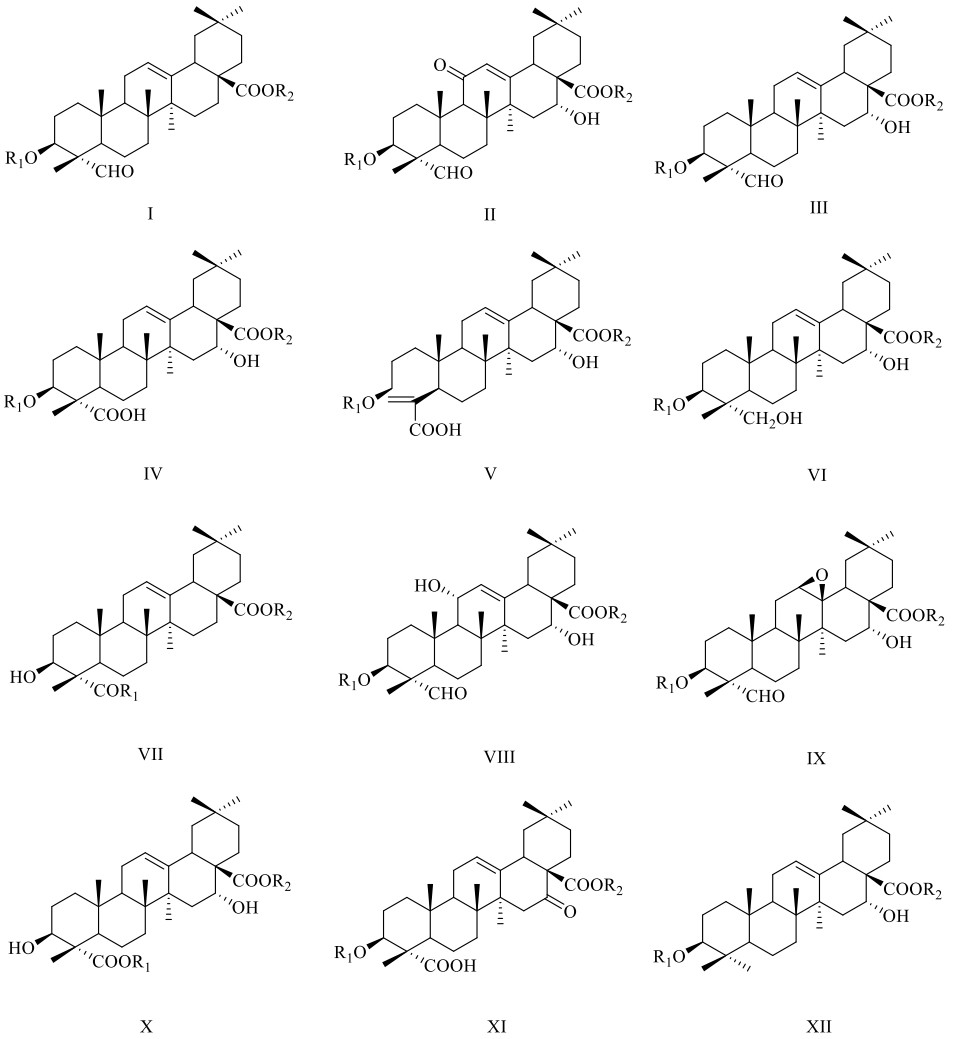

图 3　蝇子草属植物中三萜皂苷类成分母核类型

Fig. 3　Structures of triterpenoid saponins in genus *Silene*

表 4 蝇子草属植物中的三萜皂苷类成分的结构

Table 4 Structure of triterpenoid saponins isolated from genus *Silene*

编号	苷元类型	取代基 R_1	取代基 R_2
87	I	β-*D*-galactopyranosyl-(1→2)-[β-*D*-xylopyranosyl-(1→3)]-β-*D*-glucuronopyranosyl	β-*D*-xylopyranosyl-(1→3)-β-*D*-xylopyranosyl-(1→4)-α-*L*-rhamnopyranosyl-(1→2)-[3,4-di-*O*-acetyl-β-*D*-quinovopyranosyl-(1→4)]-β-*D*-fucopyranosyl
88	III	β-*D*-galactopyranosyl-(1→2)-[β-*D*-xylopyranosyl-(1→3)]-β-*D*-glucuronopyranosyl	β-*D*-xylopyranosyl-(1→4)-α-*L*-rhamnopyranosyl-(1→2)-[4,6-di-*O*-acetyl-β-*D*-glucopyranosyl-(1→3)]-4-*O*-acetyl-β-*D*-fucopyranosyl
89	I	β-*D*-galactopyranosyl-(1→2)-[β-*D*-xylopyranosyl-(1→3)]-β-*D*-glucuronopyranosyl	β-*D*-xylopyranosyl-(1→4)-α-*L*-rhamnopyranosyl-(1→2)-3,4-di-*O*-acetyl-β-*D*-fucopyranosyl
90	VII	β-*D*-glucuronopyranosyl-(1→2)-β-*D*-glucopyranosyl	β-*D*-glucopyranosyl-(1→3)-[α-*D*-galactopyranosyl-(1→6)-β-*D*-glucopyranosyl-(1→6)]-β-*D*-glucopyranosyl
91	II	β-*D*-galactopyranosyl-(1→2)-[β-*D*-xylopyranosyl-(1→3)]-β-*D*-glucuronopyranosyl	β-*D*-xylopyranosyl-(1→4)-α-*L*-rhamnopyranosyl-(1→2)-[β-*D*-glucopyranosyl-(1→3)]-β-*D*-fucopyranosyl
92	II	β-*D*-galactopyranosyl-(1→2)-[β-*D*-xylopyranosyl-(1→3)]-β-*D*-glucuronopyranosyl	β-*D*-xylopyranosyl-(1→4)-α-*L*-rhamnopyranosyl-(1→2)-[β-*D*-glucopyranosyl-(1→3)]-4-*O*-acetyl-β-*D*-fucopyranosyl
93	II	β-*D*-galactopyranosyl-(1→2)-[β-*D*-xylopyranosyl-(1→3)]-β-*D*-glucuronopyranosyl	β-*D*-xylopyranosyl-(1→3)-β-*D*-xylopyranosyl-(1→4)-α-*L*-rhamnopyranosyl-(1→2)-[β-*D*-quinovopyranosyl-(1→4)]-β-*D*-fucopyranosyl
94	VIII	β-*D*-galactopyranosyl-(1→2)-[β-*D*-xylopyranosyl-(1→3)]-β-*D*-glucuronopyrannosyl	β-*D*-xylopyranosyl-(1→3)-β-*D*-xylopyra-nosyl-(1→4)-α-*L*-rhamnopyranosyl-(1→2)-[β-*D*-quinovopyranosyl-(1→4)]-β-*D* -fucopyranosyl
95	IX	β-*D*-galactopyranosyl-(1→2)-[β-*D*-xylopyranosyl-(1→3)]-β-*D*-glucuronopyrannosyl	β-*D*-xylopyranosyl-(1→3)-β-*D*-xylopyranosyl-(1→4)-α-*L*-rhamnopyranosyl-(1→2)-[β-*D*-quinovopyranosyl-(1→4)]-β-*D*-fucopyranosyl
96	I	β-*D*-galactopyranosyl-(1→2)-β-*D*-glucuronopyranosyl	β-*D*-xylopyranosyl-(1→3)-β-*D*-xylopyranosyl-(1→4)-α-*L*-rhamnopyranosyl-(1→2)-β-*D*-fucopyranosyl
97	III	β-*D*-galactopyranosyl-(1→2)-β-*D*-glucuronopyranosyl	β-*D*-xylopyranosyl-(1→4)-[β-*D*-glucopyranosyl-(1→2)]-α-*L*-rhamnopyranosyl-(1→2)-β-*D*-fucopyranosyl
98	III	α-*L*-arabinopyranosyl-(1→3)-[β-*D*-galactopyranosyl-(1→2)]-β-*D*-glucuronopyranosyl	β-*D*-xylopyranosyl-(1→4)-[β-*D*-glucopyranosyl-(1→2)]-α-*L*-rhamnopyranosyl-(1→2)-β-*D*-fucopyranosyl
99	III	β-*D*-galactopyranosyl-(1→2)-β-*D*-glucuronopyranosyl	β-*D*-glucuronopyranosyl-(1→2)-α-*L*-rhamnopyranosyl-(1→2)-β-*D*-4-*O*-*trans*-*p*-methoxycinnamoyl-fucopyranosyl
100	III	β-*D*-galactopyranosyl-(1→2)-β-*D*-glucuronopyranosyl	β-*D*-glucuronopyranosyl-(1→2)-α-*L*-rhamnopyranosyl-(1→2)-β-*D*-4-*O*-*cis*-*p*-met-hoxycinnamoyl-fucopyranosyl
101	III	β-*D*-galactopyranosyl-(1→2)-β-*D*-glucuronopyranosyl	β-*D*-glucuronopyranosyl-(1→2)-α-*L*-rhamnopyranosyl-(1→2)-β-*D*-fucopyranosyl
102	III	β-*D*-galactopyranosyl-(1→2)-β-*D*-glucuronopyranosyl	H
103	III	β-*D*-galactopyranosyl-(1→2)-β-*D*-glucuronopyranosyl	[α-*L*-arabinopyranosyl-(1→2)-α-*L*-arabinopyranosyl-(1→3)-β-*D*-xylopyranosyl-(1→4)-α-*L*-rhamnopyranosyl-(1→2)]-[β-*D*-glucopyranosyl-(1→3)-4-*O*-acetyl-β-*D*-fucopyranosyl]
104	III	3-β-*D*-galactopyranosyl-(1→2)-β-*D*-xylopyranosyl-(1→3)-β-*D*-glucuronopyrannosyl	α-*L*-rhamnopyranosyl-(1→2)-β-*D*-3-*O*-acetyl-4-*O*-*trans*-*p*-methoxycinnamoyl-fucopyranosyl
105	III	4-β-*D*-galactopyranosyl-(1→2)-β-*D*-xylopyranosyl-(1→3)-β-*D*-glucuronopyrannosyl	α-*L*-rhamnopyranosyl-(1→2)-β-*D*-3-*O*-acetyl-4-*O*-*cis*-*p*-methoxycinnamoyl-fucopyranosyl
106	III	β-*D*-galactopyranosyl-(1→2)-β-*D*-glucuronopyranosyl	[α-*L*-arabinopyranosyl-(1→2)-α-*L*-arabinopyranosyl-(1→3)-β-*D*-xylopyranosyl-(1→4)-α-*L*-rhamnopyranosyl-(1→2)]-[6-*O*-acetyl-β-*D*-glucopyranosyl-(1→3)]-4-*O*-acetyl-β-*D*-fucopyranosyl]
107	III	β-*D*-galactopyranosyl-(1→2)-β-*D*-glucuronopyranosyl	α-*L*-rhamnopyranosyl-(1→2)-3-*O*-acetyl-4-*O*-*trans*-*p*-methoxycinnamoyl-β-*D*-fucopyranosyl
108	III	β-*D*-galactopyranosyl-(1→2)-β-*D*-glucuronopyranosyl	α-*L*-rhamnopyranosyl-(1→2)-3-*O*-acetyl-4-*O*-*cis*-*p*-methoxycinnamoyl-β-*D*-fucopyranosyl
109	III	β-*D*-galactopyranosyl-(1→2)-β-*D*-glucuronopyranosyl	α-*L*-rhamnopyranosyl-(1→2)-4-*O*-*trans*-*p*-methoxycinnamoyl-β-*D*-fucopyranosyl
110	III	β-*D*-galactopyranosyl-(1→2)-β-*D*-glucuronopyranosyl	α-*L*-rhamnopyranosyl-(1→2)-4-*O*-*cis*-*p*-methoxycinnamoyl-β-*D*-fucopyranosyl
111	III	β-*D*-galactopyranosyl-(1→2)-[β-*D*-xylopyranosyl-(1→3)]-β-*D*-glucuronopyranosyl	β-*D*-xylopyranosyl-(1→3)-β-*D*-xylopyranosyl-(1→4)-α-*L*-rhamnopyranosyl-(1→4)-[2"-*O*-acetyl-β-*D*-quinovopyranosyl-(1→2)]-3'-*O*-acetyl-β-*D*-fucopyranosyl

续表 4

编号	苷元类型	取代基 R_1	取代基 R_2
112	III	β-*D*-galactopyranosyl-(1→2)-[β-*D*-xylopyranosyl-(1→3)]-β-*D*-glucuronopyranosyl	β-*D*-xylopyranosyl-(1→3)-β-*D*-xylopyra-nosyl-(1→4)-α-*L*-rhamno-pyranosyl-(1→4)-[β-*D*-glucopyranosyl-(1→4')-β-*D*-quinovopyranosyl-(1→2)]-3'-*O*-acetyl-β-*D*-fucopyranosyl
113	III	β-*D*-galactopyranosyl-(1→2)-[β-*D*-xylopyranosyl-(1→3)]-β-*D*-glucuronopyranosyl	β-*D*-xylopyranosyl-(1→4)-α-*L*-rhamnop-yranosyl-(1→4)-[4"-*O*-acetyl-β-*D*-glucopyranosyl-(1→2)]-β-*D*-fucopyranosyl
114	III	β-*D*-galactopyranosyl-(1→2)-[β-*D*-xylopyranosyl-(1→3)]-[6'-*O*-butyl]-β-*D*-glucuronopyranosyl	β-*D*-xylopyranosyl-(1→3)-β-*D*-xylopyra-nosyl-(1→4)-α-*L*-rhamno-pyranosyl-(1→4)-[2"-*O*-acetyl-β-*D*-quinovopyranosyl-(1→2)]-3'-*O*-acetyl-β-*D*-fucopyranosyl
115	III	β-*D*-galactopyranosyl-(1→2)-[β-*D*-xylopyranosyl-(1→3)]-β-*D*-glucuronopyranosyl	H
116	III	β-*D*-galactopyranosyl-(1→2)-β-*D*-glucuronopyranosyl	α-*L*-rhamnopyranosyl-(1→2)-[β-*D*-gluc-opyranosyl-(1→3)]-4-*O*-acetyl-β-*D*-fucopyranosyl
117	III	β-*D*-galactopyranosyl-(1→2)-[β-*D*-xylopyranosyl-(1→3)]-6-*O*-butyl-β-*D*-glucuronopyranosyl	α-*L*-rhamnopyranosyl-(1→2)-[3-*O*-acetyl-4-*O*-*trans*-*p*-methoxycinnamoyl]-β-*D*-fucopyranosyl
118	III	β-*D*-galactopyranosyl-(1→2)-[β-*D*-xylopyranosyl-(1→3)]-6-*O*-butyl-β-*D*-glucuronopyranosyl	α-*L*-rhamnopyranosyl-(1→2)-[3-*O*-acetyl-4-*O*-*cis*-*p*-methoxycinnamo-yl]-β-*D*-fucopyranosyl
119	III	H	{α-*D*-mannopyranosyl-(1→4)-[α-*D*-gala-ctopyranosyl-(1→6)]-β-*D*-glucopyranosyl-(1→3)}-[β-*D*-6-*O*-((3R)-3-hydroxy-3-methylglutaryl)-glucopyranosyl-(1→6)]-β-*D*-glucopyranosyl
120	III	β-*D*-galactopyranosyl-(1→2)-[β-*D*-xylopyranosyl-(1→3)]-6-*O*-methyl-β-*D*-glucuronopyranosyl	α-*L*-rhamnopyranosyl-(1→2)-3-*O*-acetyl-4-*O*-*trans*-*p*-methoxycinnamoyl-β-*D*-fuc-opyranosyl
121	III	β-*D*-galactopyranosyl-(1→2)-[β-*D*-xylopyranosyl-(1→3)]-6-*O*-methyl-β-*D*-glucuronopyranosyl	α-*L*-rhamnopyranosyl-(1→2)-3-*O*-acetyl-4-*O*-*cis*-*p*-methoxycinnamoyl-β-*D*-fucopyranosyl
122	IV	H	β-*D*-glucopyranosyl-(1→6)-β-*D*-glucopyranosyl
123	IV	H	β-*D*-glucuronopyranosyl-(1→2)-β-*D*-glucopyranosyl
124	IV	H	β-*D*-glucopyranosyl-(1→3)-[β-*D*-glucopyranosyl-(1→6)]-β-*D*-glucopyranosyl
125	IV	H	β-*D*-glucuronopyranosyl-(1→2)-[β-*D*-glucopyranosyl-(1→6)]-β-*D*-glucopyranosyl
126	X	β-*D*-glucopyranosyl	β-*D*-(1→3)-[β-*D*-glucopyranosyl-(1→6)]-β-*D*-glucopyranosyl
127	IV	H	[β-*D*-6-*O*-((3S)-3-hydroxy-3-methylglutaryl)-glucopyranosyl-(1→3)]-[β-*D*-glucopyranosyl-(1→6)]-β-*D*-glucopyranosyl
128	XI	H	β-*D*-glucopyranosyl-(1→3)-[β-*D*-glucopyranosyl-(1→6)]-β-*D*-glucopyranosyl
129	V	H	β-*D*-glucopyranosyl-(1→3)-[β-*D*-glucopyranosyl-(1→6)]-β-*D*-glucopyranosyl
130	V	H	[β-*D*-6-methyl-glucuronopyranosyl-(1→2)]-[β-*D*-glucopyranosyl-(1→6)]-β-*D*-glucopyranosyl
131	VI	β-*D*-glucuronopyranosyl	β-*D*-glucopyranosyl-(1→3)-[β-*D*-glucopyranosyl-(1→2)]-β-*D*-fucopyranosyl
132	VI	β-*D*-glucuronopyranosyl	β-*D*-glucopyranosyl-(1→3)-[3-*O*-acetyl-β-*D*-glucopyranosyl-(1→2)]-β-*D*-fucopyranosyl
133	VI	β-*D*-glucuronopyranosyl	[3-*O*-acetyl-β-*D*-glucopyranosyl-(1→2)]-β-*D*-fucopyranosyl
134	VI	β-*D*-glucuronopyranosyl	β-*D*-glucopyranosyl-(1→3)-[6-*O*-acetyl-β-*D*-glucopyranosyl-(1→2)]-β-*D*-fucopyranosyl
135	XII	β-*D*-glucuronopyranosyl	β-*D*-glucopyranosyl-(1→3)-[3-*O*-acetyl-β-*D*-glucopyranosyl-(1→2)]-β-*D*-fucopyranosyl
136	III	β-*D*-glucuronopyranosyl	β-*D*-glucopyranosyl-(1→3)-[3-*O*-acetyl-β-*D*-glucopyranosyl-(1→2)]-β-*D*-fucopyranosyl
137	VI	β-*D*-galactopyranosyl-(1→3)-β-*D*-glucuronopyranosyl	β-*D*-glucopyranosyl-(1→3)-[β-*D*-glucopyranosyl-(1→2)]-β-*D*-fucopyranosyl
138	VI	β-*D*-galactopyranosyl-(1→3)-β-*D* -glucuronopyranosyl	β-*D*-glucopyranosyl-(1→3)-[6-*O*-acetyl-β-*D*-glucopyranosyl-(1→2)]-β-*D*-fucopyranosyl
139	VI	β-*D*-glucuronopyranosyl	β-*D*-quinovopyranosyl-(1→3)-[3-*O*-acetyl-β-*D*-glucopyranosyl-(1→2)]-β-*D*-fucopyranosyl
140	VI	β-*D*-glucuronopyranosyl	β-*D*-quinovopyranosyl-(1→3)-[β-*D*-glucopyranosyl-(1→2)]-β-*D*-fucopyranosyl
141	VI	β-*D*-galactopyranosyl-(1→3)-β-*D*-glucuronopyranosyl	β-*D*-quinovopyranosyl-(1→3)-[β-*D*-glucopyranosyl-(1→2)]-β-*D*-fucopyranosyl

1.3　其他化合物

Seo 等[52]从 *S. seoulensis* 分离出 8 个化合物，其中包括 4 个新生物碱类化合物 siliendines A～D（**142**～**145**）；Zemtsova 等[53]从 *S. saxatilis* L.中分离出 4 个黄酮类化合物；王童等[54]从瓦草 *S. viscidula* 的乙醇提取物中分离出 13 个化合物，10 个为该植物首分。具体结构见图 4 和表 5。

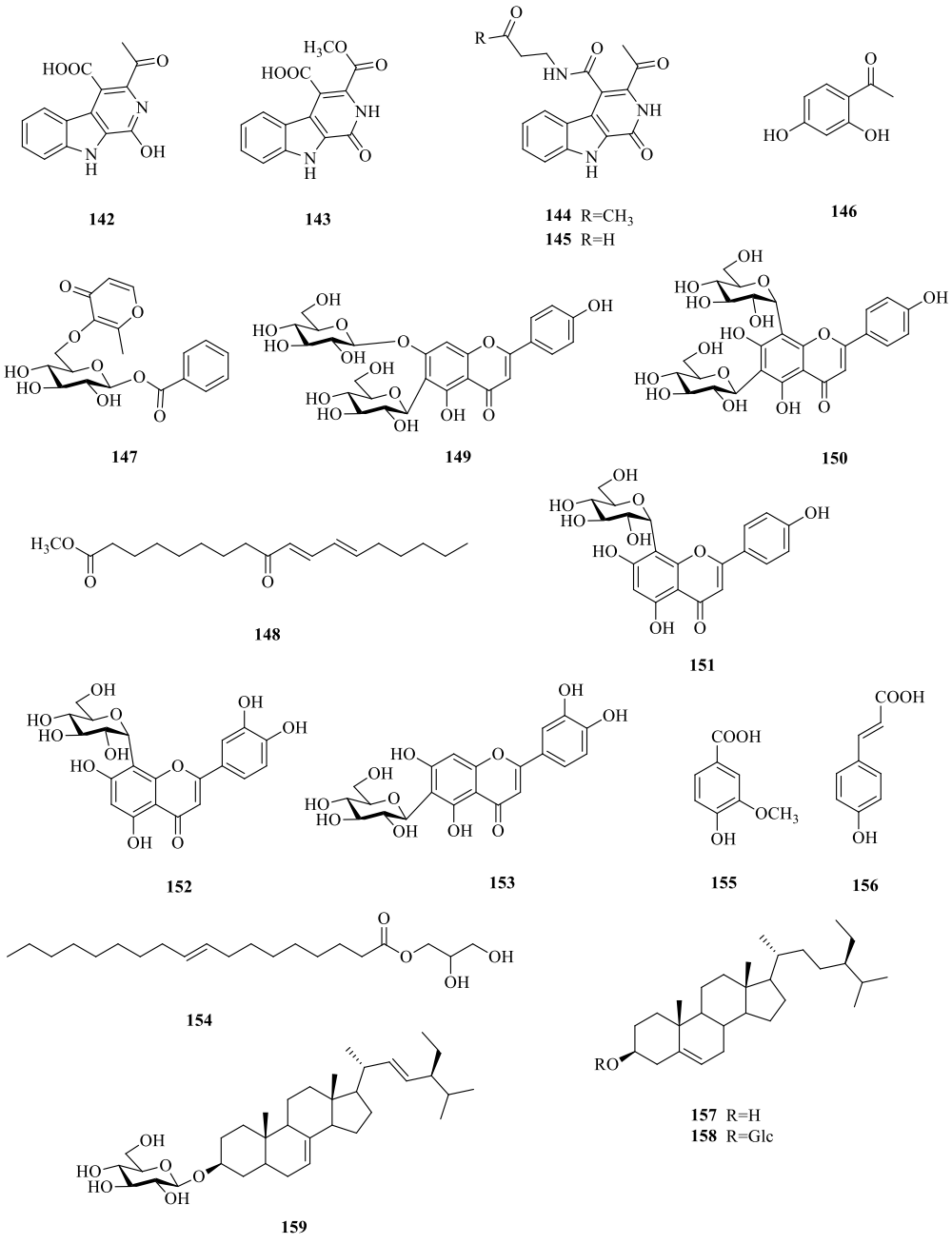

图 4　蝇子草属植物中其他类成分的结构

Fig. 4　Structure of other compounds isolated from genus *Silene*

2　药理作用

2.1　抗心律失常

Golovko 等[55]研究发现从 *S. vulgaris* L.植物中得到的果胶多糖—蝇子草果聚糖（silenan）可纠正青蛙心脏窦房区细胞间动作电位传导紊乱，主要表现在心律失常的产生和动作电位传播受损等方面，蝇子草果聚糖增加了盐水的黏度，并形成了与自由羧基数量呈比例的亲水络合物，能使心脏窦房区电活动稳定，从而达到抗心律失常的作用。

表 5 蝇子草属植物中的其他类成分

Table 5 Other compounds isolated from genus *Silene*

编号	化合物名称	来源	文献
142*	siliendine A	b	52
143*	siliendine B	b	52
144*	siliendine C	b	52
145*	siliendine D	b	52
146	resacetophenone	b	52
147	maltol β-*D*-glucopyranoside 6'-*O*-benzoate	b	52
148	methyl 9-oxo-10*E*,12*E*-octadecadienoate	b	52
149	saponarin	b	52
150	apigenin 6,8-di-*C*-glucopyranoside	c	53
151	vitexin	c	53
152	orientin	c	53
153	homoorientin	c	53
154	油酸-α-单甘油酯	S	54
155	香草酸	S	54
156	对羟基桂皮酸	S	54
157	β-谷甾醇	S	54, 55
158	胡萝卜苷	S	54, 55
159	α-菠甾醇葡萄糖苷	D	55

2.2 抗溃疡作用

Krylova 等[56]对含蜕皮激素的植物 *S. frivaldszkyana* L.和 *S. viridiflora* L.的提取物进行了抗溃疡活性研究，结果表明提取物能显著降低乙酰水杨酸所致溃疡模型的破坏作用，抑制 COX-1 和 COX-2 的释放，说明提取物具有增强黏膜屏障的保护作用和黏膜对前列腺素合成的抵抗力。

2.3 抗菌作用

Kucukboyaci 等[57]通过体外抑菌实验发现，*S. vulgaris* L.和 *S. cserei* L.种子石油醚提取物都对革兰阴性菌肺炎链球菌有显著的抑菌活性，最小抑菌浓度（MIC）为 4 μg/mL，对白色念珠菌生长有较强的的抗菌活性，MIC 为 16 μg/mL。此外，2 种样品提取物对大肠杆菌和奇异杆菌有一定的抑制作用，MIC 为 32 μg/mL，对金黄色葡萄球菌和枯草杆菌活性的 MIC 为 64 μg/mL。在抗菌方面具有广阔的发展前景。Mamadalieva 等[58]研究发现，*S. guntensis* L.三氯甲烷提取物对大肠杆菌鲍曼不动杆菌和绿脓杆菌生长均有不同程度的抑制作用。Bajpai 等[59]以水蒸气蒸馏法提取 *S. armeria* L.中的挥发油成分，并测试总挥发油抗真菌作用，结果表明总挥发油对辣椒疫霉、赤霉病菌、辣椒炭疽菌、菌核病菌、灰霉病菌和大豆根瘤菌均有显著的抑菌作用，抑菌幅度为 39.6%～67.6%，MIC 值为 62.5～1000 μg/mL，因此，*S. armeria* L.挥发油具有广泛的杀真菌活性。

2.4 抗肿瘤作用

Mamadalieva 等[58]采用 MTT 试验法评价细胞毒活性，体外研究表明 *S. guntensis* L.三氯甲烷提取物能抑制宫颈癌 HeLa 细胞的增殖，抑制质量浓度为 26.58 μg/mL，与对照组相比，50%的细胞死亡，说明该提取物具有抗肿瘤活性。马倩等[60]研究，化合物（**104**～**105**）对宫颈癌 HeLa 细胞有较强的抑制作用，半数抑制浓度（IC_{50}）为 2.37 μmol/L。化合物（**104**～**105**）诱导 HeLa 细胞凋亡是通过下调细胞周期蛋白（cyclin D1）的表达和降低 Rb 蛋白的磷酸化水平，使 HeLa 细胞阻滞在 G1 期。同时，化合物（**104**～**105**）通过上调 p16 蛋白水平和增加 β 半乳糖酶染色细胞的数量诱导 HeLa 细胞衰老[60]。

2.5 中枢抑制作用

邝荔香等[61]研究表明，九子参总皂苷对中枢神经系统有抑制作用，可减少小鼠自发活动，协同戊巴比妥催眠并有一定的镇痛作用，无对抗戊四氮和电休克惊厥作用，提高小鼠的耐缺氧能力，小鼠 ig 的半数致死量（LD_{50}）为 1.65 g/kg。

2.6 免疫调节作用

Shakhmurova 等[62]在辐射、急性毒性肝炎和长时间的体力负荷条件下，观察从 *S. viridiflora* L.中分离的总蜕皮激素对正常动物和继发性免疫缺陷小鼠对免疫系统的影响，结果表明总蜕皮激素的免疫调节活性可与已知的免疫刺激剂 T-activin 相媲美，说明总蜕皮激素具有有效的免疫调节作用。

2.7 酶抑制作用

Mamadalieva 等[63]通过对乙酰胆碱酯酶、丁基胆碱酯酶、酪氨酸酶、淀粉酶和糖苷酶的评价，从 *S. viridiflora* L.的提取物和分离的化合物表现出相当大的酶抑制潜力，抗胆碱酯酶能力按顺序排列：20-羟基蜕皮素＞2-去氧-20-羟基蜕皮素＞甲醇提取物＞2-去氧蜕皮素。值得注意的是，甲醇提取物的抗酪氨酸酶和抗淀粉酶作用最强。

2.8 抗氧化作用

Mamadalieva 等[63]对 *S. viridiflora* L.植物不同提取方式提取物进行了抗氧化活性研究，根据研究结果，甲醇提取物对清除 DPPH 自由基表现出中等活性，浸提液对铜离子（34.37 mg/g）的还原活性高于对照铁离子（22.19 mg/g）。同时，萃取物也是一种良好的金属螯合剂 EDTAE，其值为 11.23 mg/g。

2.9 抗炎镇痛作用

Ghonime 等[64]对生长在埃及的 3 种蝇子草属药用植物提取物进行研究，发现 *S. succulenta* L.和 *S. nocturna* L.提取物能抑制一氧化氮合酶（iNOS）表达和肿瘤坏死因子（TNF）-α 活性，从而降低诱导巨噬细胞产生的一氧化氮（NO）；*S. villosa* L.和 *S. nocturna* L.能显著抑制巨噬细胞刺激后产生的 COX-2 表达。张冠庆[65]发现，在 FAC 所致的大鼠足趾肿胀模型中，瓦草的正丁醇部位能缓解大鼠关节肿胀，抗炎机制可能与抑制血清中炎症因子白介素（IL）1-β、TNF-α 的表达有关。

2.10 抑制淋巴细胞增殖

Gaidi 等[47]的实验证实，皂苷化合物（**107**～**110**）在高浓度（10 μmol/L）时能抑制 T 淋巴细胞 DNA 合成，从而抑制细胞增殖，诱导细胞凋亡。

3 讨论

蝇子草属植物资源广泛，全球各地均有分布，国外研究者较多，以化学成分和药理研究为主，化学成分多以分离新化合物为主要目标，药理作用主要为提取物的活性研究。本文对蝇子草属近年来的相关文献进行了总结并整理出最新的单体化合物，报道较多的是蜕皮激素和三萜皂苷类，其他类型化合物报道较少，今后的研究者可从其他类型化合物入手，丰富蝇子草属化合物的结构类型。其中，蜕皮激素为该属植物的标志性化合物，含量高、结构丰富，具有调节糖代谢、免疫调节和治疗风湿、关节炎等药理作用，我国传统著名中药牛膝及其同属植物中，蜕皮激素为主要化学成分[66]，牛膝属植物的疗效确切，临床应用广泛，蝇子草属植物可做为其代替品，也可作为生产蜕皮激素的原料植物。近年来，对蝇子草属药理方面的研究有所增加，主要集中在抗菌、抗氧化、抗炎、抗肿瘤等方面，其中，大多数蝇子草属的植物提取物具有不同程度的抗菌作用，抗菌作用广泛。但对单体化合物的药理活性研究较少，只进行了初步的活性筛选，没有进行深入的机制研究，未能阐明抗菌物质基础。仍需进一步分离和筛选单体化合物，结合药物靶点，深入研究分子机制，寻找活性好、毒性低的天然产物进行药品的研发。

利益冲突 所有作者均声明不存在利益冲突

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