Hindawi
Journal of Chemistry
Volume 2020, Article ID 9375619, 23 pages
https://doi.org/10.1155/2020/9375619

Review Article

Review of Compounds and Pharmacological Effects of *Delphinium*

Sitan Chen,[1] Lijun Meng,[1] Fatma M. El-Demerdash,[2,3] Li Zhou,[1,2] Syed Arif Hussian Rizvi,[2,4] Lili Cui ,[1,5] and Wenyi Kang [1,2,5,6]

[1]*National R & D Center for Edible Fungus Processing Technology, Henan University, Kaifeng 475004, China*
[2]*Joint International Research Laboratory of Food & Medicine Resource Function, Henan University, Kaifeng 475004, Henan Province, China*
[3]*Department of Environmental Studies Institute of Graduate Studies and Research Alexandria University Alexandria, Alexandria, Egypt*
[4]*Institute of Plant and Environmental Protection (IPEP), National Agriculture Research Center (NARC) Islamabad, Islamabad, Pakistan*
[5]*Functional Food Engineering Technology Research Center, Kaifeng 475004, Henan Province, China*
[6]*Kaifeng Key Laboratory of Functional Components in Health Food, Kaifeng 475004, Henan, China*

Correspondence should be addressed to Lili Cui; cuill@vip.henu.edu.cn and Wenyi Kang; kangweny@hotmail.com

Received 15 June 2020; Revised 21 August 2020; Accepted 2 September 2020; Published 21 September 2020

Academic Editor: Pedro M. Mancini

Plants of *Delphinium* are herbal medicine used in the Tibet region with whole grass as a drug, which have the effects of analgesic, antibacterial, antipyretic, and anticancer. The main bioactive compounds are alkaloids, flavonoids, and sterols. This review summarized the compounds and pharmacological effects of *Delphinium* and provides a reference for further research on *Delphinium*.

1. Introduction

Delphinium of the Ranunculaceae family is widely distributed in the North temperate zone, with about 350 species worldwide. 173 species (150 endemic) of *Delphinium* are distributed in China [1]. *Delphinium* is composed of subgen. *Delphinastrum*, subgen. *Delphinium*, and subgen. *Oligophyllon*, in the world, of which subgen. *Delphinastrum* has the most species [2]. In China, there are 18 species of *Delphinium* used as folk medicine, which are used to treat bruises, rheumatism, toothache, and enteritis. In addition, four species of *Delphinium* can be used as soil pesticides for their effects of killing lice, mosquitoes, and fly larvae [3]. The main compounds of *Delphinium* are diterpenoid alkaloids, and most of them have physiological activities [4]. In addition, *Delphinium* also contains chemical constituents such as flavonoids and sterols. In recent years, with the development of analysis methods and increasing focus on *Delphinium*, more and more chemical constituents and pharmacological activities of *Delphinium* had been researched. In this paper, the chemical constituents and pharmacological effects of *Delphinium* were reviewed in order to improve the development and utilization of the *Delphinium* resources.

2. Chemical Constituents

According to the research studies, the alkaloids are the main constituents with physiological activities in *Delphinium* and diterpenoid alkaloids are the most characteristic constituents with toxicity [5]. In addition, flavonoids and sterols are also present [6].

2.1. Diterpenoid Alkaloids. Diterpenoid alkaloids are derived from the amination of tetracycline diterpenoids or pentacyclic diterpenoids to heterocyclic systems containing

β-aminoethanol, methylamine, or ethylamine nitrogen atoms [7]. There are abundant diterpenoid alkaloids in *Delphinium*, which can be classified into C-18 diterpenoid alkaloids, C-19 diterpenoid alkaloids, and C-20 diterpenoid alkaloids according to the carbon skeleton configuration [5]. Characteristic quaternary carbon signal and substituent signal are important information to distinguish different diterpene alkaloids.

C-18 diterpenoid alkaloids are the diterpenoid alkaloids whose C-18 are mostly substituted by C(4)-H/OH or the ester group, and a few of them contain 3,4-epoxide. According to the oxygen-containing groups on C-7, they can be sorted into two types (Figure 1): lappacinitine-type and ranaconitine-type, and C-7 of the ranaconitine-type has an oxygen-substituent group. C_4 (δ_c 30–40, s), C_8 (δ_c 73–84, s), and C_{11} (δ_c 47–55, s) are C-18's characteristic signals [8]. Characteristic signal of the ranaconitine-type on C-7 is at δ_c 91–93 (s), and the characteristic signal of the lappacinitine-type on C-7 is at δ_c 45–48 (s).

Most C-19 diterpene alkaloids are natural diterpenoid alkaloids and belong to pentacyclic diterpene alkaloids. According to the oxygen-containing groups on C-7 and the difference of skeleton, they can be classified into six types (Figure 2): lycoctonine-type, aconitine-type, 7,17-seco type (δ_{c8} 137–139, s; δ_{c10} 48–49, s; δ_{c14} 216–218, s), lactone-type, pyro-type ($\delta_{c8,15}$ 146–147, s), and rearranged-type (δ_{c8} 40–55, s; δ_{c10} 44–45, s; δ_{c14} 210–211, s) [8]. The majority of C-19 diterpenoid alkaloids are lycoctonine-type and aconitine-type. The differences between them are that C-7 (δ_c 87–93) of the lycoctonine-type has an oxygen-substituent group and others do not have [9]. And, C-19 diterpenoid alkaloids isolated from *Delphinium* are mostly lycoctonine-type [10]. C-19 diterpene alkaloids contain oxygen substituent (δ_H3.0–5.0; δ_c 70–90) and methoxy substituent (δ_H3.2–3.6, s; δ_c 55–59, q). C_4 (δ_c 37–41, s), C_8, and C_{11} (δ_c 47–51, s) are C-19 characteristic signals [8].

C-20 diterpenoid alkaloids are tetracyclic diterpenes with a carbon skeleton of 20 carbon atoms and have a trans-a-ring alkaloid that connects C-19 to C-20 in N-ethyl or N-β-hydroxyl ethyl [11]. Compared with C-18 and C-19, C-20 diterpene alkaloid skeletons are complex, and most of them have exocyclic double bond structures. At present, 22 types of C-20 diterpenoid alkaloids were found [12]. The C-20 diterpenoid alkaloids isolated from *Delphinium* mainly belong to atisine-type, veatchine-type, hetisine-type, hetidine-type, denudatine-type, delnudine-type [13], and vakognavine-type (Figure 3) [14, 15]. C_4 (δ_c 30–40, s), C_8 (δ_c 30–50, s), C_{11} (δ_c 30–40, s), C_{16} (δ_c-143, s), and C_{17} (δ_H-5, brs; δ_c-110, t) are C-20's characteristic signals. C_6 (δ_c 17–20, s), C_7 (δ_c 31–35, s), C_{10} (δ_c 36–40, s), C_{14} (δ_c 25–26, s), and C_{20} (δ_c 50–54, s) are characteristic signals of atisine-type, and C_6 (δ_c −24, s), C_7 (δ_c −43, s), C_{10} (δ_c 48–51, s), C_{14} (δ_c 36–39, s), and C_{20} (δ_c −69, s) are characteristic signals of hetidine-type [16].

At present, 155 alkaloids were isolated from *Delphinium*, and the details are shown in Tables 1–3 and Figures 4–6. Based on the references listed in Tables 1–3, it can be summarized that *D. anthriscifolium* varietas and *D. elatum* and its varietas have been further studied in chemistry.

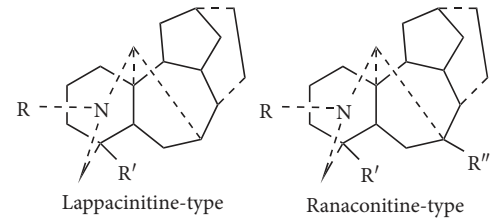


Figure 1: The skeleton structures of C-18 diterpene alkaloids.

2.2. Amide Alkaloids. The typical groups of amide alkaloids are acyl groups. 9 amide alkaloids were isolated from *Delphinium*, and the details are shown in Table 4 and Figure 7.

2.3. Other Alkaloids. Except diterpene alkaloids and amide alkaloids, one other alkaloid (No.155, anthriscifolsine A, $C_{29}H_{31}NO_7$, [49]) was isolated from *D. anthriscifolium* var. *majus*. The structure is shown in Figure 8.

2.4. Other Compounds. Delphinium also contains compounds such as flavonoids and sterols. In recent years, other compounds isolated from *Delphinium* had also been reported, and a total of 13 nonalkaloids (Table 5 and Figure 9) were isolated from *Delphinium*.

3. Biological Activities

Plants of *Delphinium* are used with whole grass as medicine. According to the ancient Tibetan medicine Jingzhubencao, plants of *Delphinium* had analgesic, anti-inflammatory, and insecticidal effects [9]. Literature studies showed that plants of *Delphinium* have many pharmacological effects including antibacterial, antiepileptic, detoxification, and Alzheimer's disease treatment. In this section, this paper reviews the research studies on the antibacterial, analgesic, anti-inflammatory, antidepressant, and anticancer effects of *Delphinium*.

3.1. Antibacterial Activity. Hari et al. found that anthriscifoldine C (5.0 mg/mL) from *D. brunonianum* had a good inhibiting effect on *Bacillus subtilis*, *Escherichia coli*, and *Salmonella flexnari*, and its MIC were 24.0 μM, 23.4 μM, and 24.2 μM, respectively, *in vitro* [61]. Ren et al. carried out the bacteriostatic test on the total alkaloids extracted from the roots of *Delphinium* and found that the MIC of the total alkaloids extracted on *S. aureus* and *Aspergillus niger* was 50 mg/mL *in vitro* [62].

3.2. Analgesic Activity. Zaheer et al. used the eddy current hot plate method and the tail flick reaction method to evaluate the analgesic activity of *D. denudatum* on Wistar albino rats. The experimental results showed that the response time of rats given *D. denudatum* ethanol extract and methanol fraction was longer than that of the propylene glycol group, and the effects of the high doses of the ethanol extract (600 mg/kg) and methanol fraction (400 mg/kg) were equal to that of the positive control group, indicating that

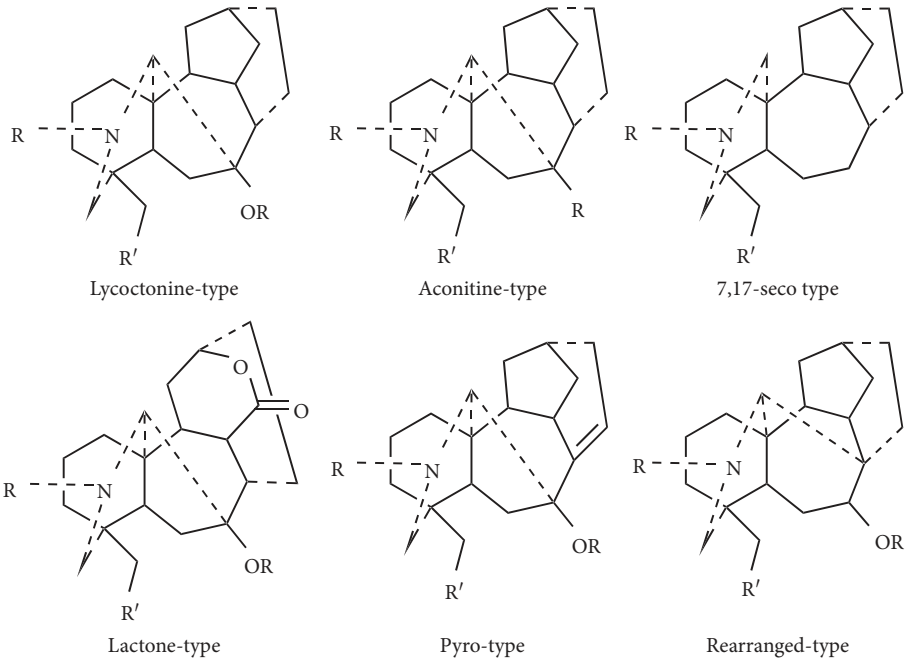


Figure 2: The skeleton structures of C-19 diterpene alkaloids.

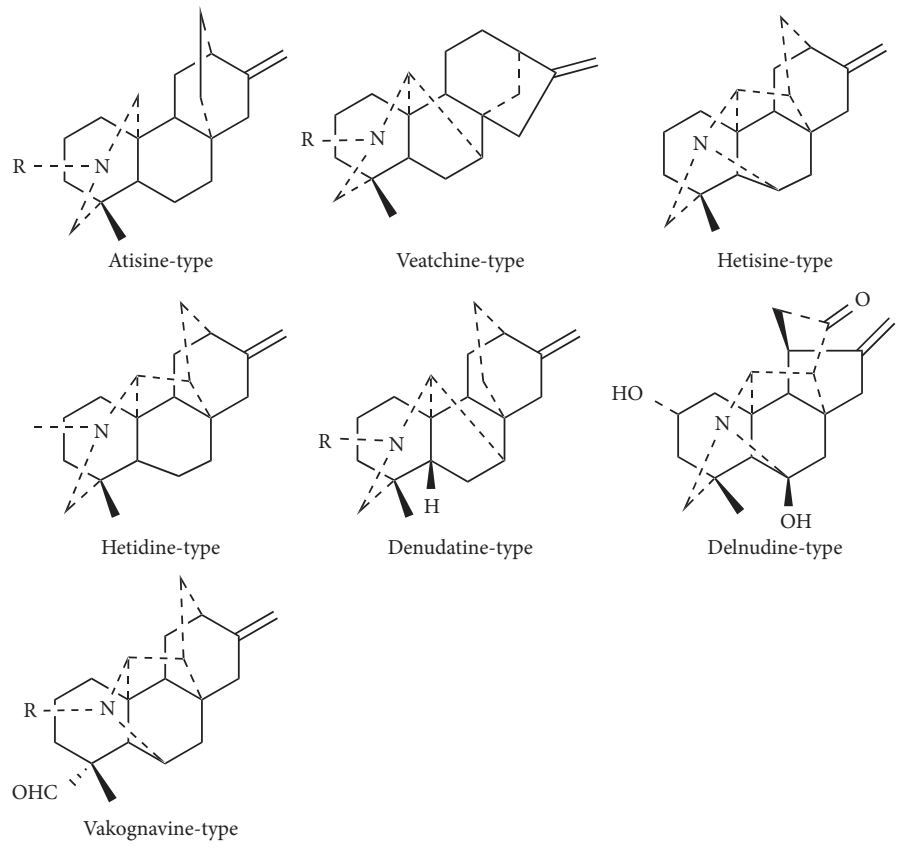


Figure 3: The skeleton structures of C-20 diterpene alkaloids.

D. denudatum had a good analgesic activity [63]. Nesterova et al. investigated chronic immune inflammation which was induced by injecting 0.1 mL of complete Freund's in outbred male rats, and the results showed that the 40% alcohol extract (0.12 mL/kg) and total alkaloids (0.05 mg/kg) of *Delphinium* could significantly reduce the frequency of joint

Table 1: C-18 diterpenoid alkaloids isolated from *Delphinium*.

No.	Compound	Type	Source	Molecular formula	Reference
1	Anthriscifolcine A	Ranaconitine	*D. anthriscifolium* var. *savatieri*	$C_{26}H_{38}NO_7$	[17]
2	Anthriscifolcine B	Ranaconitine	*D. anthriscifolium* var. *savatieri*	$C_{24}H_{37}NO_6$	[17]
3	Anthriscifolcine C	Ranaconitine	*D. anthriscifolium* var. *savatieri*	$C_{25}H_{37}NO_7$	[17]
4	Anthriscifolcine D	Ranaconitine	*D. anthriscifolium* var. *savatieri*	$C_{26}H_{39}NO_7$	[17]
5	Anthriscifolcine E	Ranaconitine	*D. anthriscifolium* var. *savatieri*	$C_{24}H_{37}NO_6$	[17]
6	Anthriscifolcine F	Ranaconitine	*D. anthriscifolium* var. *savatieri*	$C_{25}H_{37}NO_8$	[18]
7	Anthriscifolcine G	Ranaconitine	*D. anthriscifolium* var. *savatieri*	$C_{25}H_{37}NO_7$	[18]
8	Naviconine	Lappacinitine	*D. naviculare* var. *lasiocarpum* W. T. Wang.	$C_{31}H_{40}N_2O_9$	[19]
9	Anthriscifolcone A	Ranaconitine	*D. anthriscifolium* var. *majus*	$C_{27}H_{39}NO_8$	[20]
10	Anthriscifolcone B	Ranaconitine	*D. anthriscifolium* var. *majus*	$C_{23}H_{33}NO_7$	[20]
11	Grandifline A	Ranaconitine	*D. grandiflorum* Linn	$C_{22}H_{33}NO_7$	[21]
12	Tuguaconitine	Ranaconitine	*D. grandiflorum*	$C_{23}H_{35}NO_7$	[22]
13	Linearilin	Ranaconitine	*D. linearilobum* (Trautv.) N. Busch	$C_{24}H_{39}NO_8$	[23]
14	Anthriscifoltine A	Ranaconitine	*D. anthriscifolium* var. *majus*	$C_{30}H_{45}NO_9$	[24]
15	Anthriscifoltine B	Ranaconitine	*D. anthriscifolium* var. *majus*	$C_{28}H_{43}NO_8$	[24]
16	Anthriscifoltine C	Ranaconitine	*D. anthriscifolium* var. *majus*	$C_{29}H_{43}NO_9$	[25]
17	Anthriscifoltine D	Ranaconitine	*D. anthriscifolium* var. *majus*	$C_{32}H_{41}NO_9$	[25]
18	Anthriscifoltine E	Ranaconitine	*D. anthriscifolium* var. *majus*	$C_{25}H_{35}NO_8$	[25]
19	Anthriscifoltine F	Ranaconitine	*D. anthriscifolium* var. *majus*	$C_{23}H_{33}NO_7$	[25]
20	Anthriscifoltine G	Ranaconitine	*D. anthriscifolium* var. *majus*	$C_{23}H_{31}NO_7$	[25]

Table 2: C-19 diterpenoid alkaloids isolated from *Delphinium*.

No.	Compound	Type	Source	Molecular formula	Reference
21	Anthriscifoldine A	Lycoctonine	*D. anthriscifolium* var. *savatieri*	$C_{25}H_{37}NO_7$	[17]
22	Anthriscifoldine B	Lycoctonine	*D. anthriscifolium* var. *savatieri*	$C_{25}H_{39}NO_7$	[17]
23	Anthriscifoldine C	Lycoctonine	*D. anthriscifolium* var. *savatieri*	$C_{27}H_{41}NO_7$	[17]
24	Naviculine	Lycoctonine	*D. naviculare* var. *lasiocarpum* W. T. Wang.	$C_{26}H_{42}NO_7^+$	[19]
25	Naviconitine	Aconitine	*D. naviculare* var. *lasiocarpum* W. T. Wang.	$C_{34}H_{46}N_2O_9$	[19]
26	Grandifline B	Lycoctonine	*D. grandiflorum* Linn	$C_{25}H_{39}NO_8$	[21]
27	Grandifline C	Lycoctonine	*D. grandiflorum* Linn	$C_{25}H_{40}NO_7^+$	[21]
28	Olivimine	Lycoctonine	*D. grandiflorum*	$C_{24}H_{37}NO_7$	[22]
29	Hohenackeridine	Lycoctonine	*D. grandiflorum*	$C_{22}H_{31}NO_7$	[22]
30	14-O-Methyldelphinifoline	Lycoctonine	*D. grandiflorum*	$C_{24}H_{39}NO_7$	[22]
31	N-Deethyldelphatine	Lycoctonine	*D. grandiflorum*	$C_{24}H_{39}NO_7$	[22]
32	Browniine	Lycoctonine	*D. grandiflorum*	$C_{25}H_{41}NO_7$	[22]
33	14-Dehydrobrowniine	Lycoctonine	*D. grandiflorum*	$C_{25}H_{39}NO_7$	[22]
34	Linearilobin	Aconitine	*D. linearilobum* (Trautv.) N. Busch	$C_{37}H_{46}N_2O_9$	[23]
35	Melpheline	Lycoctonine	*D. elatum*	$C_{24}H_{37}NO_6$	[26]
36	19-Oxoisodelpheline	Lycoctonine	*D. elatum*	$C_{25}H_{37}NO_7$	[26]
37	N-Deethyl-19-oxoisodelpheline	Lycoctonine	*D. elatum*	$C_{23}H_{33}NO_7$	[26]
38	N-Deethyl-19-oxodelpheline	Lycoctonine	*D. elatum*	$C_{23}H_{33}NO_7$	[26]
39	N-Formyl-4,19-secopacinine	Lycoctonine	*D. elatum* cv. Pacific Giant	$C_{25}H_{37}NO_7$	[27]
40	Iminoisodelpheline	Lycoctonine	*D. elatum* cv. Pacific Giant	$C_{23}H_{33}NO_6$	[27]
41	Iminodelpheline	Lycoctonine	*D. elatum* cv. Pacific Giant	$C_{23}H_{33}NO_6$	[27]
42	Iminopaciline	Lycoctonine	*D. elatum* cv. Pacific Giant	$C_{24}H_{35}NO_6$	[27]
43	6-Dehydroeladine	Lycoctonine	*D. elatum* cv. Pacific Giant	$C_{24}H_{35}NO_6$	[27]
44	Elapacidine	Lycoctonine	*D. elatum* cv. Pacific Giant	$C_{24}H_{37}NO_6$	[27]
45	Yunnanensine A	Rearranged-type	*D. yunnanense*	$C_{37}H_{48}N_2O_9$	[28]
46	Iliensine A	Lycoctonine	*D. iliense*	$C_{40}H_{55}NO_{14}$	[29]
47	Iliensine B	Lycoctonine	*D. iliense*	$C_{26}H_{41}NO_8$	[29]
48	Pseudophnine A	Lycoctonine	*D. pseudoaemulans* C. Y. Yang et B. Wang	$C_{25}H_{40}NO_7^+$	[30]
49	Pseudophnine B	Lycoctonine	*D. pseudoaemulans* C. Y. Yang et B. Wang	$C_{24}H_{38}NO_7^+$	[30]

Table 2: Continued.

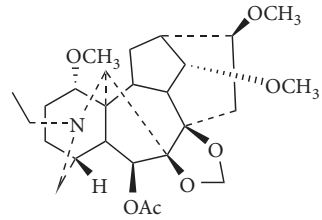
No.	Compound	Type	Source	Molecular formula	Reference
50	Pseudophnine C	Lycoctonine	*D. pseudoaemulans* C. Y. Yang et B. Wang	$C_{27}H_{42}NO_7^+$	[30]
51	Pseudophnine D	Lycoctonine	*D. pseudoaemulans* C. Y. Yang et B. Wang	$C_{26}H_{40}NO_7^+$	[30]
52	Pseudorenines A	Lycoctonine	*D. pseudoaemulans* C. Y. Yang et B. Wang	$C_{39}H_{53}N_2O_{11}^+$	[30]
53	Pseudorenines B	Lycoctonine	*D. pseudoaemulans* C. Y. Yang et B. Wang	$C_{39}H_{53}N_2O_{11}^+$	[30]
54	Pseudonidine A	Lycoctonine	*D. pseudoaemulans* C. Y. Yang et B. Wang	$C_{24}H_{35}NO_7$	[30]
55	Pseudonidine B	Lycoctonine	*D. pseudoaemulans* C. Y. Yang et B. Wang	$C_{29}H_{45}NO_8$	[30]
56	Navicularine	Lycoctonine	*D. naviculare* var. *lasiocarpum*	$C_{27}H_{43}NO_8$	[31]
57	Shawurensine	Lycoctonine	*D. shawurense* W. T. Wang	$C_{37}H_{52}N_2O_{11}$	[32]
58	Sharwuphinine B	Lycoctonine	*D. shawurense* W. T. Wang	$C_{26}H_{40}NO_7^+$	[33]
59	Ajacisine A	Lycoctonine	*D. ajacis* L.	$C_{31}H_{44}N_2O_9$	[34]
60	Ajacisine B	Lycoctonine	*D. ajacis* L.	$C_{32}H_{46}N_2O_9$	[34]
61	Ajacisine C	Lycoctonine	*D. ajacis* L.	$C_{31}H_{42}N_2O_8$	[34]
62	Ajacisine D	Lycoctonine	*D. ajacis* L.	$C_{30}H_{42}N_2O_8$	[34]
63	Ajacisine E	Lycoctonine	*D. ajacis* L.	$C_{30}H_{42}N_2O_8$	[34]
64	Caerudelphinine A	Lycoctonine	*D. caeruleum* Jacq.ex Camb	$C_{25}H_{39}NO_8$	[35]
65	Grandiflodine B	Lycoctonine	*D. grandiflorum*	$C_{33}H_{48}N_2O_{10}$	[36]
66	Majusine A	Lycoctonine	*D. majus* W. T. Wang	$C_{32}H_{44}N_2O_9$	[37]
67	Majusine B	Lycoctonine	*D. majus* W. T. Wang	$C_{24}H_{37}NO_6$	[37]
68	Majusine C	Lycoctonine	*D. majus* W. T. Wang	$C_{26}H_{37}NO_8$	[37]
69	Davidisine A	Lycoctonine	*D. davidii* Franch.	$C_{23}H_{37}NO_7$	[38]
70	Davidisine B	Lycoctonine	*D. davidii* Franch.	$C_{24}H_{37}NO_8$	[38]
71	Laxicymine 1	Lycoctonine	*D. laxicymosum* var. *pilostachyum* W. T. Wang	$C_{24}H_{35}NO_7$	[39]
72	Laxicymisine 2	Lycoctonine	*D. laxicymosum* var. *pilostachyum* W. T. Wang	$C_{24}H_{37}NO_7$	[39]
73	Laxicyminine 3	Lycoctonine	*D. laxicymosum* var. *pilostachyum* W. T. Wang	$C_{24}H_{35}NO_6$	[39]
74	Tiantaishansine	Lycoctonine	*D. tiantaishanense* W. J. Zhang et G. H. Chen	$C_{22}H_{33}NO_7$	[40]
75	Tiantaishannine	Lycoctonine	*D. tiantaishanense* W. J. Zhang et G. H. Chen	$C_{26}H_{39}NO_7$	[40]
76	Tiantaishanmine	Lycoctonine	*D. tiantaishanense* W. J. Zhang et G. H. Chen	$C_{25}H_{35}NO_7$	[40]
77	Trifoliolasine A	Lycoctonine	*D. trifoliolatum* Finet et Gagnep	$C_{35}H_{50}N_2O_9$	[41]
78	Trifoliolasine B	Lycoctonine	*D. trifoliolatum* Finet et Gagnep	$C_{36}H_{52}N_2O_9$	[41]
79	Trifoliolasine C	Lycoctonine	*D. trifoliolatum* Finet et Gagnep	$C_{40}H_{57}N_3O_{11}$	[41]
80	14-Demethyl-14-isobutyrylanhweidelphinine	Lycoctonine	*D. pentagynum* Lam.	$C_{38}H_{48}N_2O_{11}$	[42]
81	14-Demethyl-14-acetylanhweidelphinine	Lycoctonine	*D. pentagynum* Lam.	$C_{36}H_{44}N_2O_{11}$	[42]
82	Giraldine G	Lycoctonine	*D. giraldii*	$C_{40}H_{57}N_3O_{11}$	[43]
83	Giraldine H	Lycoctonine	*D. giraldii*	$C_{41}H_{59}N_3O_{11}$	[43]
84	Giraldine I	Aconitine	*D. giraldii*	$C_{22}H_{35}NO_3$	[43]
85	Giraldine D	Lycoctonine	*D. giraldii*	$C_{24}H_{37}NO_6$	[44]
86	Giraldine E	Lycoctonine	*D. giraldii*	$C_{25}H_{39}NO_7$	[44]
87	Giraldine F	Lycoctonine	*D. giraldii*	$C_{23}H_{33}NO_6$	[44]
88	Campylocine	Lycoctonine	*D. campylocentrum* Maxim.	$C_{25}H_{37}NO_7$	[45]
89	Campylotine	Lycoctonine	*D. campylocentrum* Maxim.	$C_{24}H_{37}NO_7$	[45]
90	Davidiisine A	Lycoctonine	*D. davidii* Franch	$C_{23}H_{37}NO_7$	[46]
91	Davidiisine B	Lycoctonine	*D. davidii* Franch	$C_{24}H_{37}NO_8$	[46]
92	Ajadelphine	Lycoctonine	*D. honanense* var. *piliteram* W. T. Wang	$C_{25}H_{39}NO_7$	[47]
93	Aconine	Aconitine	*D. honanense* var. *piliteram* W. T. Wang	$C_{25}H_{41}NO_9$	[47]
94	Siwanine E	Lycoctonine	*D. honanense* var. *piliteram* W. T. Wang	$C_{28}H_{39}NO_9$	[47]

Table 2: Continued.

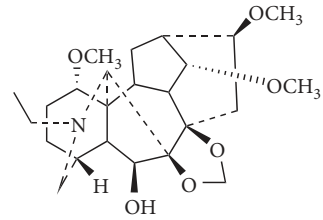
No.	Compound	Type	Source	Molecular formula	Reference
95	Grandiflorine III	Aconitine	*D. grandiflorum* L.	$C_{26}H_{39}NO_9$	[48]
96	Isotalatizidine	Aconitine	*D. grandiflorum* L.	$C_{23}H_{37}NO_5$	[48]
97	14-O-Methyl isotalatizidine	Aconitine	*D. grandiflorum* L.	$C_{24}H_{39}NO_5$	[48]
98	Anthranoyllycoctonine	Lycoctonine	*D. grandiflorum* L.	$C_{32}H_{46}N_2O_8$	[48]
99	Deoxylycoctonine	Lycoctonine	*D. grandiflorum* L.	$C_{26}H_{43}NO_6$	[48]
100	Umbrosine	Lycoctonine	*D. grandiflorum* L.	$C_{24}H_{39}NO_6$	[48]
101	Anthriscifolrine A	Lycoctonine	*D. anthriscifolium* var. *majus*	$C_{25}H_{37}NO_6$	[49]
102	Anthriscifolrine B	Lycoctonine	*D. anthriscifolium* var. *majus*	$C_{27}H_{41}NO_8$	[49]
103	Anthriscifolrine C	Lycoctonine	*D. anthriscifolium* var. *majus*	$C_{27}H_{41}NO_9$	[49]
104	Anthriscifolrine D	Lycoctonine	*D. anthriscifolium* var. *majus*	$C_{27}H_{39}NO_9$	[49]
105	Anthriscifolrine E	Lycoctonine	*D. anthriscifolium* var. *majus*	$C_{26}H_{39}NO_8$	[49]
106	Anthriscifolrine F	Lycoctonine	*D. anthriscifolium* var. *majus*	$C_{25}H_{39}NO_7$	[49]
107	Tianshanisine A	Lycoctonine	*D. tianshanicum* W. T. Wang	$C_{30}H_{41}NO_6$	[50]
108	Tianshanisine B	Lycoctonine	*D. tianshanicum* W. T. Wang	$C_{23}H_{37}NO_5$	[50]
109	Tianshanisine C	Lycoctonine	*D. tianshanicum* W. T. Wang	$C_{25}H_{39}NO_6$	[50]
110	Tianshanisine D	Lycoctonine	*D. tianshanicum* W. T. Wang	$C_{23}H_{35}NO_5$	[50]
111	Tianshanisine E	Lycoctonine	*D. tianshanicum* W. T. Wang	$C_{23}H_{35}NO_7$	[50]
112	Elapacigine	Lycoctonine	*Delphinium elatum* cv. Pacific Giant	$C_{23}H_{31}NO_6$	[51]
113	N-Deethyl-N-formylpaciline	Lycoctonine	*Delphinium elatum* cv. Pacific Giant	$C_{25}H_{37}NO_7$	[51]
114	N-Deethyl-N-formylpacinine	Lycoctonine	*Delphinium elatum* cv. Pacific Giant	$C_{24}H_{33}NO_7$	[51]
115	N-Formyl-4,19-secoyunnadelphinine	Lycoctonine	*Delphinium elatum* cv. Pacific Giant	$C_{24}H_{35}NO_7$	[51]

Table 3: C-20 diterpenoid alkaloids isolated from *Delphinium*.

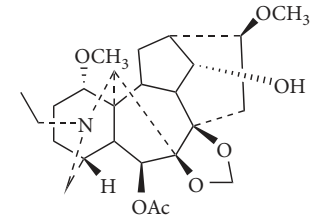
No.	Compound	Type	Source	Molecular formula	Reference
116	Yunnanensine B	Hetisine	*D. yunnanense*	$C_{28}H_{37}NO_7$	[28]
117	Yunnanensine C	Hetisine	*D. yunnanense*	$C_{26}H_{35}NO_6$	[28]
118	Grandiflodine A	Hetisine	*D. grandiflorum*	$C_{22}H_{28}N_2O_3$	[36]
119	Majusimine A	Vakognavine	*D. majus* W. T. Wang	$C_{45}H_{47}NO_{15}$	[37]
120	Majusimine B	Vakognavine	*D. majus* W. T. Wang	$C_{43}H_{45}NO_{14}$	[37]
121	Majusimine C	Vakognavine	*D. majus* W. T. Wang	$C_{41}H_{43}NO_{13}$	[37]
122	Majusimine D	Vakognavine	*D. majus* W. T. Wang	$C_{34}H_{37}NO_{12}$	[37]
123	Majusidine A	Hetisine	*D. majus* W. T. Wang	$C_{22}H_{29}NO_5$	[37]
124	Majusidine B	Hetisine	*D. majus* W. T. Wang	$C_{25}H_{33}NO_4$	[37]
125	Tiantaishandine	Hetisine	*D. tiantaishanense* W. J. Zhang et G. H. Chen	$C_{29}H_{33}NO_5$	[40]
126	2-Dehydrodeacetylhetero phylloidine	Hetidine	*D. pentagynum* Lam.	$C_{21}H_{25}NO_3$	[42]
127	Davidiisine C	Hetidine	*D. davidii* Franch	$C_{21}H_{33}NO_4$	[46]
128	12-Epinapelline	Veatchine	*D. honanense* var. *piliteram* W. T. Wang	$C_{22}H_{33}NO_3$	[47]
129	Anthriscifolsine B	Hetisine	*D. anthriscifolium* var. *majus*	$C_{24}H_{31}NO_7$	[49]
130	Anthriscifolsine C	Hetisine	*D. anthriscifolium* var. *majus*	$C_{30}H_{43}NO_7$	[49]
131	Anthriscifolmine A	Denudatine	*D. anthriscifolium* var. *savatieri*	$C_{25}H_{37}NO_5$	[52]
132	Anthriscifolmine B	Denudatine	*D. anthriscifolium* var. *savatieri*	$C_{25}H_{37}NO_6$	[52]
133	Anthriscifolmine C	Hetisine	*D. anthriscifolium* var. *savatieri*	$C_{29}H_{31}NO_7$	[52]
134	Trichodelphinines A	Hetisine	*D. tichophorum* Franch	$C_{26}H_{35}NO_5$	[53]
135	Trichodelphinines B	Hetisine	*D. tichophorum* Franch	$C_{24}H_{33}NO_4$	[53]
136	Trichodelphinines C	Hetisine	*D. tichophorum* Franch	$C_{27}H_{37}NO_5$	[53]
137	Trichodelphinines D	Hetisine	*D. tichophorum* Franch	$C_{24}H_{31}NO_5$	[53]
138	Trichodelphinines E	Hetisine	*D. tichophorum* Franch	$C_{26}H_{33}NO_5$	[53]
139	Trichodelphinines F	Delnudine	*D. tichophorum* Franch	$C_{28}H_{33}NO_4$	[53]
140	Flexiosine	Hetisine	*D. flexuosum* M. Bieb.	$C_{36}H_{43}NO_9$	[54]
141	Tatsienenseine A	Vakognavine	*D. tatsienense* Franch	$C_{43}H_{45}NO_{13}$	[55]
142	Tatsienenseine B	Hetisine	*D. tatsienense* Franch	$C_{24}H_{31}NO_4$	[55]
143	Tatsienenseine C	Hetisine	*D. tatsienense* Franch	$C_{24}H_{31}NO_3$	[55]
144	13-(2-Methyl butyryl) azitine	Atisine	*D. scabriflorum*	$C_{25}H_{37}NO_3$	[56]
145	Tatsienensine	Hetisine	*D. tatsienense*	$C_{19}H_{25}NO_2$	[57]



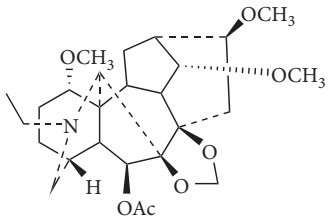
1 Anthriscifolcine A



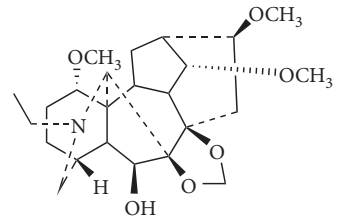
2 Anthriscifolcine B



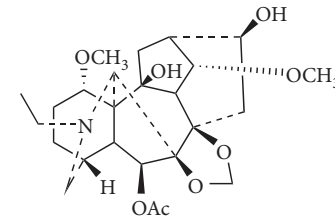
3 Anthriscifolcine C



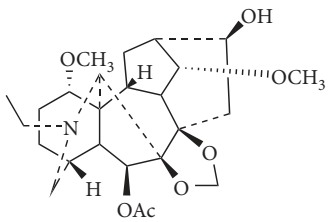
4 Anthriscifolcine D



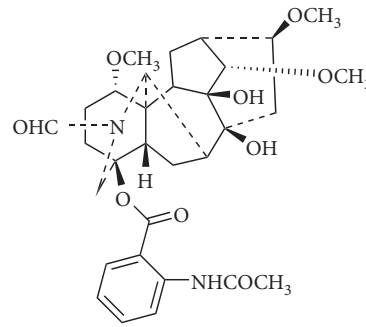
5 Anthriscifolcine E



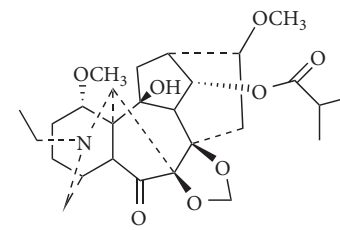
6 Anthriscifolcine F



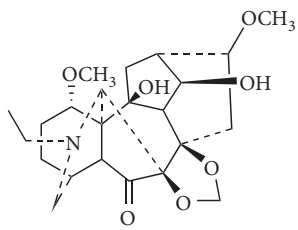
7 Anthriscifolcine G



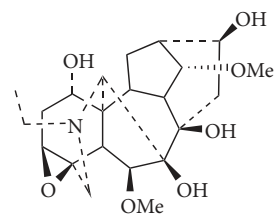
8 Naviconine



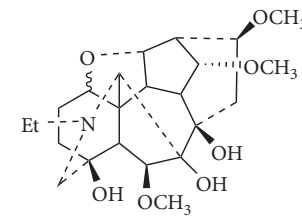
9 Anthriscifolcone A



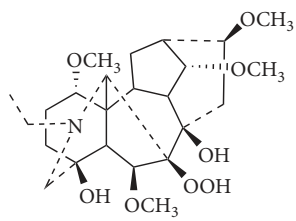
10 Anthriscifolcone B



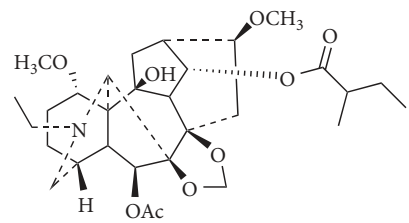
11 Grandifline A



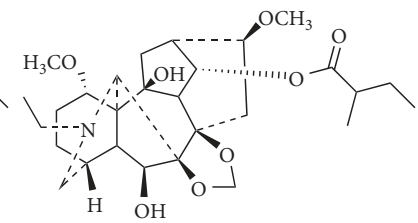
12 Tuguaconitine



13 Linearilin



14 Anthriscifoltine A



15 Anthriscifoltine B

Figure 4: Continued.

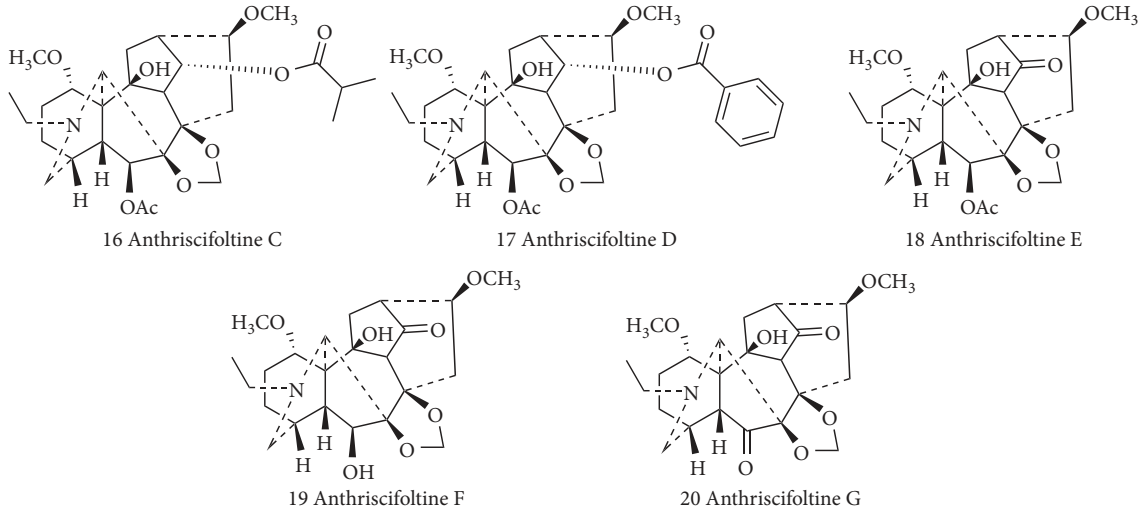


Figure 4: C-18 diterpenoid alkaloids isolated from *Delphinium*.

swelling in outbred male rats. On the 14th day, the rats in the total alkaloids (0.05 mg/kg) treatment group of *Delphinium* had no pain when their joints were bended, which indicated a good analgesic effect of *Delphinium* [64]. Through the hot-plate method and the acetic acid writhing method, Suslov et al. found that the water extract (0.5 g/kg) and the alcohol extract (0.25 g/kg) of *D. grandiflorum* L. var. *leiocarpum* could prolong the pain threshold of mice, which was similar to the effect of acetaminophen (0.2 g/kg), and performed a good analgesic effect [65].

3.3. Anti-Inflammatory Activity. Nesterova et al. found that the alkaloids and flavonoids in *Delphinium* had a good inhibitory effect on the inflammatory response through the experiment of the mice peritonitis model in the inflammatory exudation phase *in vivo*. Aqueous fraction of flavonoids (25.0 mg/kg) had a good therapeutic effect on the edema reaction caused by histamine (0.1%), and alkaloids (0.05 mg/kg) showed a good anti-inflammatory effect on the inflammatory reaction caused by 5-hydroxytryptamine (0.5 mg/kg) [66]. Andreeva and Liu established an acute inflammation model with increased capillary permeability induced by acetic acid in ICR male mice, and the results showed that the high- (1.5 g/kg), medium- (1.0 g/kg), and low-dose groups (0.5 g/kg) of the total flavonoids extracted from *D. grandiflorum* with ethanol had good anti-inflammatory activity [67].

3.4. Spiritual Influence

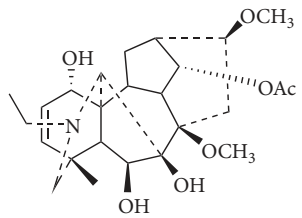
3.4.1. Antidepressant Activity. Ebrahimzadeh et al. demonstrated that the extract (250 mg/kg, 500 mg/kg, and 1000 mg/kg) of *D. elbursense* had good antidepressant activity by using the forced swimming experiment and the tail suspension experiment in mice. The results revealed that the extract at 1000 mg/kg had the same inhibitory activity as imipramine at 15 mg/kg in the control group [68].

3.4.2. Antianxiety Activity. Mohammad et al. found that the *D. denudatum* extract (200 and 400 mg/kg) had a certain therapeutic effect on anxiety in Wistar albino rats and a better synergistic effect toward the *Amaranthus spinosus* extract (100 mg/kg) [69].

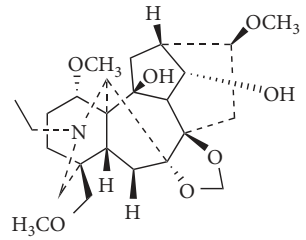
3.5. Anticancer Activity. Zheng et al. used the MTT method to determine the antihepatoma activity of the ethyl acetate extract from *D. caeruleum in vitro*. After giving 25, 50, 100, and 200 μg/mL of HepG2 cells for 12, 24, and 48 hours, they found that the ethyl acetate extract from *D. caeruleum* had good antiliver cancer activity and had a good dose-effect and time-effect relationship on HepG2 cells and had less toxicity to L-02 cells. IC_{50} of the ethyl acetate extract from *D. caeruleum* on HepG2 cells was 28.8 μg/mL [70].

3.6. Antipulmonary Fibrosis Activity. In the study on pulmonary fibrosis induced by bleomycin in SD rats, Lin et al. found that after 14 days of gavage with 4 g/kg, 2 g/kg, and 1 g/kg extracts of *D. trichophorum*, the expression of collagen in the tissues during the pathological process of pulmonary fibrosis could be inhibited and the symptoms of pulmonary fibrosis in rats could be improved [71].

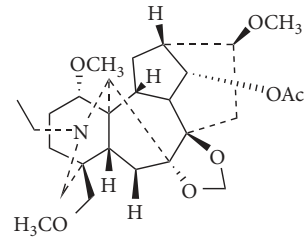
3.7. Antifeedant Activity. Shan et al. determined the antifood activity of 12 alkaloids isolated from *D. naviculare* var. *lasiocarpum* on *Spodoptera exigua*, and the results showed that the chemical shawurensine had a strong antifeedant activity with an EC_{50} of 0.45 mg/cm^2 [31]. González and Guadaño extracted 5 alkaloids from *Delphinium* for activity determination against *Spodoptera littoralis* and *Leptinotarsa decemlineata* by choice feeding assays, and the results showed that cardiopetamine had the strongest activity against *S. littoralis* with the EC_{50} of 5.48 nmol/cm^2 and 15-acetylcardiopetamine had the strongest activity against *L. decemlineata* with the EC_{50} of 12.86 nmol/cm^2 [72].



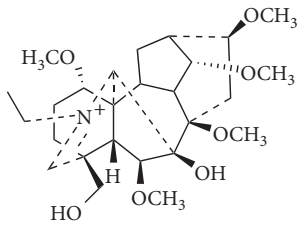
21 Anthriscifoldine A



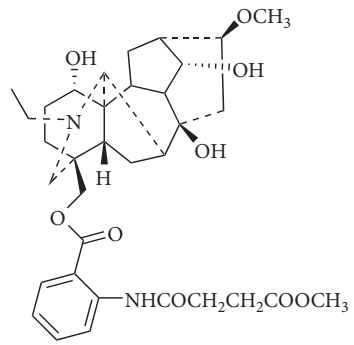
22 Anthriscifoldine B



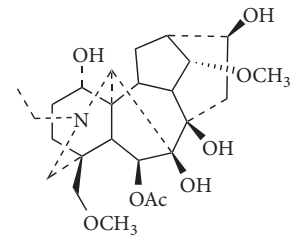
23 Anthriscifoldine C



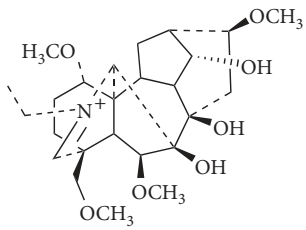
24 Naviculine



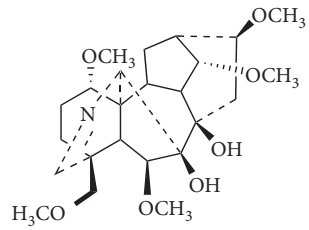
25 Naviconitine



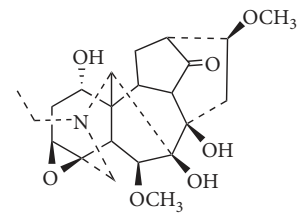
26 Grandifline B



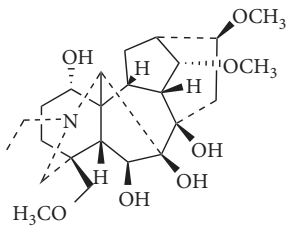
27 Grandifline C



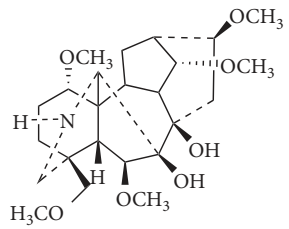
28 Olivimine



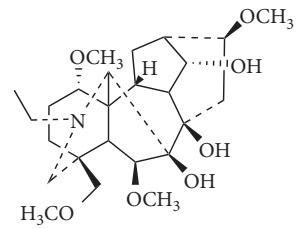
29 Hohenackeridine



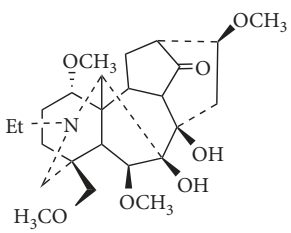
30 14-O-Methyldelphinifoline



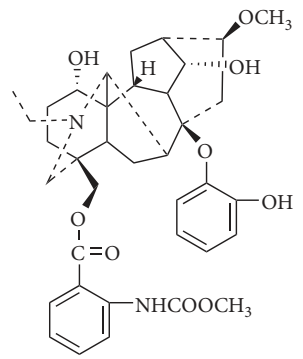
31 N-Deethyldelphatine



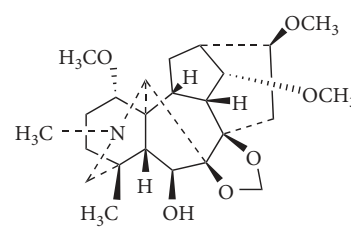
32 Browniine



33 14-Dehydrobrowniine

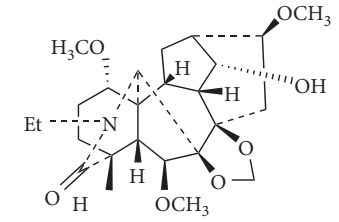


34 Linearilobin

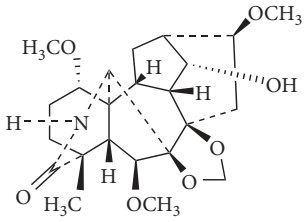


35 Melpheline

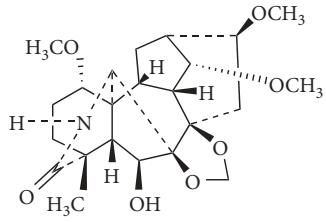
Figure 5: Continued.



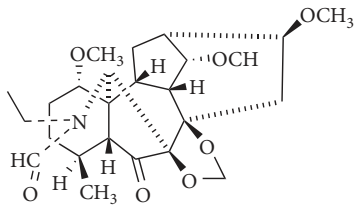
36 19-Oxoisodelpheline



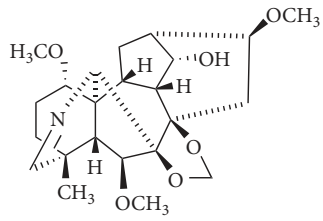
37 N-Deethyl-19-oxoisodelpheline



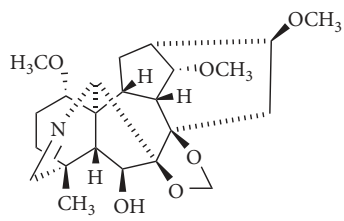
38 N-Deethyl-19-oxodelpheline



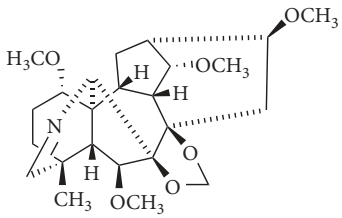
39 N-Formyl-4,19-secopacinine



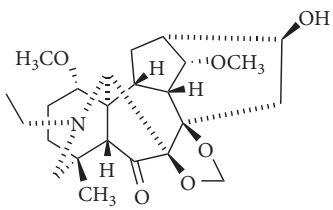
40 Iminoisodelpheline



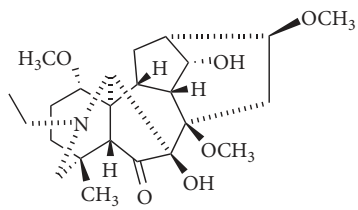
41 Iminodelpheline



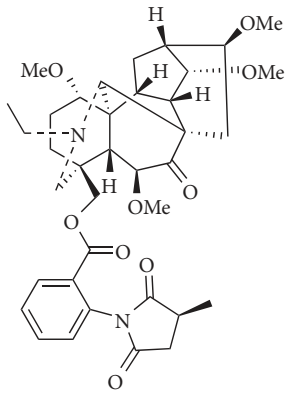
42 Iminopaciline



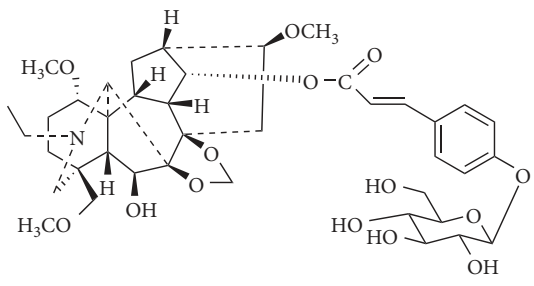
43 6-Dehydroeladine



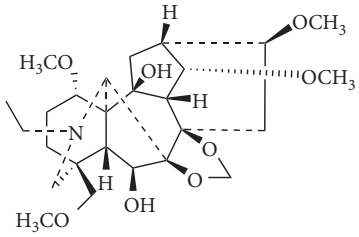
44 Elapacidine



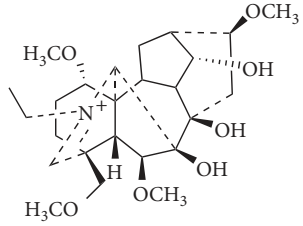
45 Yunnanensine A



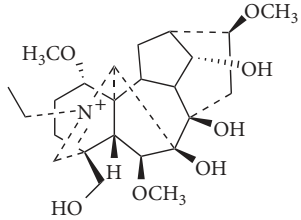
46 Iliensine A



47 Iliensine B

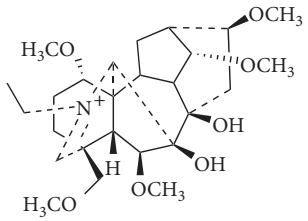


48 Pseudophnine A

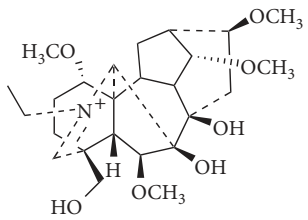


49 Pseudophnine B

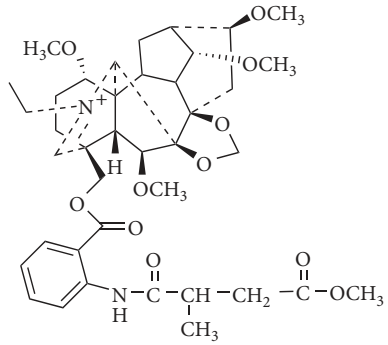
Figure 5: Continued.



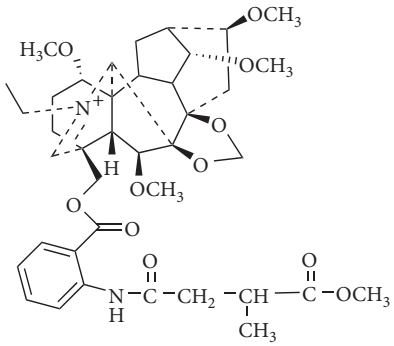
50 Pseudophnine C



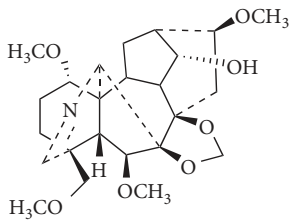
51 Pseudophnine D



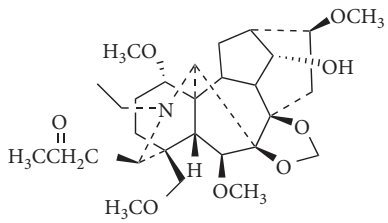
52 Pseudorenines A



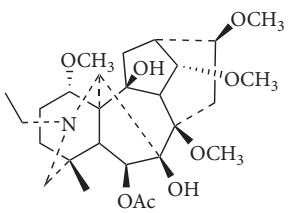
53 Pseudorenines B



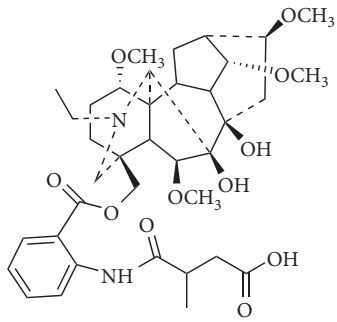
54 Pseudonidine A



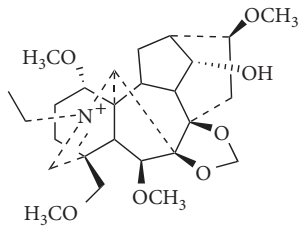
55 Pseudonidine B



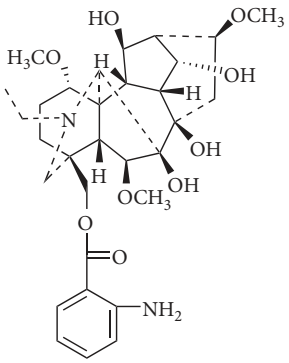
56 Navicularine



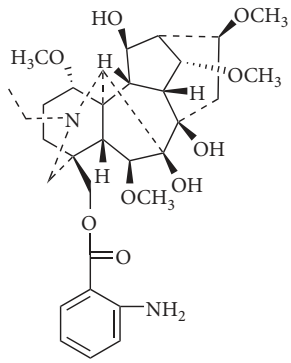
57 Shawurensine



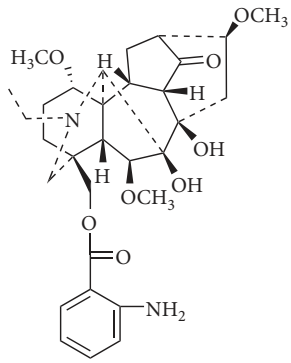
58 Sharwuphinine B



59 Ajacisine A

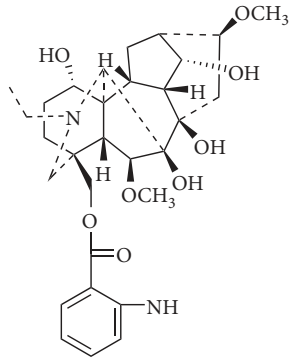


60 Ajacisine B

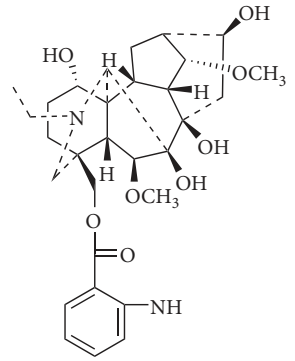


61 Ajacisine C

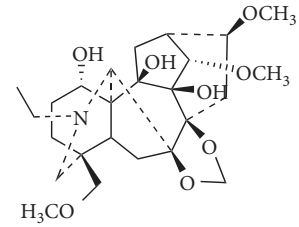
Figure 5: Continued.



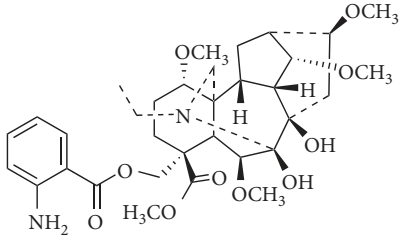
62 Ajacisine D



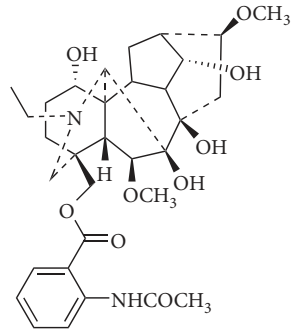
63 Ajacisine E



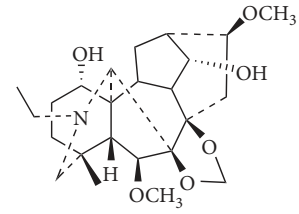
64 Caerudelphinine A



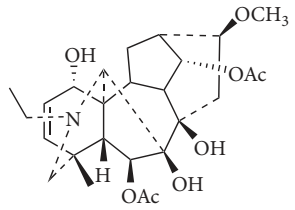
65 Grandiflodine B



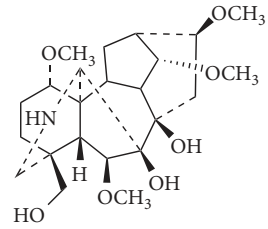
66 Majusine A



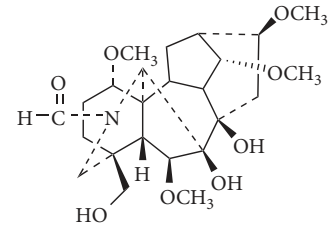
67 Majusine B



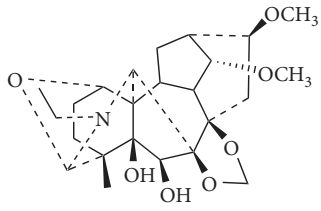
68 Majusine C



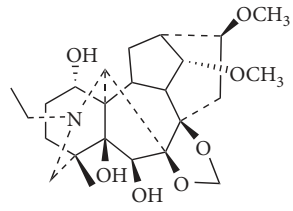
69 Davidisine A



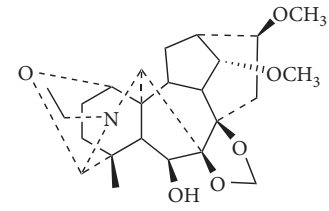
70 Davidisine B



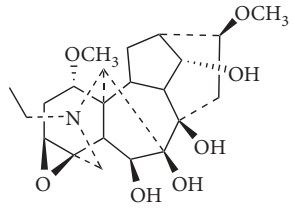
71 Laxicymine 1



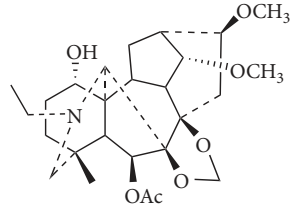
72 Laxicymisine 2



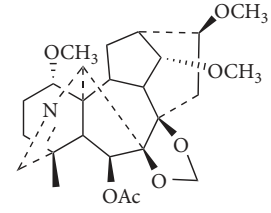
73 Laxicyminine 3



74 Tiantaishansine

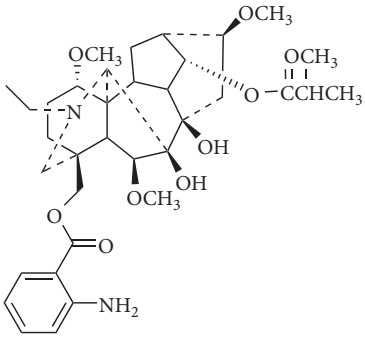


75 Tiantaishannine

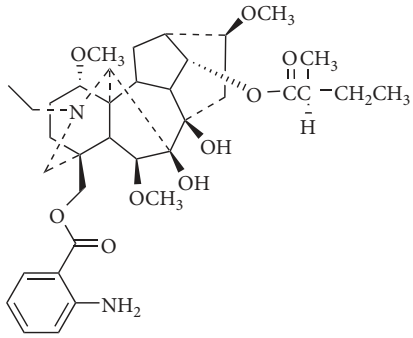


76 Tiantaishanmine

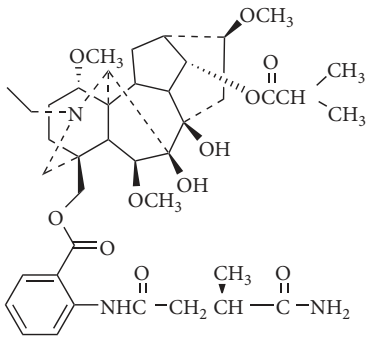
Figure 5: Continued.



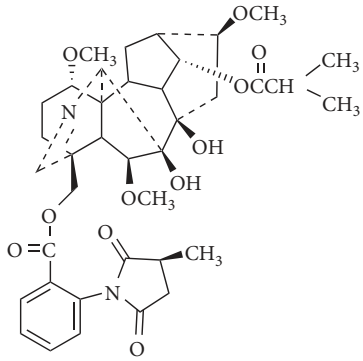
77 Trifoliolasine A



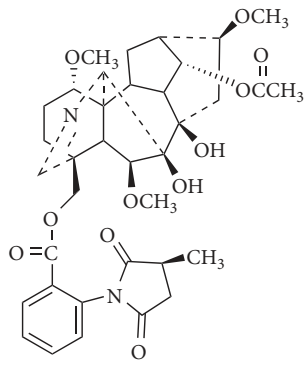
78 Trifoliolasine B



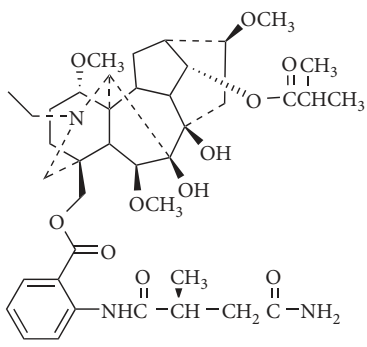
79 Trifoliolasine C



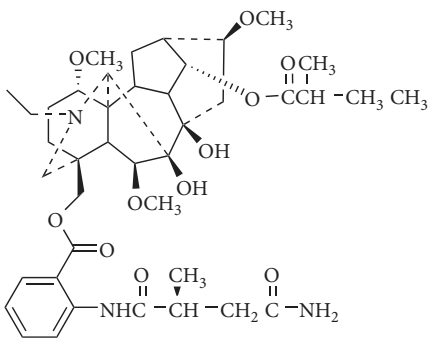
80 14-Demethyl-14-isobutyrylanhweidelphinine



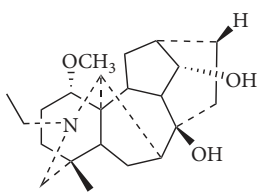
81 14-Demethyl-14-acetylanhweidelphinine



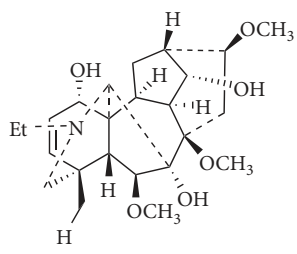
82 Giraldine G



83 Giraldine H

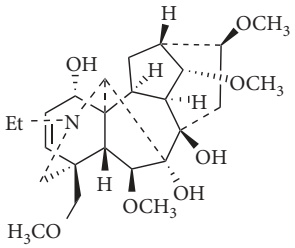


84 Giraldine I

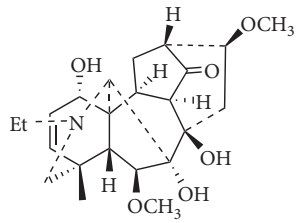


85 Giraldine D

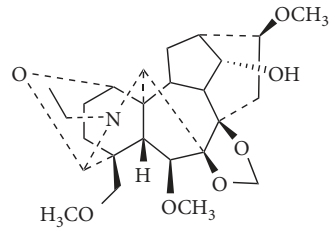
Figure 5: Continued.



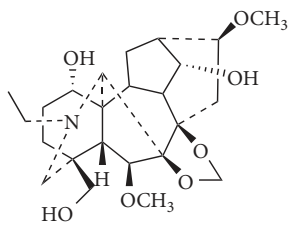
86 Giraldine E



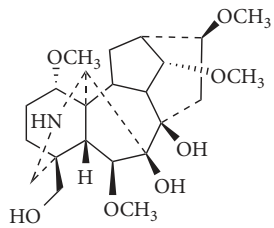
87 Giraldine F



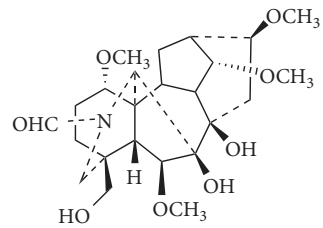
88 Campylocine



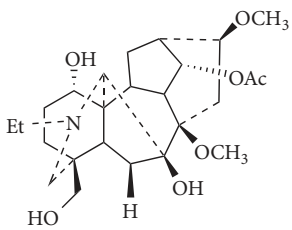
89 Campylotine



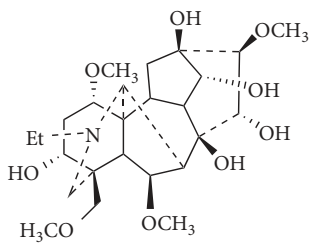
90 Davidiisine A



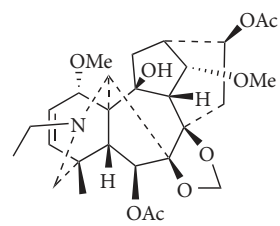
91 Davidiisine B



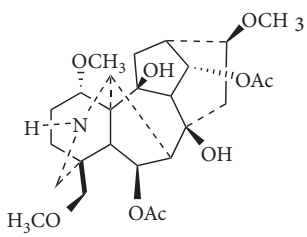
92 Ajadelphine



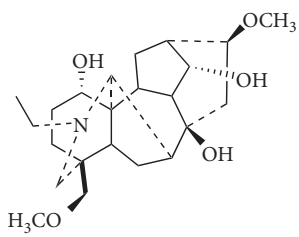
93 Aconine



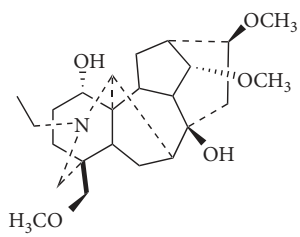
94 Siwanine E



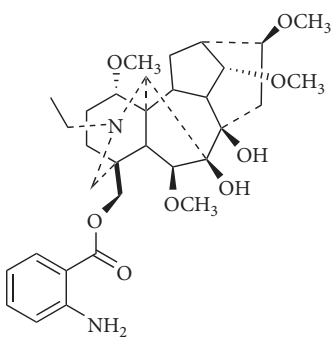
95 Grandiflorine III



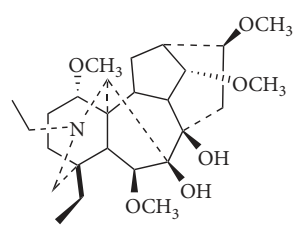
96 Isotalatizidine



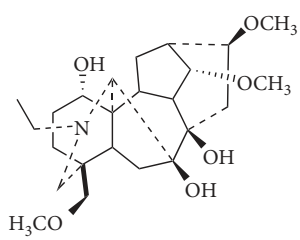
97 14-O-Methyl isotalatizidine



98 Anthranoyllycoctonine



99 Deoxylycoctonine



100 Umbrosine

Figure 5: Continued.

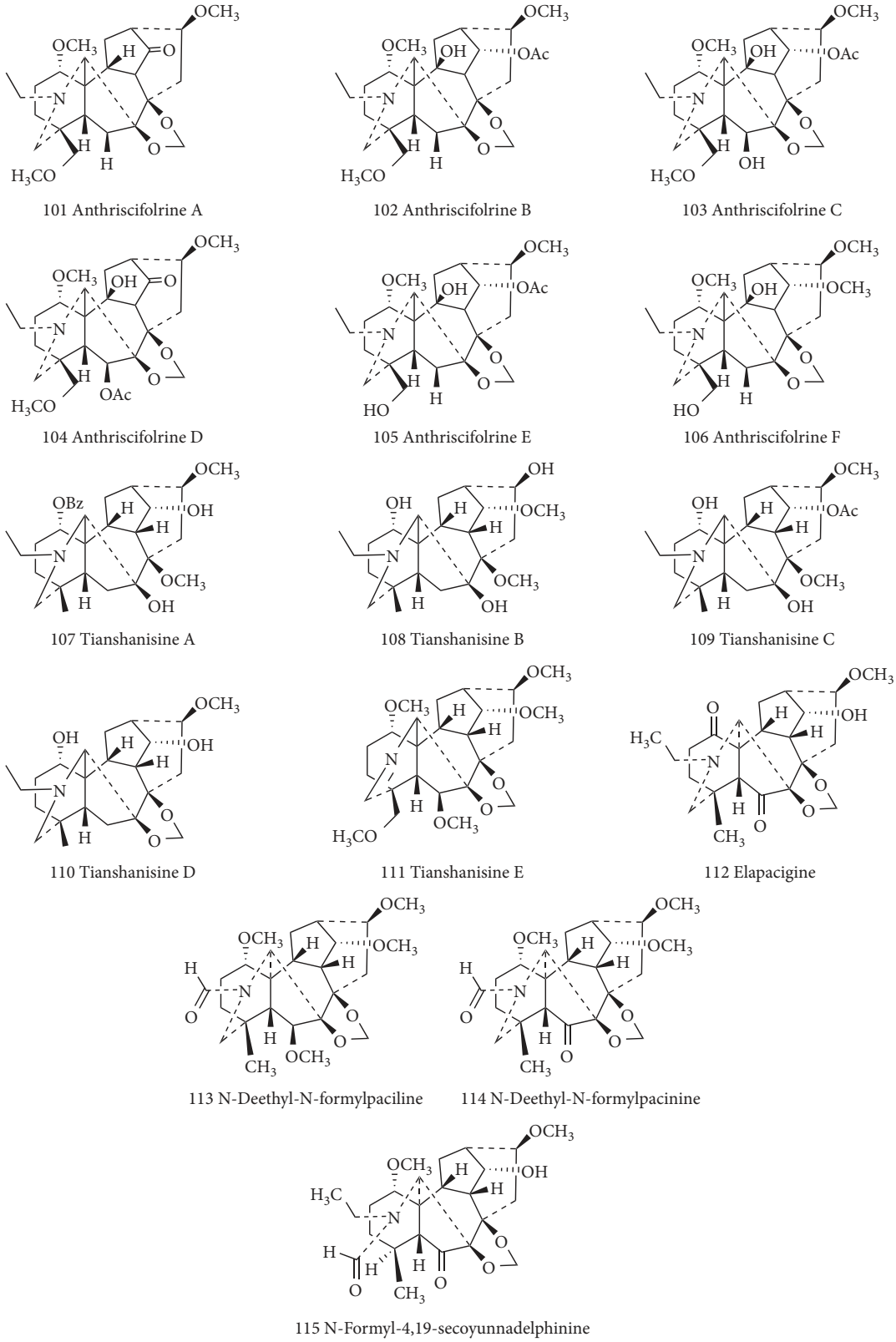
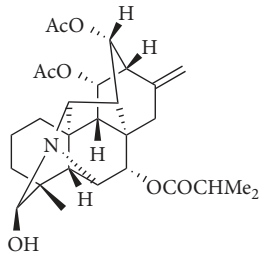
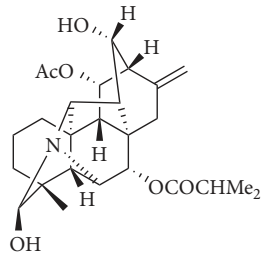


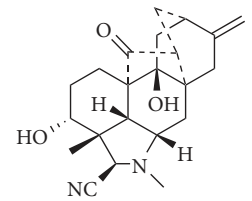
Figure 5: C-19 diterpenoid alkaloids isolated from *Delphinium*.



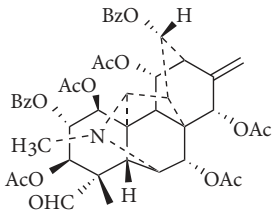
116 Yunnanensine B



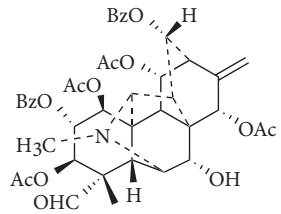
117 Yunnanensine C



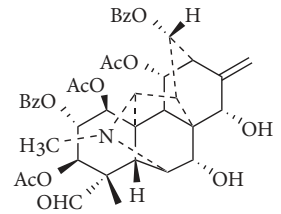
118 Grandiflodine A



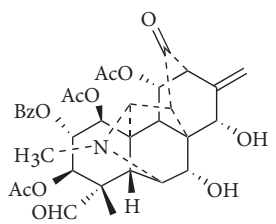
119 Majusimine A



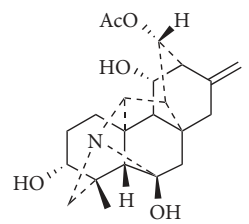
120 Majusimine B



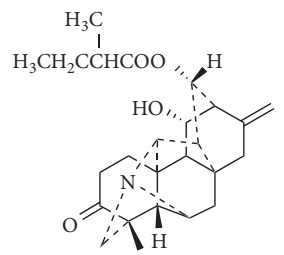
121 Majusimine C



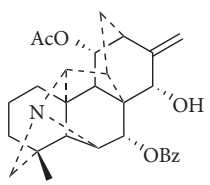
122 Majusimine D



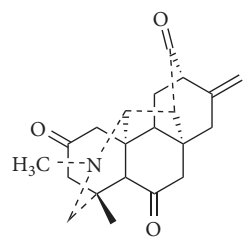
123 Majusidine A



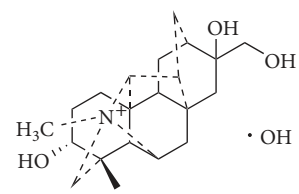
124 Majusidine B



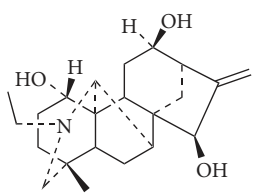
125 Tiantaishandine



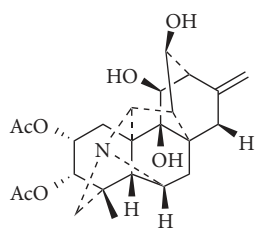
126 2-Dehydrodeacetylhetero phylloidine



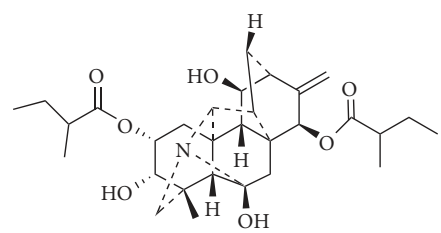
127 Davidiisine C



128 12-Epinapelline



129 Anthriscifolsine B



130 Anthriscifolsine C

Figure 6: Continued.

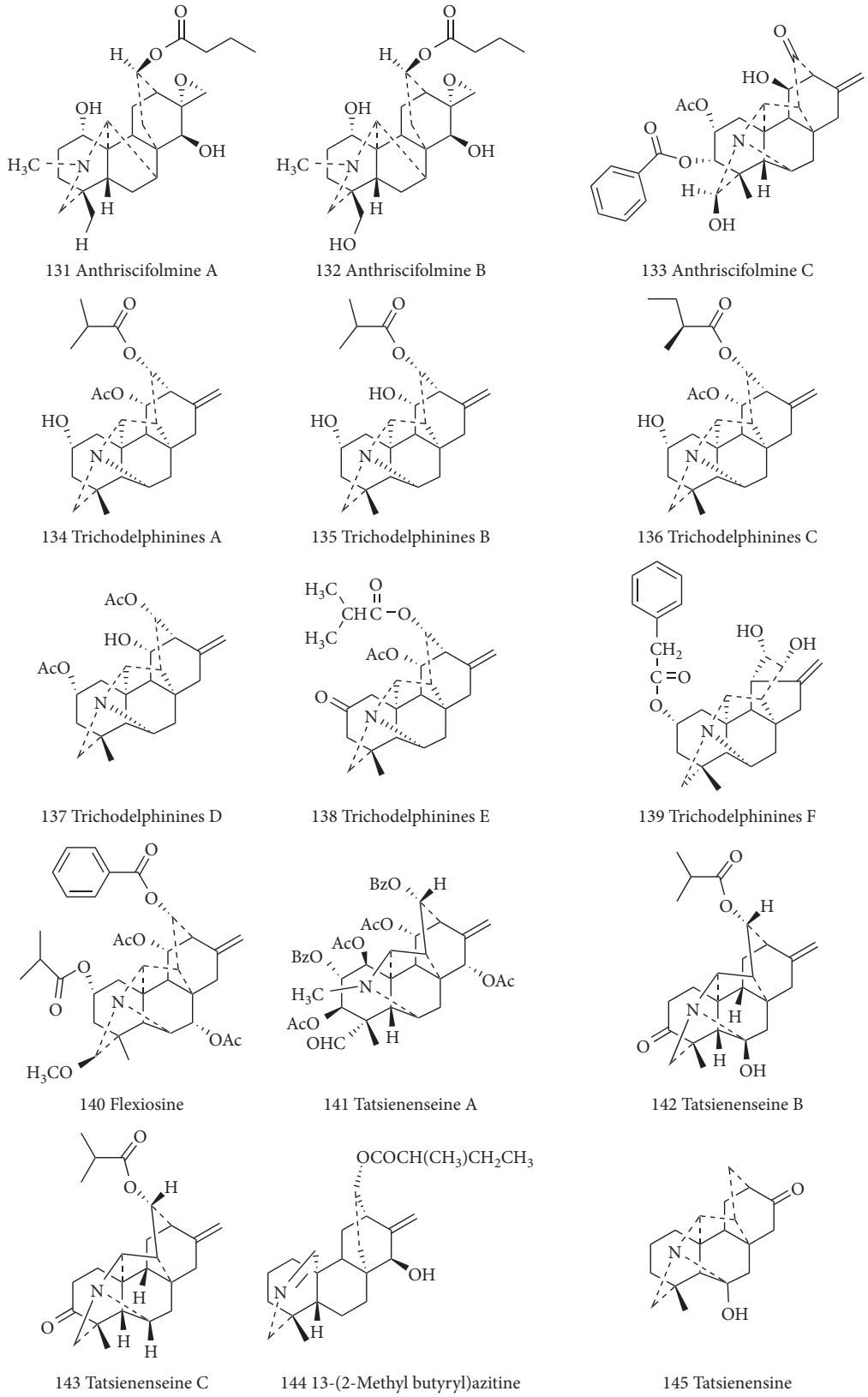
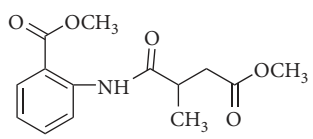


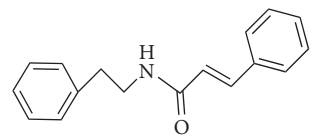
Figure 6: C-20 diterpenoid alkaloids isolated from *Delphinium*.

Table 4: Amide alkaloids isolated from *Delphinium*.

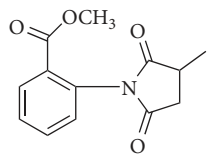
No.	Compound	Type	Source	Molecular formula	Reference
146	Benzoic acid 2-[(4-methoxy-2-methyl-1,4-dioxobutyl) amino]-methyl ester	Amide	*D. grandiflorum* Linn	$C_{14}H_{17}NO_5$	[21]
147	N-Cinnamoyl-2-phenylethylamine	Amide	*D. grandiflorum* L.	$C_{17}H_{17}NO$	[48]
148	Delamide A	Amide	*D. brunonianum*	$C_{13}H_{13}NO_4$	[58]
149	Delamide B	Amide	*D. brunonianum*	$C_{14}H_{17}NO_6$	[58]
150	Delamide C	Amide	*D. brunonianum*	$C_{13}H_{15}NO_5$	[58]
151	Delamide D	Amide	*D. brunonianum*	$C_{13}H_{15}NO_5$	[58]
152	Delamide E	Amide	*D. brunonianum*	$C_{13}H_{15}NO_5$	[58]
153	Benzoic,4-[(3,4-dimethoxybenzoyl) amino]-3-hydroxy-methyl ester	Amide	*D. brunonianum* Royle	$C_{17}H_{17}NO_6$	[59]
154	Benzoic acid 2-[(4-methoxy-3-methyl-1,4-dioxobutyl) amino]-methyl ester	Amide	*D. brunonianum* Royle	$C_{14}H_{17}NO_5$	[59]



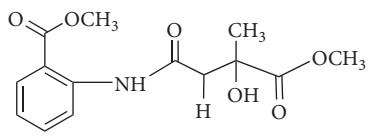
146 Benzoic acid 2-[(4-methoxy-2-methyl- 1,4- dioxobutyl) amino]-methylester



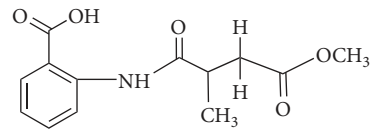
147 N-Cinnamoyl-2-phenylethylamine



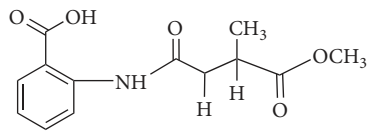
148 Delamide A



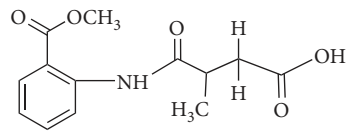
149 Delamide B



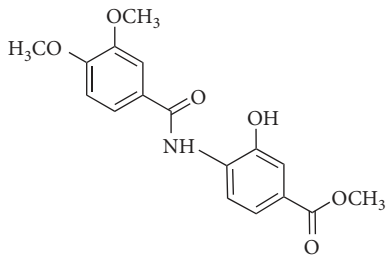
150 Delamide C



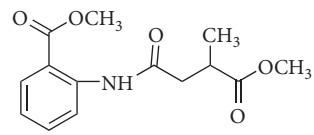
151 Delamide D



152 Delamide E

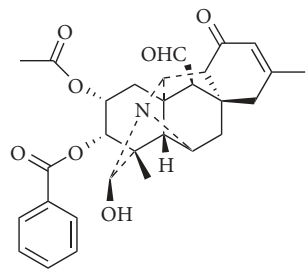


153 Benzoic,4-[(3,4-dimethoxybenzoyl) amino]-3-hydroxy-methyl ester



154 Benzoic acid 2-[(4-methoxy-3-methyl- 1,4- dioxobutyl) amino]-methyl ester

Figure 7: Amide alkaloids isolated from *Delphinium*.



155 Anthriscifolsine A

Figure 8: Other alkaloids isolated from *Delphinium*.

Table 5: Other compounds isolated from *Delphinium*.

No.	Compound	Type	Source	Molecular formula	Reference
156	β-Carotene		*D. grandiflorum* Linn	$C_{34}H_{56}NO_4$	[21]
157	3,5-Dihydroxy-4′-methoxyflavon-7-yl-O-β-D-glucopyranosyl-(1⟶4)-α-L-rhamnopyranoside	Flavonoid	*D. grandiflorum* Linn	$C_{21}H_{18}NO_8$	[21]
158	β-D-Galactopyranoside,4-hydroxyphenyl		*D. grandiflorum* Linn	$C_{11}H_{12}NO_5$	[21]
159	β-Sitosterol	Sterol	*D. honanense* var. *piliteram* W. T. Wang	$C_{29}H_{50}O$	[47]
160	4′,7-Dimethoxy-5-hydroxyflavone	Flavonoid	*D. grandiflorum* L.	$C_{17}H_{14}O_5$	[48]
161	Kaempferol-7-O-α-L-pyranorhamnoside	Flavonoid	*D. grandiflorum* L.	$C_{21}H_{20}O_{10}$	[60]
162	5,7,3′,4′-Tetrahydroxy-8-methoxyflavone	Flavonoid	*D. grandiflorum* L.	$C_{16}H_{12}O_7$	[60]
163	Tachioside	Phenolics	*D. grandiflorum* L.	$C_{13}H_{18}O_8$	[60]
164	6-Methoxycoumarin	Coumarin	*D. grandiflorum* L.	$C_{10}H_8O_3$	[60]
165	para-Hydroxybenzoic acid		*D. brunonianum* Royle	$C_7H_6O_3$	[59]
166	Benzoic acid		*D. brunonianum* Royle	$C_7H_6O_2$	[59]
167	Cinnamic acid		*D. brunonianum* Royle	$C_9H_8O_2$	[59]
168	Dibutyl phthalate		*D. brunonianum* Royle	$C_{16}H_{22}O_4$	[59]

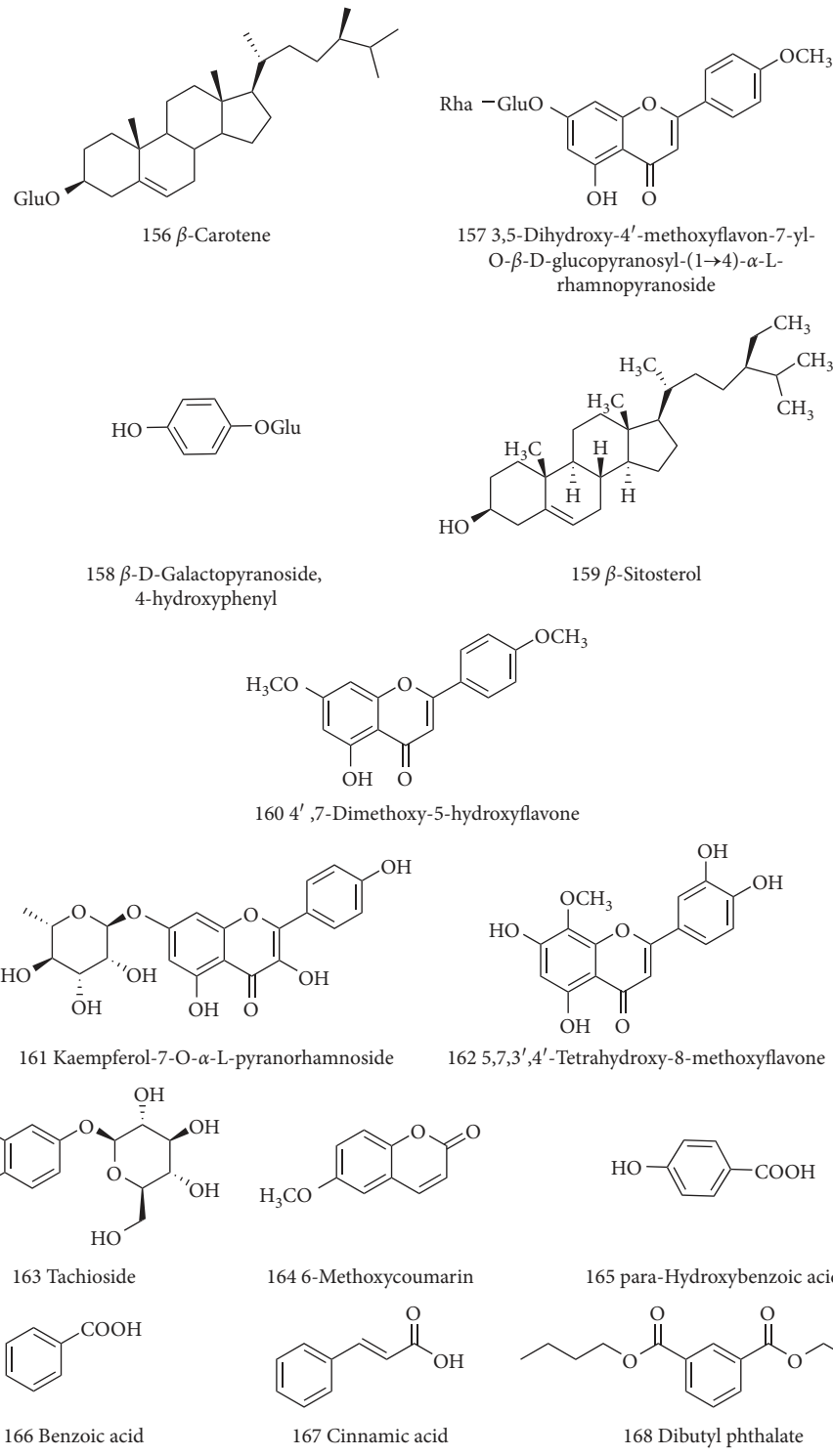


Figure 9: Other compounds isolated from *Delphinium*.

3.8. Antiparasite Activity. Reina et al. found that delphigraciline extracted from *D. gracile* had antileishmanicidal activity *in vitro*, and its IC_{50} was 7.3 μg/mL [73].

4. Summary and Analysis

Delphinium is rich in germplasm resources and has a wide range of pharmacological effects. In recent years, 168 compounds were isolated from plants of *Delphinium*, including 155 alkaloids and 13 nonalkaloids. The alkaloids in the genus *Delphinium* are mainly diterpene alkaloids, including 20 C-18 diterpenoid alkaloids, 95 C-19 diterpenoid alkaloids, and 30 C-20 diterpenoid alkaloids. The study of chemical composition for *Delphinium* mainly focuses on *D. anthriscifolium* varietas, *D. elatum*, *D. grandiflorum*, *D. brunonianum*, *D. tiantaishanense*, and *D. pseudoaemulans*.

Although there are many research studies, the pharmacological effects on the antibacterial, analgesic, anti-inflammatory, antidepressant, anticancer, antipulmonary fibrosis, antifeedant, and antiparasite effects of *Delphinium* are mainly on the crude extracts and few on compounds.

5. Future Prospects

The genus *Delphinium* is rich in new and novel compounds, but the current research is only focused on several species. In the future, more new compounds should be investigated from other species in depth. The pharmacological effects of *Delphinium* are extensive, but the current research is limited to extracts, so it is necessary to focus on the effects of the compounds from *Delphinium* and the structure-activity relationship in the future.

Data Availability

The data supporting this article are from previously reported studies, which have been cited. The data are available from the corresponding author upon request.

Conflicts of Interest

All authors declare that they have no conflicts of interest.

Authors' Contributions

Sitan Chen and Lijun Meng contributed equally to this work.

Acknowledgments

This work was supported by the Basic Project in Science and Technology Agency of Kaifeng City (1908007).

References

[1] W. C. Wang and J. W. Michael, *Flora of China*, pp. 223–274, Flora of China Editorial Committee of Chinese Academy of Sciences, Beijing, China, 2001.

[2] L. H. Shan, *Studies on Diterpenoid Alkaloids Constituents of Four Herb Aconitum*, Southwest Jiaotong University, Chengdu, China, 2017.

[3] Flora of China Editorial Committee of Chinese Academy of Sciences, *Flora Reipublicae Popularis Sinicae*, p. 326, Flora of China Editorial Committee of Chinese Academy of Sciences, Beijing, China, 1979.

[4] F. P. Wang, Q. H. Chen, and X. Y. Liu, "Diterpenoid alkaloids," *Natural Product Reports*, vol. 27, no. 4, p. 529, 2010.

[5] Teaching and Research Office of Organic Chemistry, Department of Chemistry, Nanjing University, *Organic chemistry*, p. 329, Higher Education Press, Beijing, China, 1988.

[6] H. X. Kuang, *Chemistry of Chinese Materia Medica*, China Press of Traditional Chinese Medicine, Beijing, China, 2nd edition, 1998.

[7] F. P. Wang, *Alkaloids Chemistry*pp. 410–429, Chemical and Industry Press, Beijing, China, 1st edition, 2008.

[8] T. P. Yin, Z. H. Luo, L. Cai, and Z. T. Ding, "Research progress and NMR spectral features of natural C_{19}-diterpenoid alkaloids," *Chinese Journal of Magnetic Resonance*, vol. 36, no. 01, pp. 113–126, 2019.

[9] Q. Zhang, B. Xu, Q. Jia, and Y. M. Li, "Advances in chemical constituents and pharmacological activities of C18 diterpenoid alkaloids," *Chinese Traditional Patent Medicine*, vol. 38, no. 5, pp. 1109–1114, 2016.

[10] S. M. Xie, C. Z. Lin, D. W. Zeren et al., "Review of phytochemical and pharmacological researches of medicinal plants from Genus *Delphinium* of Rannuculaceae," *Pharmacy Today*, vol. 21, no. 4, pp. 197–201, 2011.

[11] S. J. Wu, *Chemical Constituents of Modern Medicinal Herb*pp. 936–948, Chinese Medical Science and Technology Press, Beijing, China, 1st edition, 2002.

[12] F.-P. Wang and X.-T. Liang, "C20-diterpenoid alkaloids," *The Alkaloids: Chemistry and Biology*, vol. 59, pp. 1–280, 2002.

[13] K. B. m. Birnbaum, "X-ray crystal structure of delnudine, a novel alkaloid," *Tetrahedron Letters*, vol. 10, no. 60, pp. 5245-5246, 1969.

[14] R. Y. Li, F. Feng, and J. H. Liu, "Advance in studies on structure-activity relationships of C_{20}-Diterpenoid alkaloids," *Strait Pharmaceutical Journal*, vol. 25, no. 12, pp. 1–4, 2013.

[15] Y. Liang, J. L. Wu, X. Li et al., "Anti-cancer and anti-inflammatory new vakognavine-type alkaloid from the roots of *Aconitum carmichaelii*," *Tetrahedron Letters*, vol. 57, no. 52, pp. 5881–5884, 2016.

[16] L. S. Ding and Y. Z. Chen, "Natural C_{20} diterpene alkaloids," *Natural Product Research and Development*, vol. 2, no. 3, pp. 74–88, 1990.

[17] L. Song, X.-X. Liang, D.-L. Chen, X.-X. Jian, and F.-P. Wang, "New C18-Diterpenoid Alkaloids from *Delphinium anthriscifolium* var. *savatieri*," *Chemical & Pharmaceutical Bulletin*, vol. 55, no. 6, pp. 918–921, 2007.

[18] L. Jian, X.-Y. Liu, and Q.-H. Chen, "New C19- and C18-Diterpenoid Alkaloids from *Delphinium anthriscifolium* var. *savatieri*," *Chemical & Pharmaceutical Bulletin*, vol. 57, no. 2, pp. 158–161, 2009.

[19] W. J. Wang, B. Zhao, J. Y. Zhao et al., "Three new diterpenoid alkaloids from *Delphinium naviculare* var. *lasiocarpum* W. T. Wang," *Phytochemistry Letters*, vol. 33, pp. 12–16, 2019.

[20] S. Wang, X. L. Zhou, X. M. Gong et al., "Norditerpenoid alkaloids from *Delphinium anthriscifolium*," *Journal of Asian Natural Products Research*, vol. 18, no. 2, pp. 1–6, 2015.

[21] Z. D. Nan, *Studies on the Chemical Constituents of Delphinium grandifloru linn*, Lanzhou University, Lanzhou, China, 2010.

[22] Z. D. Nan, H. Z. Ren, X. A. Li et al., "Separation and identification of diterpenoid alkaloids from *Delphinium grandiflorum*," *Chinese Journal of Experimental Traditional Medical Formulae*, vol. 23, no. 24, pp. 71–77, 2017.

[23] U. Kolak, M. Oeztuerk, F. Oezgoekce et al., "Norditerpene alkaloids from *Delphinium linearilobum* and antioxidant activity," *Phytochemistry*, vol. 67, no. 19, pp. 2170–2175, 2006.

[24] L. H. Shan, J. F. Zhang, L. Chen et al., "Two new C18-diterpenoid alkaloids from *Delphinium anthriscifolium*," *Natural Product Communications*, vol. 10, no. 12, pp. 2067-2068, 2015.

[25] L.-H. Shan, J.-F. Zhang, F. Gao, S. Huang, and X.-L. Zhou, "C18-Diterpenoid alkaloids from *Delphinium anthriscifolium* var. *majus*," *Journal of Asian Natural Products Research*, vol. 20, no. 5, pp. 423–430, 2018.

[26] K. Huang, E. Asakawa, Y. Tosho et al., "Four new diterpenoid alkaloids from *Delphinium elatum*," *Phytochemistry Letters*, vol. 17, pp. 190–193, 2016.

[27] K. Nakata, R. Chiba, R. Kanazawa et al., "Six new norditerpenoid alkaloids from *Delphinium elatum*," *Phytochemistry Letters*, vol. 12, pp. 79–83, 2015.

[28] F. Z. Matsuoka, Q. H. Chen, and F. P. Wang, "Diterpenoid alkaloids from *Delphinium yunnanense*," *Helvetica Chimica Acta*, vol. 94, no. 2, pp. 254–260, 2011.

[29] J.-F. Zhang, R.-Y. Dai, L.-H. Shan et al., "Iliensines A and B: two new C 19 -diterpenoid alkaloids from *Delphinium iliense*," *Phytochemistry Letters*, vol. 17, pp. 299–303, 2016.

[30] W. J. Xu, B. Zhao, Z. Ruzi et al., "Norditerpenoid alkaloids from *Delphinium pseudoaemulans* C. Y. Yang et B. Wang," *Phytochemistry*, vol. 156, pp. 234–240, 2018.

[31] L. Shan, L. Chen, and F. Gao, "Diterpenoid alkaloids from *Delphinium naviculare* var. *lasiocarpum* with their antifeedant activity on *Spodoptera exigua*," *Natural Product Research*, vol. 33, no. 22, pp. 3254–3259, 2018.

[32] D. Y. Zhou, H. A. Aisa, S. K. Usmanova, and " Shawurensine, "Shawurensine, a new C19-diterpenoid alkaloid from *Delphinium shawurense*," *Chemistry of Natural Compounds*, vol. 43, no. 3, pp. 298–301, 2007.

[33] B. Zhao, S. K. Usmanova, A. Yili, A. Kawuli, R. Abdulla, and H. A. Aisa, "New C19-norditerpenoid alkaloid from *Delphinium shawurense*," *Chemistry of Natural Compounds*, vol. 51, no. 3, pp. 519–522, 2015.

[34] L. Kawuli, Y. B. Zhang, L. Zhuang et al., "Diterpenoid alkaloids from *Delphinium ajacis* and their anti-RSV activities," *Planta Medica*, vol. 83, no. 1-2, pp. 111–116, 2016.

[35] C.-Z. Wang, Z.-J. Liu, and Z.-D. Bairi, "A new diterpenoid alkaloid isolated from *Delphinium caeruleum*," *Chinese Journal of Natural Medicines*, vol. 15, no. 1, pp. 45–48, 2017.

[36] N.-H. Zhu, Y.-B. Zhang, W. Li et al., "Grandiflodines A and B, two novel diterpenoid alkaloids from *Delphinium grandiflorum*," *RSC Advances*, vol. 7, no. 39, pp. 24129–24132, 2017.

[37] F.-Z. Li, D.-L. Chen, and Q.-H. Chen, "Diterpenoid alkaloids from *Delphinium majus*," *Journal of Natural Products*, vol. 72, no. 1, pp. 18–23, 2009.

[38] X. X. Wang, D. L. Chen, and F. P. Wang, "Two new C19-diterpenoid alkaloids from *Delphinium davidii* Franch," *Chinese Chemical Letters*, vol. 17, no. 11, pp. 1473–1476, 2007.

[39] P. Tang, D. L. Chen, Q. H. Chen et al., "Three new C19-diterpenoid alkaloids from *Delphinium laxicymosum* var. *pilostachyum*," *Chinese Chemical Letters*, vol. 18, no. 6, pp. 700–703, 2007.

[40] J. Li, D.-L. Chen, and X.-X. Jian, "New diterpenoid alkaloids from the roots of *Delphinium tiantaishanense*," *Molecules*, vol. 12, no. 3, pp. 353–360, 2007.

[41] X. L. Wang, Q. H. Chen, and F. P. Wang, "New C19-diterpenoid alkaloids from *Delphinium trifoliolatum*," *Chemical and Pharmaceutical Bulletin*, vol. 52, no. 4, pp. 381–383, 2004.

[42] G. D. Jess, G. R. Juan, and H. Werner, "Alkaloids from *Delphinium pentagynum*," *Phytochemistry*, vol. 65, no. 14, pp. 2123–2127, 2004.

[43] X.-L. Zhou, Q.-H. Chen, and F.-P. Wang, "Three new C19-diterpenoid alkaloids from *Delphinium giraldii*," *Chemical & Pharmaceutical Bulletin*, vol. 52, no. 4, pp. 456–458, 2004.

[44] X. L. Zhou, Q. H. Chen, and F. P. Wang, "Three new lycoctonine-type C19-diterpenoid alkaloids from *Delphinium giraldii*," *Heterocycles*, vol. 63, no. 1, pp. 123–128, 2004.

[45] L. P. Yan, D. L. Chen, and F. P. Wang, "Structure elucidation of diterpenoid alkaloids from *Delphinium campylocentrum*," *Organic Chemistry*, vol. 27, no. 8, pp. 976–980, 2007.

[46] X. X. Liang, *Studies on the Chemical Constituents of Alkaloids in Delphinium davidii*, Sichuan University, Chengdu, China, 2007.

[47] Y. Q. He, Z. Y. Ma, Q. Yang et al., "Study on chemical constituents from *Delphinium honanense* var.*piliteram*," *China Journal of Chinese Materia Medica*, vol. 33, no. 23, p. 2784, 2008.

[48] Y. L. Han, *Studies on Chemical Constitudents of Gueldenstaedita multiflora Bge. and Delphinium grandiflorum L*, Northwest Normal University, Lanzhou, China, 2007.

[49] L. H. Shan, L. Chen, F. Gao et al., "Diterpenoid alkaloids from *Delphinium anthriscifolium* var. *majus*," *Scientific Reports*, vol. 7, no. 1, 2017.

[50] J. F. Zhang, L. H. Shan, F. Gao et al., "Five new C_{19}-diterpenoid alkaloids from *Delphinium tianshanicum* W. T. wang," *Chemistry and Biodiversity*, vol. 14, no. 4, Article ID e1600297, 2017.

[51] H. Yamashita, M. Katoh, A. Kokubun et al., "new C_{19} -diterpenoid alkaloids from *Delphinium elatum*," *Phytochemistry Letters*, vol. 24, pp. 6–9, 2018.

[52] X.-Y. Uchimura, Q.-H. Chen, and F.-P. Wang, "New C20-Diterpenoid Alkaloids from *Delphinium anthriscifolium* var. *savatieri*," *Helvetica Chimica Acta*, vol. 92, no. 4, pp. 745–752, 2009.

[53] C. Z. Lin, Z. X. Zhao, S. M. Xie et al., "Diterpenoid alkaloids and flavonoids from *Delphinium trichophorum*," *Phytochemistry*, vol. 97, pp. 88–95, 2014.

[54] T. M. Gabbasov, E. M. Tsyrlina, D. M. Anatov, and M. S. Yunusov, "Flexiosine, a new C20-diterpene alkaloid from roots of *Delphinium flexuosum*," *Chemistry of Natural Compounds*, vol. 53, no. 1, pp. 105–108, 2017.

[55] F.-Z. Spirikhin, Q.-H. Chen, and X.-Y. Liu, "Diterpenoid alkaloids from *Delphinium tatsienense*," *Helvetica Chimica Acta*, vol. 94, no. 5, pp. 853–858, 2011.

[56] M. S. Wang and K. Alfred, "Diterpenoid alkaloids from the roots of *Delphinium scabriflorum*," *Journal of Natural Products*, vol. 67, no. 9, pp. 1574–1576, 2004.

[57] F. Z. Chen, S. H. Li, Q. Zhao, and X. J Gou, "Tatsienensine, a norditerpenoid alkaloid from *Delphinium tatsienense*," *Natural Product Communications*, vol. 14, no. 11, pp. 1–3, 2019.

[58] Y.-S. Zou, Z. Dawa, C.-Z. Lin et al., "New amide alkaloids from *Delphinium brunonianum*," *Fitoterapia*, vol. 136, Article ID 104186, 2019.

[59] Z. D. Zhang, X. A. Li, Y. X. Chen et al., "Chemical constituents from the *Delphinium grandiflorum* herbs," *Journal of Chinese Medicinal Materials*, vol. 40, no. 9, pp. 2077–2080, 2017.

[60] Y. S. Zou, D. W. Zeren, C. Z. Lin et al., "Chemical constituents from *Delphinium brunonianum*," *Journal of Chinese Medicinal Materials*, vol. 42, no. 8, pp. 1806–1809, 2019.

[61] P. T. Hari, P. S. Ram, P. T. Yagna et al., "An assessment of ethnomedicinal use, chemical constituents analysis and bioactivity evaluation on high altitude medicinal plant *Delphinium brunonianum* of Manang District," *Nepal Journal of Science and Technology*, vol. 12, pp. 111–118, 2011.

[62] S. Y. Ren, G. L. Qiansiri, H. Y. Wang et al., "Extraction and antibacterial test of alkaloid from root of *Delphinium grandiflorum*," *Journal of Dalian Polytechnic University*, vol. 28, no. 4, pp. 248–250, 2009.

[63] I. Zaheer, S. Z. Rahman, R. A. Khan et al., "Evaluation of analgesic activity of extracts of *Delphinium denudatum* in animal models: a dose dependent pre-clinical trial (Article)," *Journal of Clinical and Diagnostic Research*, vol. 12, no. 12, pp. FC1–FC4, 2018.

[64] Y. V. Nesterova, T. N. Povetieva, Y. G. Nagornyak, T. V. Vetoshkina, and T. I. Andreeva, "Correction of adjuvant arthritis with delphinium extracts and alkaloids," *Bulletin of*

Experimental Biology and Medicine, vol. 147, no. 6, pp. 711–714, 2009.

[65] G. S. Suslov, Z. P. Jia, S. Z. Qiao et al., "Experimental studies on haemostasis and analgesic effect of *Delphinium grandiflorum* L. var. *leiocarpum*," *Chinese Journal of Hospital Pharmacy*, vol. 30, no. 11, pp. 898–900, 2010.

[66] Y. V. Nesterova, T. N. Poveteva, Y. G. Nagornyak, T. I. Andreeva, and N. I. Suslov, "Effects of bioactive substances from tall delphinium on the development of acute inflammation of different genesis," *Bulletin of Experimental Biology and Medicine*, vol. 145, no. 6, pp. 724–727, 2008.

[67] L. Andreeva and Y. J. Liu, "Study of *Delphinium grandiflorum* flavonoids on inhibition of inflammation in mice," *China Modern Medcine*, vol. 18, no. 32, p. 14+59, 2011.

[68] M. A. Ebrahimzadeh, S. F. Nabavi, S. M. Nabavi et al., "Biological and pharmacological effects of *Delphinium elbursense*," *African Journal of Biotechnology*, vol. 9, no. 34, pp. 5548–5555, 2010.

[69] A. Mohammad, G. A. Kumar, and A. K. Najam, "In vivo psychopharmacological investigation of *Delphinium denudatum* and *Amaranthus spinosus* extracts on Wistar rats," *Basic and Clinical Neuroscience Journal*, vol. 8, no. 6, pp. 503–512, 2017.

[70] S. J. Zheng, C. Xu, J. Yang et al., "In vitro anticancer screening of Tibetan medicines," *Journal of Huazhong Normal University (Natural Sciences)*, vol. 51, no. 3, pp. 328–334, 2017.

[71] C. Z. Lin, C. C. Zhu, F. L. Liu et al., "The protective effects of extracts of *Delphinium trichophorum* on bleomycin-induced pulmonary fibrosis in rats," *Journal of Chinese Medicinal Materials*, vol. 41, no. 5, pp. 1181–1185, 2018.

[72] C. González and G. Guadaño, "Antifeedant *delphinium* diterpenoid alkaloids. Structure-activity relationships," *Journal of Agricultural and Food Chemistry*, vol. 46, no. 1, 1998.

[73] M. Reina, R. Mancha, A. Gonzalez-Coloma, M. Bailen, M. L. Rodriguez, and R. A. Martinez-Diaz, "Diterpenoid alkaloids from *Delphinium gracile*," *Natural Product Research*, vol. 21, no. 12, pp. 1048–1055, 2007.