

New 23-Spirocholestane Derivatives from *Ypsilandra thibetica*

Bai-Bo Xie¹, Chang-Xiang Chen¹, Yong-Hui Guo², Yu-Ye Li³,
Ya-Juan Liu³, Wei Ni¹, Liu-Meng Yang³, Ning-Bo Gong²,
Yong-Tang Zheng³, Rui-Rui Wang³, Yang Lü², Hai-Yang Liu¹

¹ State Key Laboratory of Phytochemistry and Plant Resources in West China, Kunming Institute of Botany, Chinese Academy of Sciences, Kunming, P.R. China

² Institute of Materia Medica, Chinese Academy of Medical Sciences, Beijing, P.R. China

³ Key Laboratory of Animal Models and Human Disease Mechanisms of Chinese Academy of Sciences & Yunnan Province, Kunming Institute of Zoology, Chinese Academy of Sciences, Kunming, P.R. China

Abstract

Three new unusual 23-spirocholestane derivatives, ypsilanogenin (1), ypsilanogenin 3-O- β -D-glucopyranoside (2), and 4'-acetylypsilanogenin 3-O- β -D-glucopyranoside (3), were isolated from the whole plants of *Ypsilandra thibetica*. The structures of compounds 1–3 were deduced by spectroscopic and chemical methods, and the structure of 1 was further confirmed by a single-crystal diffraction analysis. All isolates were evaluated for their inhibitory activities against HIV-1.

Key words

Ypsilandra thibetica · Liliaceae · 23-spirocholestane glycosides · anti-HIV-1 activity

Supporting information available online at
<http://www.thieme-connect.de/ejournals/toc/plantamedica>

Ypsilandra thibetica, a perennial plant belonging to the Liliaceae family, is mainly distributed in southwestern China [1]. The whole plant has been used for treatment of scrofula, urine negative, edema, uterine bleeding, and traumatic hemorrhage [2,3]. Our previous studies on the species have resulted in the isolation of a series of steroidal saponins with cytotoxic and antifungal activities [4–9]. Reinvestigation of the phytochemical constituents of this plant afforded three new cholestane-type steroids, ypsilanogenin (1), ypsilanogenin 3-O- β -D-glucopyranoside (2), and 4'-acetylypsilanogenin 3-O- β -D-glucopyranoside (3) (Fig. 1). Compounds 1–3 had a unique 23-spirocholestane skeleton with a ketal carbon at C-23 to link to C-16 and C-2' of the fucosyl moiety and an oxygen bridge between C-24 and C-1' of the fucosyl moiety. We present herein the isolation, structural elucidation, and anti-HIV activities of the three new compounds.

Compound 1, obtained as colorless prisms, had a molecular formula of C₃₃H₅₂O₈ as determined by the HR-ESI-MS ion at *m/z* 575.3580 [M – H][–] (calcd. for C₃₃H₅₁O₈, 575.3583), thus requiring eight double-bond equivalents. The IR absorptions implied the presence of hydroxyl (3446 cm^{–1}) and carbonyl (1709 cm^{–1}) groups. In accordance with its molecular formula, all 33 carbons were well resolved in the ¹³C NMR spectrum (Table 1) and were further classified by DEPT experiments as six methyls, eight methylenes, 14 methines (7 oxygenated ones), two quaternary carbons, an acetal, a ketal, and a carbonyl. In addition, two tertiary methyls at δ_H 0.73 (s) and 0.77 (s), four secondary methyls at

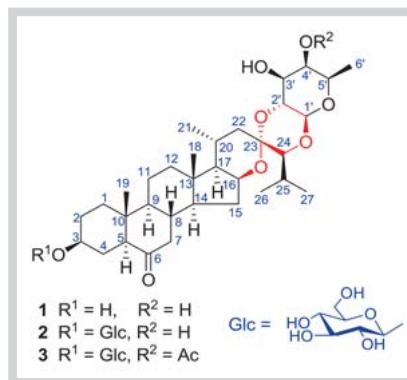


Fig. 1 Structures of compounds 1–3. (Color figure available online only.)

δ_H 0.78 (d, *J* = 6.3 Hz), 1.10 (d, *J* = 6.6 Hz), 1.16 (d, *J* = 6.6 Hz), and 1.58 (d, *J* = 6.3 Hz), and an acetal proton at δ_H 4.58 (d, *J* = 6.7 Hz) were distinguished by ¹H NMR data (Table 1). The carbonyl group accounted for one out of the eight degrees of unsaturation, and the remaining seven degrees of unsaturation implied compound 1 to be heptacyclic (rings A–G). Interpretation of ¹H-¹H COSY spectra of 1 revealed four spin systems (a–d) as shown with bold bonds in Fig. 2. Further, the HMBC correlations (Fig. 2) from H₂-4, H-5, H₂-7, and H-8 to C-6, from Me-18 to C-12, C-13, C-14, and C-17, from Me-19 to C-1, C-5, C-9, and C-10, and from H-16, H-20, H-24, H-25, and H-2' to C-23 led to unambiguous assignment for the connectivities of the substructures a–c to four quaternary carbons [δ_C 210.1 (C-6); δ_C 40.9 (C-10); δ_C 42.3 (C-13); and δ_C 100.3 (C-23)], and two tertiary methyls. In addition, the diagnostic HMBC correlation from H-1' to C-5' allowed connection of C-1' to C-5' by an oxygen bridge. The E-ring and G-ring were connected by extensive interpretation of the well-resolved HMBC spectrum. The HMBC correlations of H-1' (δ_H 4.58) with C-24 (δ_C 85.9), and H-2' (δ_H 4.10) with C-23 (δ_C 100.3) indicated the linkages in order of C-23–O–C-2' and C-24–O–C-1'. The above data revealed the planar structure of 1. The different ring junctions and the stereochemistry around rings A, F, and G were deduced from detailed analysis of the ROESY experiment (Fig. 2). The clear NOE correlations from H-8 to Me-18 and Me-19, from H-14 to H-9, H-16, and H-17, and from H-5 to H-3 and H-9 in the ROESY spectrum indicated the usual *trans* ring fusion for rings A/B, B/C, and C/D as well as a *cis* junction for rings D/E and β -configuration for OH-3, and that the rings A–C adopted a chair conformation. Moreover, NOEs of H-20 with Me-18 was consistent with the β -configuration for H-20. In addition, the ROESY correlations of H-17/H-22 α , H₂-22/H-2', H-1'/H-24, H-1'/H-3', H-1'/H-5', H-3'/H-4', and H-3'/H-5' indicated that H-24, H-1', H-3', H-4', and H-5' were α -oriented, while H-2' and Me-6' were β -oriented and rings F–G also adopted a chair conformation. The oxygen-bridge between C-23 and C-2' was α -oriented. Finally, the structure and relative configuration of 1 were unequivocally confirmed by single-crystal X-ray diffraction (Fig. 3). Therefore, the structure of 1 was established as shown in Fig. 1, and the compound was named ypsilanogenin.

Compound 2 was obtained as colorless prismatic crystals (MeOH). Its negative ion HR-ESI-MS exhibited a quasimolecular ion peak at *m/z* 737.4109, consistent with a molecular composition of C₃₉H₆₁O₁₃ (calcd. 737.4112). The deduced molecular formula was higher by C₆H₁₀O₅ than that of 1, and the ¹H NMR spectrum (Table 1) showed a signal for an anomeric proton at 5.04 (d, *J* = 7.7 Hz), along with signals for five cholestane-type steroid methyl protons at δ_H 0.63 (s), 0.70 (s), 0.75 (d, *J* = 6.6 Hz), 1.08

Table 1 ¹H and ¹³C NMR data of compounds **1–3** in C₅D₅N.

Position	1		2		3	
	δ _H (J in Hz)	δ _C	δ _H (J in Hz)	δ _C	δ _H (J in Hz)	δ _C
1α	1.18 m	37.0	1.03 m	36.7	1.00 m	36.9
1β	1.66 m		1.52 m		1.52 m	
2α	2.05 m	31.8	2.05 m	29.5	2.04 m	29.5
2β	1.67 m		1.57 m		1.57 m	
3	3.84 m	70.0	3.98 m	76.6	3.95 m	76.8
4α	2.31 m	31.3	2.37 m	27.0	2.36 m	27.1
4β	1.91 m		1.72 m		1.72 m	
5	2.25 m	56.9	2.08 m	56.4	2.01 m	56.5
6		210.1		209.7		209.7
7α	2.38 m	46.9	2.36 m	46.8	2.36 m	46.8
7β	1.98 m		1.99 m		1.97 m	
8	1.60 m	26.0	1.57 m	26.0	1.60 m	26.1
9	1.15 m	53.8	1.11 m	53.7	1.09 m	53.8
10		40.9		40.9		40.9
11α	1.52 m	21.6	1.45 m	21.5	1.43 m	21.5
11β	1.27 m		1.22 m		1.21 m	
12α	1.77 m	40.2	1.74 m	40.1	1.73 m	40.1
12β	1.09 m		1.05 m		1.03 m	
13		42.3		42.2		42.2
14	0.90 m	52.5	0.89 m	52.5	0.87 m	52.5
15α	1.87 m	32.8	1.87 m	32.7	1.84 m	32.7
15β	1.20 m		1.18 m		1.18 m	
16	4.47 m	71.4	4.48 m	71.4	4.43 m	71.5
17	0.80 m	58.8	0.80 m	58.8	0.80 m	58.8
18	0.73 s	14.9	0.70 s	14.9	0.71 s	14.9
19	0.77 s	13.3	0.63 s	13.1	0.64 s	13.1
20	1.82 m	37.0	1.77 m	36.9	1.76 m	36.7
21	0.78 d (6.3)	20.9	0.75 d (6.6)	20.9	0.83 d (6.1)	20.9
22α	2.23 m	37.3	2.21 m	37.3	2.38 m	37.4
22β	1.09 m		1.10 m		1.23 m	
23		100.3		100.3		100.5
24	3.59 d (5.1)	85.9	3.58 d (6.2)	85.9	3.58 d (4.6)	86.1
25	2.08 m	28.2	2.07 m	28.2	2.09 m	28.2
26	1.10 d (6.6)	18.1	1.08 d (6.5)	18.1	1.09 d (6.7)	18.1
27	1.16 d (6.6)	22.9	1.14 d (6.5)	22.9	1.15 d (6.7)	22.9
1'	4.58 d (6.7)	101.4	4.56 d (6.3)	101.4	4.59 d (7.9)	101.2
2'	4.10 m	72.3	4.12 m	72.3	4.29 m	70.0
3'	4.12 m	73.6	4.12 m	73.6	4.00 m	74.0
4'	4.05 brs	73.0	4.07 brs	73.0	5.60 d (3.4)	74.3
5'	3.86 (m)	73.5	3.87 m	73.5	3.98 m	71.8
6'	1.58 d (6.3)	17.2	1.57 d (5.9)	17.2	1.32 d (6.3)	16.6
1''			5.04 d (7.7)	102.2	5.01 d (7.6)	102.2
2''			4.05 m	75.4	4.04 m	75.4
3''			4.30 m	78.7	4.28 m	78.7
4''			4.23 m	71.8	4.24 m	71.9
5''			4.00 m	78.7	4.00 m	78.6
6''a			4.61 d (11.2)	63.0	4.61 m	63.0
6''b			4.39 dd (12.5, 5.6)		4.40 m	
Ac					2.19 s	171.0
						21.0

(3H, d, *J* = 6.5 Hz), and 1.14 (d, *J* = 6.5 Hz). On comparison of the whole ¹³C NMR spectrum of **2** with **1** (Table 1), a set of six signals corresponding to a D-glucopyranosyl moiety were observed at δ_C 102.2 (d), 75.4 (d), 78.7 (d), 71.8 (d), 78.7 (d), and 63.0 (t), and the signals due to C-3 of the aglycone and its neighboring carbon varied, while all other signals remained almost unaffected. Acid hydrolysis of **2** with 4 M TFA released D-glucose residue, as determined by GC analysis of the corresponding trimethylsilylated L-cysteine adduct [10]. The β-configuration of the

anomeric center of the glucopyranosyl was supported by the relatively large *J* value of the anomeric proton (*J* = 7.7 Hz). The HMBC spectrum showed a long-range correlation peak from the anomeric proton of the glucopyranosyl group at δ_H 5.04 to C-3 of the aglycone at δ_C 76.6. Consequently, these considerations established the structure of **2** as indicated in Fig. 1, and the compound was named ypsilanogenin 3-O-β-D-glucopyranoside. Compound **3** was obtained as white amorphous powder and had the molecular formula C₄₁H₆₄O₁₄ on the basis of the negative ion

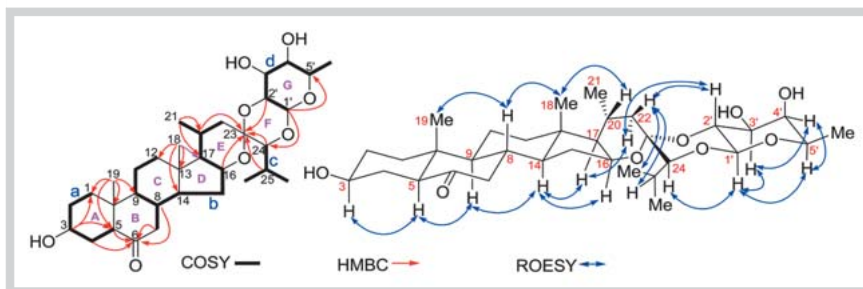


Fig. 2 Selected 2D NMR correlations of compound **1**. (Color figure available online only.)

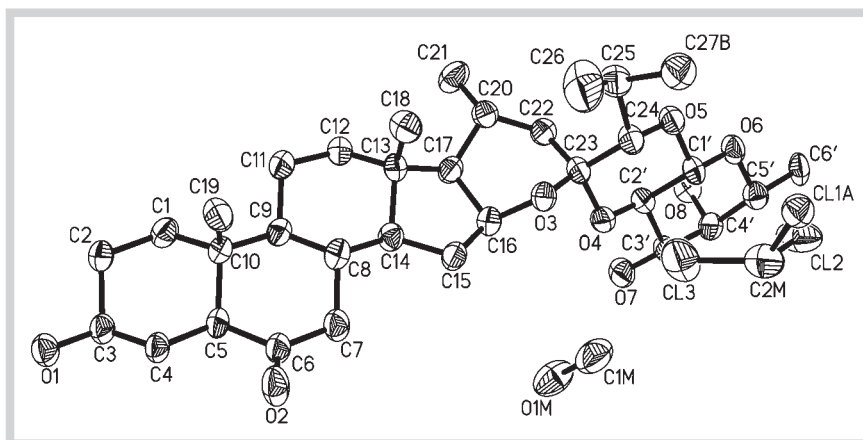


Fig. 3 Single-crystal X-ray structure of compound **1**.

HR-ESI-MS (m/z 779.4201 [$M - H$] $^-$; calcd. 779.4217). Comparison of the 1H - and ^{13}C NMR spectra of **3** with those of **2** showed their considerable structural similarity. However, **3** had an additional acetyl group, which was supported by the NMR signals at δ_H 2.19 (3H, s), δ_C 21.0 (q), and δ_C 171.0 (s), and by the mass difference of $m/z = 42$ between **3** and **2**. The above evidence suggested that compound **3** is a monoacetate of **2**. The acetoxy group was positioned at C-4' on the basis of HMBC correlations of H-4' (δ_H 5.60) with the acetyloxy group (δ_C 171.0), C-2' (δ_C 70.0), C-3' (δ_C 74.0), and C-5' (δ_C 71.8). Accordingly, the structure of **3** was assigned as depicted in **Fig. 1**, and the compound was named 4'-acetylpsilanogenin 3-O- β -D-glucopyranoside.

To the best of our knowledge, helojaposide [11] obtained from *Heloniopsis japonica* (Liliaceae) was the only example having the same skeleton as compounds **1–3**, but it possessed a hydroxyl group at C-22 and a β -orientation for the oxygen-bridge between C-23 and C-2'. Compounds **1–3** were tested for cytotoxicities against C8166 cells (EC_{50}), and anti-HIV-1 activities were evaluated by the inhibition assay for the cytopathic effects of HIV-1 (EC_{50}), using AZT as a positive control. Each experiment was repeated three times. The results (**Table 2**) indicated that only compound **1** showed weak anti-HIV-1 activity with an EC_{50} value of 19.34 μ g/mL and a therapy index (TI) of 6.57.

Materials and Methods

The whole plants of *Y. thibetica* were collected in Zhaotong, Yunnan Province, China, in May 2011, and were identified by one of the authors, Prof. Chang-Xiang Chen. A voucher specimen (No. 0303771) was deposited at the Herbarium of the Department of Taxonomy, Kunming Institute of Botany, Chinese Academy of Sciences.

The powdered air-dried whole plants of *Y. thibetica* (30 kg) were extracted with 70% EtOH (3 \times 180 L, total amount 540 L) under reflux for a total of 6 h. After removal of the solvent *in vacuo*, the residue was suspended in H₂O (20 L) and successively extracted with petroleum ether (3 \times 15 L), EtOAc (3 \times 15 L), and *n*-BuOH (3 \times 15 L). TLC of the EtOAc extract showed different spots from the reported steroidal saponins isolated from the species. The solvent was removed to give the EtOAc extract (820 g), of which 800 g was further defatted over a column (10 \times 140 cm) of MCI gel CHP20P (4 L) eluted with 90% methanol (25 L) and then applied to silica gel column chromatography (20 \times 120 cm, 200–300 mesh, 6.4 kg; gradient CHCl₃-MeOH, 20:1 \rightarrow 0:1, 300 L) to afford fractions 1–8. Fr. 4 (8.0 g) was further separated by RP-18 column chromatography (3 \times 48 cm, 150 g; 70–90% aqueous MeOH, 10 L) to afford **1** (30 mg). Fr. 5 (15 g) was repeatedly purified by silica gel (5 \times 60 cm, 300 g; CHCl₃-MeOH = 12:1, 15 L), Sephadex LH-20 (3 \times 180 cm, MeOH, 1.5 L), and then semiprep. HPLC (MeOH-H₂O = 75:25, flow rate 3 mL/min) to yield **3** (10 mg). Fr. 6 (3.3 g) was subjected to silica gel CC (2.5 \times 60 cm, 100 g), eluted with CHCl₃-MeOH (10:1, 5.5 L) and then Sephadex LH-20 (1.5 \times 180 cm, MeOH, 0.5 L) to give **2** (100 mg).

Isolates

Ypsilanogenin (1): colorless prisms (CHCl₃-MeOH 4:1); mp 208–209 °C; $[\alpha]_D^{25} + 5.3$ (c 0.76, pyridine); IR (KBr) ν_{max} 3446, 2957, 2870, 1709, 1454, 1383, 1061 cm^{-1} ; 1H NMR (pyridine-*d*₅, 400 MHz) and ^{13}C NMR (pyridine-*d*₅, 100 MHz), see **Table 1**; FAB-MS (negative): m/z 575 [$M - H$] $^-$; HR-ESI-MS m/z 575.3580 [$M - H$] $^-$ (calcd. for C₃₃H₅₁O₈, 575.3583).

Ypsilanogenin 3- β -D-glucopyranoside (2): colorless prisms (MeOH); mp 228–229 °C; $[\alpha]_D^{25} - 25.7$ (c 0.70, pyridine); IR (KBr) ν_{max} 3456, 2951, 2872, 1703, 1456, 1389, 1370, 1062, 892 cm^{-1} ; 1H NMR (pyridine-*d*₅, 400 MHz) and ^{13}C NMR (pyridine-*d*₅,

Compound	EC ₅₀ ^a (μg/mL)	CC ₅₀ ^b (μg/mL)	TI ^c
1	19.34 ± 2.16	127.05 ± 12.11	6.57
2	96.33 ± 7.83	> 200	> 2.07
3	69.24 ± 4.46	> 200	> 2.89
AZT ^d	0.00351 ± 0.00034	1210.00 ± 74.68	344 729.34

^a EC₅₀: effective concentration required to protect C8166 cells against the cytopathogenicity of HIV-1 by 50%. ^b CC₅₀: cytotoxic concentration required to reduce C8166 cell proliferation by 50% tested by the MTT method. ^c TI: therapeutic index, ratio of the CC₅₀ value/EC₅₀ value. ^d AZT was used as a positive control

Table 2 Anti-HIV-1 activities of compounds **1–3**.

100 MHz), see **Table 1**; FAB-MS (negative): *m/z* 737 [M – H][–]; HR-ESI-MS *m/z* 737.4109 [M – H][–] (calcd. for C₃₉H₆₁O₁₃, 737.4112).

4'-Acetylpsilangenin 3-β-D-glucopyranoside (3): colorless amorphous powder; [α]_D²⁵ – 13.3 (c 0.95, pyridine); IR (KBr) ν_{max} 3443, 2957, 2872, 1743, 1711, 1454, 1382, 1371, 1061, 892 cm^{–1}; ¹H NMR (pyridine-d₅, 400 MHz) and ¹³C NMR (pyridine-d₅, 100 MHz), see **Table 1**; FAB-MS (negative): *m/z* 779 [M – H][–], 737 [M – H – 42][–], 617 [M – H – 162][–], 575 [M – H – 42–162][–]; HR-ESI-MS *m/z* 779.4201 [M – H][–] (calcd. for C₄₁H₆₃O₁₄, 779.4217).

X-ray crystal structure analysis

Colorless crystals of **1** were obtained from the mixture of chloroform and methanol. Diffraction intensity data were collected with a MAC DIP-2030K diffractometer employing graphite monochromated Mo Kα radiation and operating in the ω scan mode. The crystal structure was solved by the direct method SHELXS-97 [12], expanded by using difference Fourier techniques and refined by the program and method NOMCSDP and full-matrix least-squares calculations. The hydrogen atoms were fixed at their calculated positions.

Crystal data: C₃₃H₅₂O₈·CH₃OH·CHCl₃, MW = 576.77 (no solvent of crystallization); monoclinic system, space group P2₁; crystal cell parameters *a* = 15.161 (2) Å, *b* = 8.649 (1) Å, *c* = 15.652 (2) Å, β = 108.44 (2)°; *V* = 1947.0 (3) Å³, *Z* = 2, *D*_{calc} = 1.122 g/cm³. A crystal of dimensions 0.20 × 0.50 × 1.50 mm was used for measurements (2θ_{max} = 50.0°). The total number of independent reflections measured was 3319, of which 3306 were observed (*I*[F]² ≥ 3σ [*I*]²). The final indices were *R*₁ = 0.0684, *wR*₂ = 0.1904, and *S* = 1.001. Crystallographic data for **1** has been deposited in the Cambridge Crystallographic Data Centre with the deposition number CCDC 885109. These data can be obtained free of charge from the Cambridge Crystallographic Data Centre via http://www.ccdc.cam.ac.uk/data_request/cif.

Acid hydrolysis

Compounds **2** and **3** (3 mg) were refluxed with 4 M TFA-dioxane (1 : 1 v/v, 2 mL) in a water bath for 2 h. After cooling, the reaction mixture was extracted with EtOAc (3 × 5 mL). The aqueous layer was evaporated to dryness with MeOH until neutral. The dried residue was dissolved in 0.5 mL anhydrous pyridine and treated with L-cysteine methyl ester hydrochloride (1.0 mg) stirred at 60 °C for 1 h. Trimethylsilylimidazole (0.5 mL) was added to the reaction mixture which was then kept at 60 °C for 30 min. The supernatants (2 μL) were analyzed by GC, respectively, under the following conditions: H₂ flame ionization detector; column: 30QC2/AC-5 quartz capillary column (30 m × 0.32 mm); column temperature: 180–280 °C with the rate of 3 °C/min, and carrier gas N₂ (1 mL/min); injector temperature: 250 °C; split ratio: 1/50. The configuration of D-glucose for compounds **2** and **3** was

determined by comparison of the retentions times of the corresponding derivatives with those of standard D-glucose giving a single peak at 19.01 min.

Anti-HIV-1 assay

The cytotoxicity assay against C8166 cells (CC₅₀) was performed using the MTT method, and anti-HIV-1 activity was evaluated by the inhibition assay for cytopathic effects of HIV-1 (EC₅₀) [13]. Three tested compounds gave a single peak upon HPLC analysis, and their purity was therefore at least 98%. AZT (Sigma, 98%) was used as the positive control.

Supporting information

1D and 2D NMR spectra of compounds **1–3** and crystal data of **1** are available as Supporting Information.

Acknowledgements

This work was financially supported by the National Natural Science Funding of China (No. 31170333, 81102483), the Natural Science Foundation of Yunnan Province (No. 2009CC019), the West Light Foundation of the Chinese Academy of Sciences (No. 2908025712W1), and the 973 Program (2009CB522300).

Conflict of Interest

The authors declare no conflict of interest in this work.

References

- Hou KZ. Dictionary of the families and genera of Chinese seed plants, 2nd edition. Beijing: Science Press; 1982: 521–522
- Jiangsu New Medicinal College. Dictionary of traditional Chinese materia medica. Shanghai: Shanghai Scientific and Technological Press; 1977: 1841–1841
- Yunnan Food and Drug Administration. The Yunnan Chinese materia medica standards, Volume 6 (Yi Nationality Medicine, III). Kunming: Yunnan Scientific and Technological Press; 2010: 5–6
- Xie BB, Liu HY, Ni W, Chen CX, Lü Y, Wu L, Zheng QT. Five new steroidal compounds from *Ypsilandra thibetica*. Chem Biodivers 2006; 3: 1211–1218
- Xie BB, Liu HY, Ni W, Chen CX. Ypsilandrosides C–G, five new spirostanol saponins from *Ypsilandra thibetica*. Steroids 2009; 74: 950–955
- Lu Y, Chen CX, Ni W, Hua Y, Liu HY. Spirostanol tetraglycosides from *Ypsilandra thibetica*. Steroids 2010; 75: 982–987
- Lu Y, Xie BB, Chen CX, Ni W, Hua Y, Liu HY. Ypsilactosides A and B, two new C₂₂-steroidal lactone glycosides from *Ypsilandra thibetica*. Helv Chim Acta 2011; 94: 92–97
- Liu HY, Chen CX, Lu Y, Yang JY, Ni W. Steroidal and pregnane glycosides from *Ypsilandra thibetica*. Nat Prod Bioprospect 2012; 2: 11–15
- Zhang XD, Chen CX, Yang JY, Ni W, Liu HY. New minor spirostane glycosides from *Ypsilandra thibetica*. Helv Chim Acta 2012; 95: 1087–1093
- Hara S, Okabe H, Mihashi K. Gas-liquid chromatographic separation of aldose enantiomers as trimethylsilyl ethers of methyl 2-(polyhydroxyalkyl)-thiazolidine-4(R)-carboxylates. Chem Pharm Bull 1987; 35: 501–506

- 11 Shingu K, Mito K, Yahara S, Nohara T, Ono M, Kawasaki T, Nakano K, Tomimatsu T, Haratake M, Marubayashi N, Ueda I. A novel cholestane derivative as root growth inhibitor from *Heloniopsis japonica*. *Tetrahedron Lett* 1992; 33: 2529–2530
- 12 Sheldrick GM. SHELXL97, Program for crystal structure solution. Göttingen: University of Göttingen; 1997
- 13 Wang RR, Yang LM, Wang YH, Pang W, Tam SC, Tien P, Zheng YT. Sifuvirtide, a potent HIV fusion inhibitor peptide. *Biochem Biophys Res Commun* 2009; 382: 540–544

received January 23, 2013

revised May 10, 2013

accepted May 20, 2013

Bibliography

DOI <http://dx.doi.org/10.1055/s-0032-1328719>

Published online July 1, 2013

Planta Med 2013; 79: 1063–1067

© Georg Thieme Verlag KG Stuttgart · New York ·

ISSN 0032-0943

Correspondence

Dr. Hai-Yang Liu

State Key Laboratory of Phytochemistry and Plant Resources in West China

Kunming Institute of Botany, Chinese Academy of Sciences

132# Lanhei Road

Kunming 650201

P.R. China

Phone: + 86 8 71 65 22 32 46

Fax: + 86 8 71 65 22 32 45

haiyangliu@mail.kib.ac.cn

Copyright of Planta Medica is the property of Georg Thieme Verlag Stuttgart and its content may not be copied or emailed to multiple sites or posted to a listserv without the copyright holder's express written permission. However, users may print, download, or email articles for individual use.