Triterpene Glycosides and Glucosyl Esters, and a Triterpene from the Leaves of *Schefflera actinophylla*

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From the EtOAc and 1-BuOH fractions, three new ursane-type and four new lupane-type triterpenes, along with nine known glycosides and glycosyl esters of lupane-type were isolated from the leaves of *Schefflera actinophylla*. All the isolated compounds were obtained for the first time from this plant. The structures of the new triterpenes were determined through a combination of spectroscopic and chemical analyses.

Key words *Schefflera actinophylla*; Araliaceae; triterpene glycoside; ursane; lupane

The Araliaceae family is one of the most medicinally important plant families, which include about 55 genera and 700 species of trees, shrubs, lianas and perennial herbaceous plants. Chemical and pharmacological investigations have indicated that triterpenoid saponins are important bioactive components existing in the plants of Araliaceae family.[1)]

Schefflera actinophylla (ENDLICHER) HARMS, (synonym: *Brassaia actinophylla* ENDLICHER) is an evergreen tree in the Araliaceae family and native to tropical rainforests and gallery forests in Australia, New Guinea and Java. This distinctive ornamental plant is easily recognized by the several trunks mostly unbranched, a few very large palmately compound leaves with 7—12 leaflets as in an umbrella, and the large showy clusters of many dark red or crimson flowers on 10—20 widely spreading dark purple axes, suggesting arms of an octopus. Hence, common names include umbrella tree and octopus tree. Up till now, there have been no phytochemical and bioactivities reports on this species.

In this manuscript, we described the isolation and structure elucidation of three new ursane-type triterpene glycosides (**1**—**3**), two new lupane-type triterpene glucosides (**4**, **6**), one new lupane-type triterpene (**5**) and one new lupane-type triterpene glucosyl ester (**7**), along with nine known lupane-type triterpene glycosides (**8**—**16**) that were identified by comparing their spectroscopic data with the previously reported ones.

Results and Discussion

The air-dried and powdered leaves of *Schefflera actinophylla* were extracted with 70% MeOH till exhaustion and then concentrated under reduced pressure to yield a viscous gummy material. The concentrated methanol extract was washed with *n*-hexane. The methanolic layer was evaporated, suspended in water and then extracted with EtOAc and 1-BuOH, successively. The 1-BuOH-soluble fraction as well as the EtOAc-soluble fraction was subjected to Diaion HP-20, silica gel, octadecylsilanized (ODS) silica gel column chromatographies (CC), droplet counter-current chromatography (DCCC), and high-performance liquid column chromatography (HPLC) to afford seven new compounds (**1**—**7**), along with nine known triterpene compounds, 3α-hydroxylup-20(29)-ene-23,28-dioic acid (**8**),[2)] 3α-hydroxylup-20(29)-ene-23,28-dioic acid 28-*O*-[4″-*O*-α-L-rhamnopyranosyl-6′-*O*-β-D-glucopyranosyl]-β-D-glucopyranosyl ester (**9**),[3)] 3α,23-dihydroxylup-20(29)-en-28-oic acid 28-*O*-[4″-*O*-α-L-rhamnopyranosyl-6′-*O*-β-D-glucopyranosyl]-β-D-glucopyranosyl ester (**10**),[4)] 3-*epi*-betulinic acid 3-*O*-sulfate (**11**),[5)] 3-*epi*-betulinic acid 3-*O*-β-D-glucopyranoside (**12**),[6)] 3-*epi*-betulinic acid 3-*O*-sulphate, 28-*O*-[4″-*O*-α-L-rhamnopyranosyl-6′-*O*-β-D-glucopyranosyl]-β-D-glucopyranosyl ester (**13**),[7)] 3-*epi*-betulinic acid 28-*O*-[4″-*O*-α-L-rhamnopyranosyl-6′-*O*-β-D-glucopyranosyl]-β-D-glucopyranosyl ester (**14**),[8)] 3-*epi*-betulinic acid 3-*O*-β-D-glucopyranoside, 28-*O*-[4″-*O*-α-L-rhamnopyranosyl-6″-*O*-β-D-glucopyranosyl]-β-D-glucopyranosyl ester (**15**),[9)] 3-*epi*-betulinic acid 3-*O*-β-D-6′-acetylglucopyranoside, 28-*O*-[4″-*O*-α-L-rhamnopyranosyl-6″-*O*-β-D-glucopyranosyl]-β-D-glucopyranosyl ester (**16**)[10)] (Fig. 1).

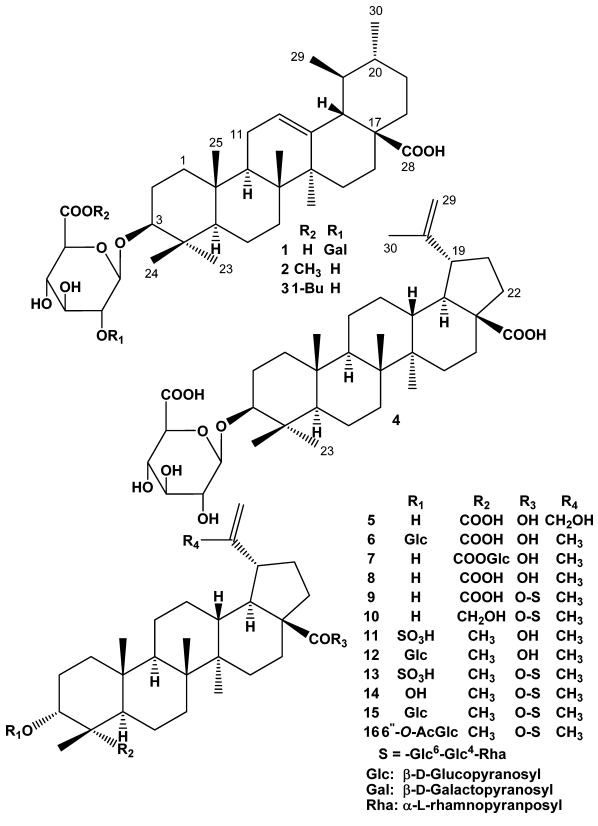

Fig. 1. Structures of Isolated Compounds

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Compound **1**, $[\alpha]_D^{25}$ +2.5°, was obtained as a white amorphous powder. The positive-ion high-resolution (HR)-electrospray ionization (ESI)-time of flight (TOF)-MS spectrum exhibited a $[M+Na]^+$ at *m/z* 817.4334, corresponding to a molecular formula of $C_{42}H_{66}O_{14}$. It showed IR absorptions at 3381 cm^{-1} for hydroxy, 1719 and 1692 cm^{-1} for carbonyl groups and 1048 cm^{-1} for ether linkages. The ^{1}H-NMR spectrum revealed signals for five singlet methyl groups at δ_H 0.82, 1.01, 1.08, 1.25 and 1.30, two secondary methyl groups at δ_H 0.97 (d, *J*=6 Hz) and 1.01 (d, *J*=6 Hz), an oxygenated methine proton at δ_H 3.32 and an olefinic proton at δ_H 5.44 (br s)[11] (Table 1). The ^{13}C-NMR and distortionless enhancement by polarization transfer (DEPT) spectral data revealed the presence of 42 carbon signals, 30 for a triterpenoid aglycone and the remaining signals were for the sugar moiety (Table 2). It showed two downfield signals at δ_C 125.6 and 139.2, corresponding to C-12 and C-13, respectively, two signals at (δ_C 39.4, 39.5) for C-19 and C-20, respectively, and a characteristic signal [δ_C 53.6 with δ_H 2.60 (1H, d, *J*=11 Hz)] belonging to C-18. All these above mentioned

Table 1. ^{1}H-NMR Spectral Data for Compounds **1**—**7** (600 MHz, Pyridine-d_5)

Compd.	**1**	**2**	**3**	**4**	**5**	**6**[a]	**7**
1	0.77 m	0.82 m	0.88 m	0.84 m	1.44 m	1.42 m	1.41 m
	1.38 m	1.42 ddd 13, 4, 4	1.49 m	1.53 m	1.65 m	1.86 m	1.73 m
2	1.87 m	1.84 m	1.85 m	1.88 m	1.85 m	1.85 m	1.14 m
	2.24 dd 13, 4	2.15 ddd 13, 13, 4	2.16 m	2.31 m	2.03 dd 13, 13	2.12 m	1.95 m
3	3.32 dd 12, 4	3.39 dd 12, 4	3.39 dd 12, 4	3.42 dd 12, 4	4.23 br s	4.31 br s	4.13 br s
5	0.74 d 11	0.80 m	0.82 m	0.78 m	2.49 br d 12	2.52 d 12	2.47 d 12
6	1.23 m	1.27 m	1.28 m	1.30 m	1.55 m	1.54 m	1.43 m
	1.47 m	1.50 m	1.50 m	1.49 m	1.81 m	1.88 m	1.66 m
7	1.32 m	1.33 m	1.34 m	1.35 m	1.39 m	1.38 ddd 12, 3, 3	1.25 m
	1.51 m	1.53 m	1.49 m	1.44 m	1.80 m	1.77 m	1.69 m
9	1.54 dd 9, 9	1.55 dd 9, 9	1.59 m	1.37 m	1.63 m	1.56 dd 12, 3	1.60 br d 12
11	1.86 m	1.89 m	1.91 m	1.17 m	1.19 m	1.22 m	1.20 m
				1.39 m	1.43 m	1.45 m	1.47 m
12	5.44 br s	5.47 br s	5.47 br s	1.24 m	1.20 m	1.02 m	1.20 m
				1.96 m	1.74 m	1.86 m	1.87 d 12
13				2.73 ddd 11, 11, 4	2.69 ddd 12, 12, 3	2.69 ddd 12, 12, 4	2.66 ddd 12, 12, 4
15	1.19 d 14	1.20 d 14	1.21 d 14	1.25 m	1.20 br d 10	1.20 m	1.08 m
	2.29 ddd 13, 13, 4	2.30 ddd 13, 13, 4	2.31 ddd 13, 13, 4	1.80 m	1.83 m	1.85 m	1.74 m
16	1.96 m	1.96 m	1.96 m	1.54 m	1.50 ddd 13, 13, 3	1.48 dd 13, 3	1.45 m
	2.11 ddd 13, 13, 4	2.13 ddd 13, 13, 4	2.12 m	2.61 m	2.56 ddd 13, 3, 3	2.58 dd 13, 3	2.54 d 13
18	2.60 d 11	2.64 d 11	2.64 d 11	1.77 m	1.93 dd 11, 11	1.68 dd 11, 11	1.68 dd 11, 11
19	1.49 m	1.51 m	1.48 m	3.51 ddd 12, 12, 4	3.46 ddd 11, 11, 4	3.50 ddd 11, 11, 4	3.47 ddd 11, 11, 4
20	0.96 m	0.96 m	0.95 m				
21	1.40 m	1.46 m	1.47 m	1.53 m	1.77 m	1.55 m	1.50 m
	1.47 m	1.50 m	1.59 m	2.28 m	2.36 m	2.20 m	2.19 m
22	1.41—1.51 m	1.49 m	1.50 m	1.57 m	1.63 m	1.53 m	1.51 m
	1.95 m	1.97 m	1.97 m	2.27 m	2.19 dd 12, 12	2.23 m	2.18 m
23	1.30 s	1.29 s	1.30 s	1.29 s			
24	1.08 s	0.97 s	0.97 s	0.97 s	1.42 s	1.44 s	1.38 s
25	0.82 s	0.82 s	0.83 s	0.77 s	0.91 s	0.90 s	0.85 s
26	1.01 s	1.02 s	1.02 s	1.04 s	1.08 s	1.07 s	1.03 s
27	1.25 s	1.26 s	1.26 s	1.13 s	0.93 s	0.78 s	0.81 s
29	1.01 d 6	1.03 d 6	1.00 d 6	4.76 br s	5.13 br s	4.93 d 2	4.72 br s
				4.94 br s	5.48 br s	4.78 br s	4.90 br s
30	0.97 d 6	0.98 d 6	0.96 d 6	1.79 s	4.46 br s	1.79 s	1.75 s
1′	4.99 d 7	4.98 d 8	4.98 d 8	5.00 d 7		4.87 d 8	6.34 d 8
2′	4.25 dd 8, 7	4.08 dd 8, 8	4.07 dd 8, 8	4.12 dd 9, 7		3.94 m	4.16 m
3′	4.33 m	4.24 dd 9, 8	4.25 m	4.28 dd 9, 9		4.15 dd 9, 9	3.97 dd 9, 9
4′	4.58 m	4.46 dd 9, 9	4.49 dd 9, 9	4.54 m		3.90 m	4.24 m
5′	4.52 m	4.59 d 9	4.56 d 9	4.61 m		3.92 m	4.26 m
6′						4.01 dd 11, 5	4.23 m
						4.38 dd 11, 3	4.38 dd 12, 3
1″	5.19 d 7						
2″	4.53 m						
3″	4.14 dd 10, 3						
4″	4.66 dd 3, 3						
5″	4.02 m						
6″	4.36 dd 10, 5						
	4.55 dd 10, 3						
OMe		3.75 s					
1‴			4.29 m				
2‴			1.59 m				
3‴			1.35 m				
4‴			0.78 t 7				

a) Measured at 400 MHz. s: singlet, d: doublet, br: broad, m: multiplet or overlapped with other signals and its multiplicity and *J* values were both obscure.

Table 2. ^{13}C-NMR Spectral Data for Compounds **1**—**7** (100 MHz, Pyridine-d_5)

Compd.	1	2	3	4	5	6	7
1	38.9	38.8	38.9	39.0	33.0	32.9	32.9
2	26.6	26.6	26.6	26.7	26.1	21.6	26.1[a]
3	89.2	89.2	89.2	89.1	72.9	79.9	73.1
4	39.9	39.9	40.0	39.6	51.9	51.6	52.8
5	55.8	55.8	55.8	55.9	44.9	45.2	44.5
6	18.5	18.5	18.5	18.4	21.7	21.8	21.7
7	33.5	33.5	33.5	34.8	34.7	34.5	34.5
8	39.9	39.9	40.0	41.1	42.8	41.7	41.7
9	47.9	48.1	48.0	50.8	50.9	50.7	51.0
10	36.8	36.8	36.9	37.1	37.4	37.3	37.3
11	23.6	23.6	23.6	21.2	21.0	21.0	21.1
12	125.6	125.6	125.6	26.1	27.1	25.9	26.0[a]
13	139.2	139.2	139.2	38.6	38.6	38.5	38.6
14	42.5	42.5	42.5	42.8	41.7	42.8	42.8
15	28.7	28.7	28.7	30.2	30.2	30.2	30.0
16	24.9	24.9	24.9	32.9	32.7	32.8	32.8
17	48.0	47.9	48.1	56.6	56.6	56.6	56.5
18	53.6	53.6	53.6	49.8	50.1	49.6	49.7
19	39.4	39.5	39.5	47.7	43.5	47.7	47.7
20	39.5	39.4	39.4	151.3	156.9	151.3	151.3
21	31.1	31.1	31.1	31.2	32.9	31.1	31.2
22	37.4	37.5	37.5	37.6	37.4	37.5	37.5
23	28.2	28.2	28.2	28.3	179.6	178.8	175.9
24	16.7	16.9	16.9	16.7	17.9	18.2	17.4
25	15.6	15.5	15.5	16.4	16.7	16.7	16.7[b]
26	17.4[a]	17.4[a]	17.4[a]	16.3	16.7	16.7	16.6[b]
27	23.9	23.9	23.9	14.9	14.8	14.7	14.6
28	179.8	179.9	179.8	178.8	178.8	178.9	178.7
29	17.3[a]	17.5[a]	17.5[a]	109.9	106.0	109.9	109.8
30	21.4	21.4	21.4	19.5	64.4	19.4	19.4
1′	105.5	107.3	107.3	107.1			
2′	83.9	75.4	75.4	75.5			
3′	77.7	77.9	78.0	78.1			
4′	74.7	73.1	73.0	73.5			
5′	77.1	77.1	77.3	77.9			
6′	172.2	170.8	170.3	nd			
1″	107.4					102.0	96.4
2″	73.1					74.7	74.5
3″	74.9					78.6	79.5
4″	69.8					72.3	71.3
5″	76.9					77.7	78.3
6″	61.3					63.3	62.3
OMe		52.0					
1‴			64.9				
2‴			30.9				
3‴			19.2				
4‴			13.7				

a) Interchangeable in each column. *b*) Interchangeable in each column. nd: not detected, probably due to salt formation.

data indicated that the aglycone belonged to the urs-12-ene group of triterpenoids.[12] These observations were further confirmed by the correlations detected in the heteronuclear multiple bond connectivity (HMBC) spectrum between H-30 (δ_H 0.97) and C-19, H-29 (δ_H 1.01) and both C-20 and C-18, and H-12 (δ_H 5.44) and C-18. Detailed analysis of the heteronuclear single quantum coherence (HSQC), ^{1}H–^{1}H correlation spectroscopy (COSY) and HMBC spectra allowed the assignment of all the ^{1}H- and ^{13}C-NMR signals, confirming the structure of aglycone as 3-hydroxyurs-12-en-28-oic acid (Fig. 2). The presence of two anomeric proton signals at δ_H 4.99 (d, J=7 Hz) and 5.19 (d, J=7 Hz), together with two corresponding anomeric carbon signals at δ_C 105.5 and 107.4, indicated that **1** is an ursane-type triterpene glycoside

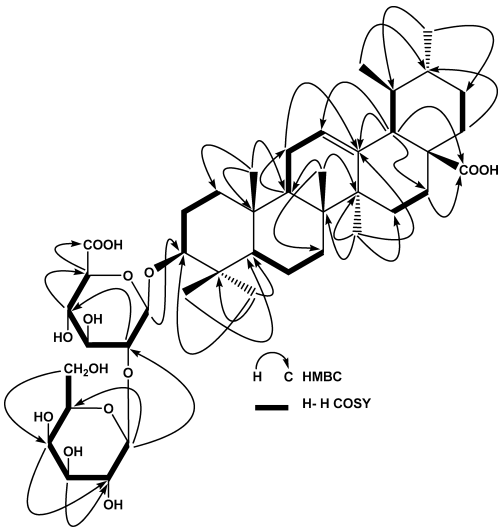

Fig. 2. Selected COSY and HMBC Correlations of **1**

with a disaccharide unit. The oxygenated methine signal at δ_H 3.32 was a typical H-3ax proton (dd, J=12, 4 Hz), namely 3β-hydroxy, due to axial–axial (J=12 Hz) and axial–equatorial coupling (J=4 Hz) with H-2ax and H-2eq, respectively. Acid hydrolysis of **1** yielded D-glucuronolactone, together with D-galactose as sugar components. Comparison of the NMR signals of the terminal sugar was coincided with β-D-galactopyranoside.[14] On the other hand, the C-2′ signal of the glucuronyl unit of **1** was downfield shifted by 8.5 ppm compared with the related compounds (**2**, **3**). Thus, it was apparent that the terminal sugar was linked to the 2-hydroxy group of the glucuronyl unit. This was confirmed in the HMBC spectrum, showing the long-range correlation between the anomeric proton of galactose H-1″ (δ_H 5.19) and C-2′ (δ_C 83.9) of glucuronyl moiety. Moreover, HMBC data displayed the correlation between the anomeric proton of the glucuronyl moiety (δ_H 4.99, d, J=7, indicating its β configuration) and C-3 (δ_C 89.2) of the aglycone, giving an evidence that the glycosylation of this aglycone was on the hydroxy group at C-3. These results and detailed analysis of ^{1}H- and ^{13}C-NMR, and 2-dimensional NMR spectral data indicated compound **1** to be 3β-hydroxyurs-12-en-28-oic acid 3-*O*-[β-D-galactopyranosyl-(1→2′)]-β-D-glucuronopyranoside.

Compound **2**, $[\alpha]_D^{25}$ +11.5°, was obtained as a white amorphous powder and its molecular formula was determined as $C_{37}H_{58}O_9$ on positive-ion HR-ESI-TOF-MS. ^{1}H- and ^{13}C-NMR spectral data indicated that compound **2** possessed the same aglycone as that of **1**, but differed in a sugar moiety (Tables 1, 2). ^{1}H- and ^{13}C-NMR data of the sugar moiety were in good accordance with a glucuronic acid methyl ester displaying anomeric carbon signal at δ_C 107.3 [with δ_H 4.98 (1H, d, J=8 Hz, indicating its β configuration)], C-6′ signal at δ_C 170.8 and a methyl signal at δ_C 52.0 [with δ_H 3.75 (3H, s)]. The HMBC correlation peak between the singlet methyl (δ_H 3.75) and C-6′ (δ_C 170.8) confirmed the site of esterification. Therefore, the structure of compound **2** was elucidated to be 3β-hydroxyurs-12-en-28-oic acid 3-*O*-β-D-glucuronopyranoside 6′-*O*-methyl ester. Methyl ester was probably formed during extraction.

Compound **3**, $[\alpha]_D^{25}$ +9.0°, was obtained as a white amorphous powder, its molecular formula was determined as

$C_{40}H_{64}O_9$ on positive-ion HR-ESI-TOF-MS showing pseudo-molecular ion peak at *m/z* 711.4449 $[M+Na]^+$. The ^{1}H- and ^{13}C-NMR spectra of compound **3** were almost superimposable with those of the aforementioned compound **2**, except for the ester alcohol moiety (Tables 1, 2). The ^{13}C-NMR spectrum showed extra signals (δ_C 64.9, 30.9, 19.2, 13.7), instead of the disappearance of signal at δ_C 52.0 of **2**, suggesting the presence of an ester-linked butyl group. Thus, the structure of compound **3** was assigned as 3β-hydroxyurs-12-en-28-oic acid 3-*O*-β-D-glucuronopyranoside 6′-*O*-butyl ester.[13] Butyl ester was probably formed during partition procedure.

Compound **4**, $[\alpha]_D^{25}$ −11.9°, was isolated as an amorphous powder. Its molecular formula was determined to be $C_{36}H_{56}O_9$ on negative-ion HR-ESI-TOF-MS showing pseudo-molecular ion peak at 631.3863 $[M-H]^-$. The ^{1}H-NMR spectrum displayed five tertiary methyl signals (δ_H 0.77, 0.97, 1.04, 1.13, 1.29), in addition to the characteristic signals of lup-20(29)-ene derivatives having a free carboxylic group at C-17, *e.g.* δ_H 1.79 (3H, s, H-30), 3.51 (1H, td, H-19), 4.76 and 4.94 (olefinic protons at C-29) (Table 1).[6] Moreover, it gave a deshielded signal corresponding to an anomeric proton at δ_H 5.00 (d, J=7 Hz) confirmed by the presence of an anomeric carbon signal at δ_C 107.1 (Table 2). Analysis of ^{1}H-, ^{13}C-NMR data and DEPT assignments in comparison with those of literature, confirmed that this compound had typical lupane-type aglycone with one sugar residue at C-3. The orientation of the hydroxy group at C-3 was concluded to be β depending on the basis of coupling constants of H-3 [(δ_H 3.42 (dd, J=12, 4 Hz)] that was observed as doublet of doublets due to axial–axial (J=12 Hz) and axial–equatorial coupling (J=4 Hz) with H-2ax and H-2eq, respectively. Acid hydrolysis of **4** afforded one sugar moiety that was determined to be D-glucuronolactone. Furthermore, HMBC experiment showed the correlation of the anomeric proton H-1′ at δ_H 5.00 (d, J=7 Hz) to C-3 (δ_C 89.1) of the aglycone confirming the 3-*O*-glycosylation. Measurements of ^{1}H–^{1}H COSY and HMBC spectra enabled the respective signals to be assigned for both the aglycone and the sugar unit (Fig. 3). Depending on all mentioned data and evidence, compound **4** was assigned as 3β-hydroxylup-20(29)-en-28-oic acid 3-*O*-β-D-glucuronopyranoside.

Compound **5**, $[\alpha]_D^{25}$ −19.8°, was isolated as an amorphous powder. Its molecular formula was determined to be $C_{30}H_{46}O_6$ on negative-ion HR-ESI-TOF-MS showing pseudo-molecular ion peak at 501.3221 $[M-H]^-$. The ^{13}C-NMR and DEPT spectrum showed the presence of two carboxyl groups at δ_C 179.6 and 178.8, one 1,1-disubstituted double bond at δ_C 156.9 (s) and 106.0 (t), one oxygen-bearing methine carbon at δ_C 72.9, an additional primary alcohol signal at δ_C 64.4 (t), along with five methines, ten methylenes and four tertiary methyl carbons (Table 2). The ^{1}H-NMR spectrum confirmed these data by showing four tertiary methyl groups (δ_H 0.91, 0.93, 1.08, 1.42), two olefinic protons (δ_H 5.48, 5.13), and one proton signal corresponding to H-3 (δ_H 4.23) appearing as broad singlet indicating its β orientation (Table 1). Moreover, it displayed an additional broad singlet peak (δ_H 4.46, 2H), corresponding to the primary alcohol. These data were in good accordance with triterpene aglycone of lup-20(29)-ene-23,28-dioic acid structure with an additional primary alcohol group.[15] The location of this primary alcohol was determined to be at C-30 depending on the analysis of the HMBC spectrum that showed cross peaks between H_2-30 (δ_H 4.46) and both of C-20 (δ_C 156.9), and C-29 (δ_C 106.0). All the other two-dimensional NMR data (^{1}H–^{1}H COSY and HMQC) and the remaining correlations of HMBC spectrum confirmed the structure of compound **5** to be 3α-hydroxylup-20(29)-en-30-ol-23,28-dioic acid.

Compound **6**, $[\alpha]_D^{25}$ −21.3°, was isolated as an amorphous powder. Its molecular formula was determined to be $C_{36}H_{56}O_{10}$ on positive-ion HR-ESI-TOF-MS showing pseudo-molecular ion peak at 671.3763 $[M+Na]^+$. The ^{13}C-NMR and DEPT spectra showed the presence of 36 carbon signals corresponding to a lupane-type triterpene monoglucoside analogous to 3α-hydroxylup-20(29)-ene-23,28-dioic acid (compound **8**) (Table 2). The ^{1}H-NMR spectral data indicated the proton peak at δ_H 4.87 (d, J=8 Hz) as an anomeric proton of β-D-glucoside (Table 1). The carbon signal at C-3 was shifted downfield than that of the free aglycone in literature,[2] indicating its glucosylation at this position. This was confirmed from the analysis of HMBC spectrum that showed correlation cross peak between H-1′ of the glucose moiety with C-3 of the aglycone at (δ_C 79.9). Analysis of the HMBC and ^{1}H–^{1}H COSY spectra proved the structure of compound **6** to be 3α-hydroxylup-20(29)-en-23,28-dioic acid 3-*O*-β-D-glucopyranoside.

Compound **7**, $[\alpha]_D^{25}$ −11.2°, was isolated as an amorphous powder. The molecular formula was determined to be

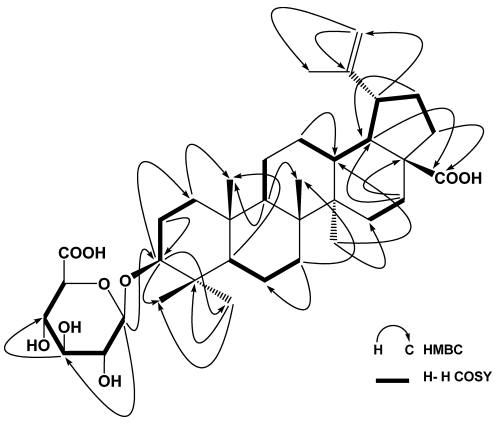

Fig. 3. Selected COSY and HMBC Correlations of **4**

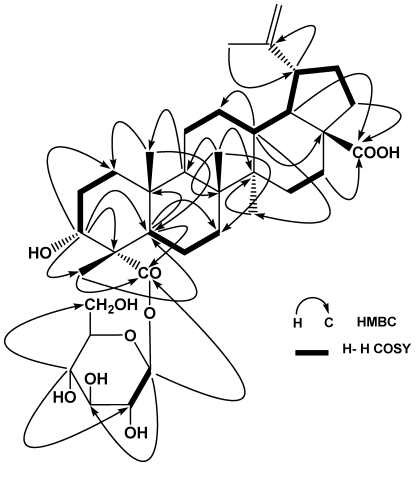

Fig. 4. Selected COSY and HMBC Correlations of **7**

$C_{36}H_{56}O_{10}$ on positive-ion HR-ESI-TOF-MS showing pseudo-molecular ion peak at 671.3765 $[M+Na]^+$. The analysis of the HMBC and ^1H–^1H COSY spectra, **7** was also a lupane-type triterpene monoglucoside as **6**, except for the attached position of the sugar moiety (Fig. 4). The ^{13}C-NMR data showed C-3 signal appeared upfield (6.8 ppm) than that of **6**, giving evidence that it had free hydroxy group at this position (Table 2). On the other hand, the C-23 signal appeared upfield (2.9 ppm), providing the glucosylation of this carboxylic group. On the other hand, the chemical shift of the anomeric carbon signal at 96.4 ppm was more indicative. Moreover, the HMBC spectrum showed the cross peak correlation between the anomeric proton H-1′ at δ_H 6.34 (d, J=8 Hz) and the C-23 (δ_C 175.7). Therefore, the structure of compound **7** was elucidated to be 3α-hydroxylup-20(29)-ene-23,28-dioic acid 23-*O*-β-D-glucopyranosyl ester.

Experimental

General Experimental Procedures Optical rotation data were measured on a JASCO P-1030 polarimeter. IR spectra were obtained on a Horiba (FT-710) Fourier transform infrared spectrophotometer. ^1H- and ^{13}C-NMR spectra were recorded on JEOL ECA-600 and JNM α-400 spectrometers, respectively, with tetramethylsilane (TMS) as an internal standard. HR-ESI mass spectra were taken on an Applied Biosystems QSTAR XL System. Highly porous synthetic resin Diaion HP-20 was purchased from Mitsubishi Chemical Co., Ltd. (Tokyo, Japan). Silica gel column chromatography (CC) was performed on silica gel 60 [(E. Merck, Darmstardt, Germany) 70—230 mesh]. Reversed-phase [octadecylsilanized silica gel (ODS)] open CC (RPCC) was performed on Cosmosil 75C_{18}-OPN (Nacalai Tesque, Kyoto, Japan) (Φ=2 cm, L=40 cm, 10 g fractions being collected). The droplet counter-current chromatography (DCCC) (Tokyo Rikakikai, Tokyo, Japan) was equipped with 500 glass columns (Φ=2 mm, L=40 cm), and the lower and upper layers of a solvent mixture of $CHCl_3$–MeOH–H_2O–1-PrOH (9 : 12 : 8 : 2) were used as the mobile and stationary phases, respectively. Five-gram fractions were collected and numbered according to their order of elution with the mobile phase. High-performance liquid chromatography (HPLC) was performed on an ODS column [Inertsil ODS-3; GL Science, Tokyo, Japan; (Φ=6 mm, L=25 cm, flow rate: 1.5 ml/min), and Cosmosil 5C_{18}-AR-II; Nacalai Tesque, Tokyo, Japan; (Φ=4.6 mm, L=25 cm, flow rate: 1.0 ml/min) using a refractive index refractometer and/or UV detector. Precoated silica gel 60 F_{254} plates (E. Merck; 0.25 mm in thickness) were used for TLC analyses, visualized by spraying with a 10% H_2SO_4 solution in ethanol and heating to around 150 °C on a hotplate.

Plant Material The leaves of *S. actinophylla* were collected in March 2008 from Al Zohreya Garden in Cairo, Egypt. A voucher specimen of the plant is deposited in our laboratory (Minia-08-Mar-SA-ZG).

Extraction and Isolation The air-dried powdered leaves (2.5 kg) of *Schefflera actinophylla* was extracted with 70% methanol (5 l×5) till exhaustion and then concentrated under reduced pressure to yield a viscous gummy material. This residue (250 g) was dissolved in 250 ml of water and defatted with *n*-hexane (1 l×5). The aqueous layer was evaporated to remove a race amount of organic solvent, and then extracted with EtOAc and 1-BuOH, successively (1 l×5 each). The EtOAc and 1-BuOH fractions were concentrated under reduced pressure to give 90 g and 36 g of residues, respectively. The remaining aqueous layer was concentrated to furnish a water-soluble fraction (50 g).

The EtOAc fraction (90 g) was subjected to silica gel CC (2.5 kg), (Φ=80 mm, L=70 cm). The column was eluted initially with $CHCl_3$ (5 l), then with $CHCl_3$–MeOH (9 : 1, 4 : 1, 7 : 3, 1 : 1, 2 : 3, 3 : 7, 5 l each) and 100% MeOH (5 l), 500 ml fractions being collected. The similar fractions have been combined, affording 16 subfractions (E-1—E-16). Subfraction E-2 (7.0 g) was subjected to silica gel (500 g) column chromatography using $CHCl_3$ (2 l), $CHCl_3$–MeOH (9 : 1, 4 : 1, 7 : 3, 1 : 1, 2 : 3, 2 l each) and MeOH (2 l). The effluents were collected in 200 ml for each fraction. Similar fractions were combined, yielding six fractions. The fourth fraction (1.5 g) was purified on RPCC using 60% MeOH in H_2O to afford compound **8** (50.0 mg).

Subfraction E-5 (4.0 g) was subjected to RPCC using [55, 60, 70, 80, 90, 100% MeOH in H_2O, 1 l] to afford compound **5** (15.0 mg) from the fractions at 80% MeOH.

Subfraction E-7 (8.0 g) was subjected to RPCC using (50, 60, 70, 80, 90, 100% MeOH in H_2O, 1 l each), producing seven fractions. The fifth fraction (4.0 g) was subjected to silica gel (400 g) CC using $CHCl_3$ (2 l), $CHCl_3$–MeOH (9 : 1, 4 : 1, 7 : 3, 1 : 1, 2 : 3, 2 l each) and 100% MeOH (2 l). The effluents were collected in 200 ml for each fraction and the fractions which showed similar behavior on TLC were combined, producing eight fractions. The fourth fraction was purified by repeated silica gel CC using the same solvent system to afford compound **7** (25 mg). The sixth fraction (100 mg) was subsequently purified by DCCC to yield compound **12** (9.0 mg) in fractions 134—138.

Subfraction E-11 (1.5 g) was treated on RPCC using (50, 60, 70, 80, 90, 100% MeOH in H_2O, 1 l each) to afford 23 fractions. The residue (480 mg) obtained after the combination of fraction 12 and 13 that obtained at 70% MeOH was subjected to DCCC to afford compound **14** (50 mg) and compound **6** (24 mg) respectively. The eleventh fraction (115 mg) was purified by HPLC (Cosmosil, 65% MeOH in H_2O) to afford compound **16** (40 mg) from the peak at 13 min.

Subfraction E-13 (5.0 g) was subjected to silica gel (400 g) CC (Φ=20 mm, L=40 cm) that was eluted initially with $CHCl_3$ (2 l), then with $CHCl_3$–MeOH (9 : 1, 4 : 1, 7 : 3, 1 : 1, 2 : 3 and 100% MeOH, 2 l). The effluents were collected in 250 ml for each fraction. Similar fractions were combined to afford nine fractions. The seventh fraction (530 mg) was treated on RPCC using 40% MeOH as an eluent with gradient elution till 100% MeOH (1 l each) to give compound **15** (66 mg). The sixth fraction (750 mg) was subjected to RPCC starting with 50% methanol with gradient elution till 100% MeOH (1 l each), producing 11 fractions. The fraction 11 (115 mg) was purified by HPLC (Cosmosil) (65% MeOH in H_2O) to afford compound **10** (32 mg) from the peak at 15 min.

Subfraction E-16 (10 g) was subjected to silica gel (400 g) CC, (Φ= 40 mm, L=40 cm) with $CHCl_3$–MeOH–H_2O (15 : 6 : 1, 3 l), 250 ml fractions being collected to afford 12 fractions. Fraction 10 (1.5 g) was treated on RPCC starting with 50% MeOH (1 l) with gradient elution till 100% methanol (1 l), 100 ml fractions being collected. The residue (10 mg) in fractions 14 and 15 of 70% MeOH in H_2O eluate was identified as compound **4**. Fraction 12 (2.0 g) was separated again by silica gel (300 g) CC using ($CHCl_3$–MeOH–H_2O) (15 : 6 : 1, 2 l), 50 ml fractions being collected. The residue eluted (120 mg in fractions 9—11) was purified on RPCC to afford compound **9** (88 mg in fractions 106—120). The residue (30 mg) in fractions 16 and 17 of 80% MeOH in H_2O eluate of the same RPCC experiment was further subjected to RPCC starting with 30% MeOH in H_2O gradient till 100% MeOH, fractions of 5 ml being collected. The residue eluted with the 40% MeOH (12 mg), which was subsequently purified by HPLC (Cosmosil) (80% MeOH in H_2O) to afford compound **2** (2.0 mg) from the peak at 30 min, and the residue eluted with 50% MeOH (15.0 mg) was also purified by HPLC (Inertsil) (90% MeOH in H_2O) to afford compound **3** (2.0 mg) from the peak at 13.5 min.

The 1-BuOH fraction (30 g) was subfractionated by CC on a highly porous synthetic resin, Diaion HP-20 (Φ= 40 mm, L=55 cm). The column was eluted initially with H_2O (3 l), then with MeOH–H_2O stepwise gradient with increasing MeOH content using 40% (2 l), 80% (2 l) and 100% MeOH (3 l). The effluents were collected in subfractions (500 ml each). The similar fractions were combined to provide three subfractions. The fraction eluted with 40% MeOH (10 g) was subjected to silica gel (500 g) CC using $CHCl_3$ (2 l), $CHCl_3$–MeOH (9 : 1, 4 : 1, 7 : 3, 1 : 1, 2 : 3, 2 l each) and MeOH (2 l), yielding seven fractions. The fourth fraction (800 mg) was purified on RPCC (20, 30, 40, 50, 60, 70, 100% MeOH in H_2O, 1 l each), affording compound **13** (50 mg) in fractions 140—155. The fraction eluted with 80% MeOH (6.0 g) and 100% MeOH fractions from the Diaion HP-20 column were combined and then subjected to silica gel (500 g) CC using $CHCl_3$ (2 l), $CHCl_3$–MeOH (9 : 1, 8 : 2, 7 : 3, 5 : 5, 4 : 6, 2 l each), and MeOH (2 l), 200 ml fractions being collected and the similar fractions were combined to yield four fractions. The third fraction was identified as compound **11** (25 mg). The fourth fraction (1.0 g) was treated on RPCC using (20, 30, 40, 50, 60, 70, 80, 90, 100% MeOH in H_2O, 1 l each), 500 ml fractions being collected. The residue (300 mg) in fractions 55—65 of the 35% MeOH eluate was subjected to silica gel CC using $CHCl_3$–MeOH (9 : 10, 8 : 2, 7 : 3, 6 : 4, 5 : 5, 500 ml each) and MeOH (500 ml), providing eight fractions. The eighth fraction (35 mg) eluted from the silica gel CC at 50% MeOH in $CHCl_3$ was further purified by HPLC (Inertsil) (MeOH–CH_3CN–H_2O, 3 : 2 : 5) to afford compound **1** (8.0 mg) from the peak at 8.7 min.

Compound **1**: Amorphous powder. $[\alpha]_D^{25}$ +2.5° (c=0.80, MeOH); IR ν_{max} (film) cm^{-1}: 3381, 2940, 1719, 1692, 1453, 1048; ^1H-NMR (600 MHz, pyridine-d_5) and ^{13}C-NMR (100 MHz, pyridine-d_5): Tables 1 and 2, respectively; HR-ESI-MS (positive-ion mode) m/z: 817.4334 $[M+Na]^+$ (Calcd for $C_{42}H_{66}O_{14}Na$: 817.4334).

Compound **2**: Amorphous powder. $[\alpha]_D^{25}$ +11.5° (c=0.20, MeOH); IR ν_{max} (film) cm^{-1}: 3381, 2925, 1747, 1692, 1455, 1047; ^{1}H-NMR (600 MHz, pyridine-d_5) and ^{13}C-NMR (100 MHz, pyridine-d_5): Tables 1 and 2, respectively; HR-ESI-MS (positive-ion mode) m/z: 669.3964 $[M+Na]^+$ (Calcd for $C_{37}H_{58}O_9Na$: 669.3973).

Compound **3**: Amorphous powder. $[\alpha]_D^{25}$ +9.0° (c=0.20, MeOH); IR ν_{max} (film) cm^{-1}: 3388, 2928, 1733, 1692, 1457, 1062; ^{1}H-NMR (600 MHz, pyridine-d_5) and ^{13}C-NMR (100 MHz, pyridine-d_5): Tables 1 and 2, respectively; HR-ESI-MS (positive-ion mode) m/z: 711.4449 $[M+Na]^+$ (Calcd for $C_{40}H_{64}O_9Na$: 711.4442).

Compound **4**: Amorphous powder. $[\alpha]_D^{25}$ −11.9° (c=0.45, MeOH); IR ν_{max} (film) cm^{-1}: 3398, 2942, 1689, 1641, 880; ^{1}H-NMR (600 MHz, pyridine-d_5) and ^{13}C-NMR (100 MHz, pyridine-d_5): Tables 1 and 2, respectively; HR-ESI-MS (negative-ion mode) m/z: 631.3863 $[M-H]^-$ (Calcd for $C_{36}H_{55}O_9$: 631.3851).

Compound **5**: Amorphous powder. $[\alpha]_D^{25}$ −19.8° (c=0.22, MeOH); IR ν_{max} (film) cm^{-1}: 3441, 2943, 1700, 1650; ^{1}H-NMR (600 MHz, pyridine-d_5) and ^{13}C-NMR (100 MHz, pyridine-d_5): Tables 1 and 2, respectively; HR-ESI-MS (negative-ion mode) m/z: 501.3221 $[M-H]^-$ (Calcd for $C_{30}H_{45}O_6$: 501.3221).

Compound **6**: Amorphous powder. $[\alpha]_D^{25}$ −21.3° (c=0.33, MeOH); IR ν_{max} (film) cm^{-1}: 3398, 2944, 1690, 1646, 886; ^{1}H-NMR (600 MHz, pyridine-d_5) and ^{13}C-NMR (100 MHz, pyridine-d_5): Tables 1 and 2, respectively; HR-ESI-MS (positive-ion mode) m/z: 671.3763 $[M+Na]^+$ (Calcd for $C_{36}H_{56}O_{10}Na$: 671.3765).

Compound **7**: Amorphous powder. $[\alpha]_D^{25}$ −11.2° (c=0.31, MeOH); IR ν_{max} (film) cm^{-1}: 3462, 2942, 1733, 1647, 884; ^{1}H-NMR (600 MHz, pyridine-d_5) and ^{13}C-NMR (100 MHz, pyridine-d_5): Tables 1 and 2, respectively; HR-ESI-MS (positive-ion mode) m/z: 671.3768 $[M+Na]^+$ (Calcd for $C_{36}H_{56}O_{10}Na$: 671.3765).

Analysis of the Sugar Moiety About 2 mg each of compounds **1**, **4**, **6** and **7** was hydrolyzed with 1 N HCl (0.1 ml) at 88 °C for 2 h. The reaction mixtures were partitioned with an equal amount of EtOAc (0.1 ml), and the water layers were analyzed for its sugar components. The sugars were determined by HPLC on an amino column [Asahipak NH_2P-50 4E, CH_3CN–H_2O (75 : 25), 1 ml/min], using chiral detector (JASCO OR-2090*plus*), in comparison with authentic sugars (D-glucuronolactone, D-galactose and D-glucose). Compound **1** gave peaks for D-glucuronolactone and D-galactose at retention times of 5.0 min and 8.5 min respectively (positive optical rotation signs). Compound **4** gave a peak for D-glucuronolactone at the retention time of 5.0 min (positive optical rotation sign). Compounds **6** and **7** gave a peak for D-glucose at the retention time of 8.0 min (positive optical rotation sign).

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